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Longitudinal Assessment of the Achievement of the Desired Goals and Characteristics of a First-Year Engineering Course Redesign

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Keywords: first year, design, course redesign, project-based

Abstract
(Complete Evidence-based Practice)
For nearly 20 years, the first-year introductory engineering course at Bucknell University followed a seminar-based format. This course was successful, but opportunities for improvement were apparent in recent years. The desired outcomes and associated characteristics were reconsidered with the solicitation of the College of Engineering in 2020 and a three-year redesign was undertaken and completed in Fall 2023 with its third iteration.

This paper assesses how the redesign achieved the initial goals and how its delivery reflects the desired characteristics. Four course outcomes were adopted: 1) Develop creative solutions by applying engineering design, math, science, and data analysis, 2) Construct an effective prototype or model using technology and tools, 3) Demonstrate improved power skills (communication, teamwork, information literacy, professionalism), and 4) Employ NSPE Code of Ethics to examine case studies and extrapolate for other situations. In terms of the course outcomes, this paper describes how students self-assessed their achievement of these course outcomes through course evaluation surveys over three years. The appropriateness of the selected outcomes is evaluated by constituents of the program (students, faculty, staff, and expo attendees) to inform future direction of the course.

In addition to the course outcomes, the coordinators identified several desired characteristics of the redesigned course based on feedback from colleagues throughout the process. The College of Engineering colleagues desired a course that incorporated a focus on design, hands-on projects, transferable power skills, transferable technical skills, and an ethical grounding. It was also desired that the redesigned course reflect Bucknell's engineering identity, excitement for the profession of engineering, create an inclusive community, and develop professionalism in the first-year students. After three iterations of the course (with small additions/improvements incorporated annually), a survey was administered to all engineering students who experienced the redesigned course to determine if the course delivery and student experience achieved these desired characteristics.

The results of the survey are analyzed and indicate that the achievement of course outcomes has improved over the three iterations of the course. The effectiveness of specific activities and aspects of course delivery in achieving the desired course characteristics are also assessed. Finally, the authors reflect on the process of redesigning a college-wide course and coordinating efforts across multiple sections.

Introduction and Purpose

Bucknell University has required that first-year incoming engineering students complete a college-wide cornerstone course for more than 30 years, since 1989. The evolution of the course over this time is reviewed in the next section, and the College of Engineering generally agreed that a redesign was necessary to incorporate current best practices in pedagogy, address changes in student interests, and explicitly address inclusivity in response to shifts in the university demographics. A deliberate choice in the redesign was a smaller, common, focused set of learning outcomes, which significantly deemphasized discipline-specific content and peripheral activities such as student exploration of different engineering majors, and this choice created tensions that persist and are discussed later in this paper.

The purpose of this paper is to assess how well the most recent 3-year redesign of the course achieved the initial goals and how well its delivery reflects the desired outcomes and attributes set out in 2020 [1]. The new course has been offered three times and the assessment data consists of course evaluation surveys over the three years and an additional survey administered to all engineering students who experienced the redesigned course. The paper is organized with background information in the next section followed by a description of the assessment data methodology and analysis of results in terms of overarching themes.

Background

Bucknell University is a predominantly undergraduate institution with a College of Engineering situated within the liberal arts context. The College of Engineering typically enrolls around 200 students each year, currently divided among eight degree programs (Biomedical, Chemical, Civil, Computer, Computer Science, Electrical, Environmental, and Mechanical Engineering). ENGR 100 is the cornerstone course taken by all incoming first-year engineering students, as well as an introductory elective for students in Arts and Sciences or Management. This course is one of four courses in the common, first semester curriculum for all engineering students.

For roughly the first decade from 1989-2001, the course was delivered primarily in a lecture hall with more than 200 students along with weekly lab sessions in smaller groups. The course was substantially redesigned in 2002 to include three three-week seminars with smaller sizes (around 33 students) that were quasi-discipline-specific with team-based, hands-on projects [2], [3]. The six course outcomes in the 2002 redesign were: *(1) Provide overview of basic engineering practice, including histories, impact on society, skills employed, and professional/ethical responsibilities; (2) Provide instruction to knowledge bases, skills, problem types, and analysis techniques of the five engineering disciplines at Bucknell; (3) Develop skills for productively working in multifunctional teams, supported through guided practice and reflection; (4) Develop strategies for addressing open-ended problems, and engage in design of systems intended to meet specific needs; (5) Develop technical communication skills; (6) Provide knowledge and guidance allowing students to make an informed decision about choice of engineering major.* The rotating seminar version of the course achieved the course outcomes, and key features included faculty autonomy in focusing their seminar on a topic of their choice and students exploring various engineering disciplines. However, several challenges became apparent over the seminar-based version of the course, prompting a major redesign in 2021 [1]. The key challenges that prompted this redesign include a desire to incorporate current best practices in pedagogy, respond to changes in student interests, and explicitly address inclusivity in response to shifts in the university demographics.

Three full-time, tenure-track faculty members from chemical, civil, and mechanical engineering formed a coordination team with a three-year contract, and initiated a major redesign of ENGR

100 for the Fall 2021 [1]. With input from the College of Engineering, the new course outcomes were determined as follows:

1. *Develop creative solutions for problems facing our world by applying engineering design principles, math and science, and data analysis*
2. *Construct an effective prototype or model utilizing appropriate technology and tools*
3. *Demonstrate improved proficiency with "power skills" such as communication, teamwork, information literacy, and professional development* and
4. *Employ the NSPE (National Society of Professional Engineers) code of ethics to examine ethical case studies and extrapolate principles for other situations*.

In addition to these learning outcomes, the coordinators identified nine common desired and aspirational attributes to be embedded in the course:

1. *Design-focused*
2. *Hands-on projects*
3. *Transferable power skills*
4. *Transferable technical skills*
5. *Engineering ethics considerations*
6. *Bucknell's engineering identity*
7. *Excitement for profession for engineering*
8. *Inclusive community*
9. *Professionalism*

Incorporating more modern pedagogical approaches and placing an emphasis on more consistent experiential learning across the student body, the redesigned ENGR 100 course delivered a project-based learning of a simplified engineering design process, in two half-semester sessions, under a central theme of "sustainability on campus". Eight/nine co-instructors, who represented all of the engineering disciplines within the College, had mixed majors in their sessions and led the course in a discipline-agnostic fashion.

In the second year of the redesign period, the coordinators focused on integrating engineering ethics seamlessly into the project-based sessions [4]. In the previous version of ENGR 100, ethics was introduced after the series of three discipline-specific modules in a single, concentrated week. By fundamentally shifting the approach of ethics case studies from famous, historic, national disasters to scenarios that are lower stakes and much closer to home, such as considerations for constructing a wind turbine on campus, the instructors were able to develop a broader sense of engineering ethics, underscored by the triple-bottom line of sustainability.

In the third and final year of the redesign period, a new out-of-class, team activity called "Engineering Quest" was implemented, where the students gained general knowledge about College's disciplines in a scavenger/puzzle hunt while bonding with their project teams [5]. In addition, the instructors focused on promoting better student reflection on their course activities and life-long learning skills by way of e-portfolio assignments.

A three-year period was advantageous in not only rolling out redesigned course components in stages, but also continuous improvements based on student and co-instructor feedback each year.

While individual assessments of the newly implemented pedagogical approaches taken during the redesign would be useful, the authors focus this paper on a longitudinal and comprehensive assessment of the 3-year redesign period, which is particularly valuable for cornerstone and capstone courses using the project-based learning pedagogy [6], [7].

Methodology

Several sources of data were collected in this study to examine all three years of the course redesign. First, a portion of the course evaluations were utilized to examine the student self-reported achievement of course outcomes. Second, an electronic survey of the College of Engineering faculty was developed to determine if our colleagues were in agreement with the final choice of course outcomes. Third, an electronic survey of all engineering students that completed the course to examine their perception of the course meeting the intended outcomes and desired characteristics. The surveys were designated exempt and approved by Bucknell University's IRB #2324-048.

Student achievement of course outcomes was assessed via the University standard course evaluation platform, at the end of each half-semester session (six course evaluations over the three-year period). A set of four common questions on the evaluation form asks "How well did you perform on the following learning goals." Each question then iterates one of the four ENGR 100 course objectives and the students self-report their achievement of those objectives on a five-point Likert scale ranging from "extremely well" to "not well at all".

Both the faculty/staff and student surveys were administered through Qualtrics. The faculty survey was sent through a listserv for the College of Engineering and the student survey was sent to engineering students who had successfully completed the course in Fall 2021, 2022, or 2023. The surveys remained open for two weeks with a single reminder sent after one week. To increase the response rate on the student survey, a financial incentive ($50 gift certificate) was provided to twenty randomly identified respondents.

The faculty survey was short, only asking about the appropriateness of the selected four course outcomes on a five-point Likert scale (strongly agree to strongly disagree). A single open-ended question was included for respondents to offer additional feedback on their perception of the redesigned course.

The student survey was longer and was organized in two sections: the first section focused on the importance of the course outcomes. Students were asked to rate, on a five-point Likert scale, how important each outcome was for the ENGR 100 course and how important it was for subsequent courses in their curriculum. The second section focused on the attributes or characteristics of the course delivery. The survey asked about each of the nine attributes that the course delivery was expected to demonstrate (design-focused, hands-on projects, transferable power skills, transferable technical skills, engineering ethics considerations, Bucknell's engineering identity, excitement for the profession, creating an inclusive community, and professionalism). Students were asked if they thought the course demonstrated each attribute and then were asked to identify, from a list of course elements, which contributed to that attribute. Finally, two open-ended questions were available for students to give advice to future ENGR 100 course instructors/coordinators and to give advice to future ENGR 100 students.

At the conclusion of the survey window, the raw data was exported to Excel for quantitative analysis of the results and thematic analysis of the open-ended questions. The authors eliminated responses from surveys that were less than 75% complete.

Analysis and Results

Overview of data

While the data collected in this study draws from a variety of sources and is relatively large, there are several notes to be made about the data and how it was analyzed.

The ENGR 100 course evaluations were administered by individual instructors. While the student response rate on course evaluations is high (>90%), the authors compiled the results from those instructors who voluntarily shared the course evaluation results. The number of evaluations received vs. the number enrolled for each of the three years are as follows: Fall 2021-138/201; Fall 2022-188/208; Fall 2023-155/169.

The faculty survey was sent to 91 faculty in the College of Engineering via listserv with only 17 responses. While this response rate is less than 20%, it is important to note that only 15 faculty have taught in the course in the past three years because they have taught in multiple iterations of the course, often by choice. Despite sharing several white papers, surveys, updates at College meetings, and invitations to attend an Expo for the course, the number of colleagues who have personal experience with the redesigned course is still relatively small so the low response rate was not surprising.

The student survey was sent to 516 students across all three years of the course redesign. The total response rate was 32.6%, but varied from each class year, as shown in Table 1. It is not surprising that the response rate from the cohort of students that had finished the ENGR 100 course two years ago was lower than the response rate of the cohort of students who were just finishing the course when the survey was administered. The authors hoped that the gift certificate drawing incentive would increase the response rate equally across all years, but it is evident that was not the case [8].

Table 1: Distribution of response rates by course completion year

	Completed surveys	Received surveys	Response rate
Fall 2021	22	161	13.7%
Fall 2022	40	187	21.3%
Fall 2023	106	168	63.1%
Total	168	516	32.6%

It was noted that students, particularly in Fall 2021, were expecting the old version of the course as the dialogue provided through admissions staff was not updated prior to their acceptance. This was evident in several of the responses from Fall 2021 where three responses selected "strongly disagree" or "no" across the entire survey and left comments in the open-ended section such as "Scrap everything you did. Worst thing ever!" In addition, the authors are aware of at least one social media post that encouraged group behavior to "tank the survey" with negative comments.

Discussion

The results are presented in the form of thematic takeaways that emerged as the data were reviewed. The themes pertain to the longitudinal nature of a course redesign, based on both direct and indirect assessment.

<u>Theme 1: Course redesign takes time and resources</u>

The redesign of a college-wide or interdisciplinary course that involves multiple instructors and sections is a significant undertaking that needs to be recognized as such by the administration. Sufficient time and resources need to be dedicated if a successful redesign is to be achieved. This was also acknowledged in a description of the previous redesign of the same course in 2007 [3]: "The change from the single-class to the seminar model represented a significant investment of faculty time and university resources."

The redesign of this course did not happen quickly or with significant constraints. An agreement between the coordination team and the Dean of the College of Engineering was clearly written to identify the expectations of the redesign, resources available to the team, timeline for the project, and desired deliverables. This agreement specified that the team planned to redesign and implement specific elements each year of a three-year timeframe, not all at once. The team negotiated both course release for the redesign and summer salary, as significant work was necessary to be completed while the redesign team was off-contract. In addition to support for the redesign team, financial support to facilitate the delivery of the course (course materials and related expenses) was also included. The upfront discussion of expectations and resources to achieve those expectations was critical.

This course redesign process followed many of the engineering design process practices that the students are learning in class. Starting with a three-person, interdisciplinary co-coordinators makeup, the teamwork of the entire instruction team was the primary key to success. With many repeat instructors over the course of three years, team cohesion led to constant, candid discussions with a goal of improving the course together.

Considering ENGR 100 is a cornerstone course that represents the College of Engineering, the coordinators paid particular attention to constant communication and dissemination of changes with various stakeholders (students, instructors, faculty and staff in the College, College of Engineering Leadership Council, Provost's office, and ASEE community) in an inclusive manner. Feedback to implemented changes and plans for change were constantly sought. The coordinators have been kept abreast of the philosophical and pedagogical tensions that exist in a non-discipline-specific course, and have been able to make balanced, compromised decisions.

As discussed above, the three-year redesign period was necessary and helpful in iterating on the course, as the coordinators were able to improve the course continuously in an agile and manageable fashion. In addition to the redesign elements that were planned for each year, the team identified additional opportunities for improvement through annual instructor meetings and college-wide surveys. The resulting improvements were implemented in the next iteration of the course.

From our personal experience, the deliberate compartmentalization of various course redesign aspects that were developed and implemented in subsequent years was critical. It was clear that the coordination team did not have the bandwidth in a single year to implement all of the changes that were possible over the three-year window. By focusing their effort each year, the changes implemented were achieved at a higher level than if all of the changes were attempted in year one. For example, changes were made after the first iteration to more intentionally introduce students to the Makerspaces on campus, supporting Outcome 2 related to prototyping. From the course evaluation data shown in Table 2, the self-reported achievement of this outcome increased from 69% reporting that they achieved this extremely well or very well in Fall 2021 with no intentional programming to 78% and 81% in Fall 2022 and Fall 2023 when the interventions were implemented. It is noted that the specific changes related to Outcome 4 (ethics) which were implemented in 2022 did not yield the same increase in self-reported achievement.

As seen in the shift of percentages of "extremely well" and "very well" on the student achievement of course outcomes in Table 2, the improvements are gradual and incremental, but appreciable especially when combined with anecdotal evidence and instructor's self-evaluation of the effectiveness of the course, such as: "As an instructor in all three years of the redesigned course, I thought the thoughtful discussions at the biweekly instructor team meetings allowed for continuous improvement by the entire teaching team. I could see steady, visible improvements in course delivery each year, both in my personal delivery and as a team."

Table 2: Percentage "extremely well" and "very well" (top 2 of 5 Likert-scale choices) in self-reported achievements of the four outcomes in course evaluations

	2021	2022	2023	compared to: 2018-2019 (Pre-pandemic) outcomes	
	n= 138	n= 188	n= 155	n = 296	
O1: DESIGN	73%	78%	81%	63%	(engage in design of systems intended to meet specific needs)
O2: PROTOTYPE	69%	78%	81%		
O3: POWER SKILLS	76%	79%	81%	72%	(develop skills for working in multifunctional teams)
O4: ETHICS	73%	73%	75%	71%	(provide an overview of engineering practice, including professional/ethical responsibilities)

As an additional comparison, Table 2 compares the three-year outcome achievement numbers to equivalent survey results administered for the pre-redesign (and pre-pandemic) version of the same course. While the course outcomes have all shifted, three comparisons of similar outcomes indicate that the redesign has generally led to higher self-reported achievements in application of engineering design principles, demonstration of teamwork and other power skills, and consideration of engineering ethics.

<u>Theme 2: Successful achievement of desired outcomes was linked to deliberate actions</u>

Before the redesign began, the coordination team solicited input from the entire College of Engineering through surveys and focus groups. The coordination team asked about desired outcomes of the course and this input came in the form of both learning outcomes and desired characteristics that did not explicitly tie to a learning outcome. The College also had established several aspirational goals for the redesign. This information was utilized to narrow the list of course outcomes to the four listed in the Background section and the attributes were used to guide the pedagogical approach and delivery methods of the course.

The appropriateness of the selected four outcomes was assessed through the faculty survey and the student survey. The faculty were asked to “rate your level of agreement that these are the “right” outcomes for ENGR 100”. The students responded to the statement “This course outcome was important and relevant to me as an entering engineering student in ENGR 100.” The results from the faculty survey are shown in Figure 1 and results from the student survey are shown in Figure 2.

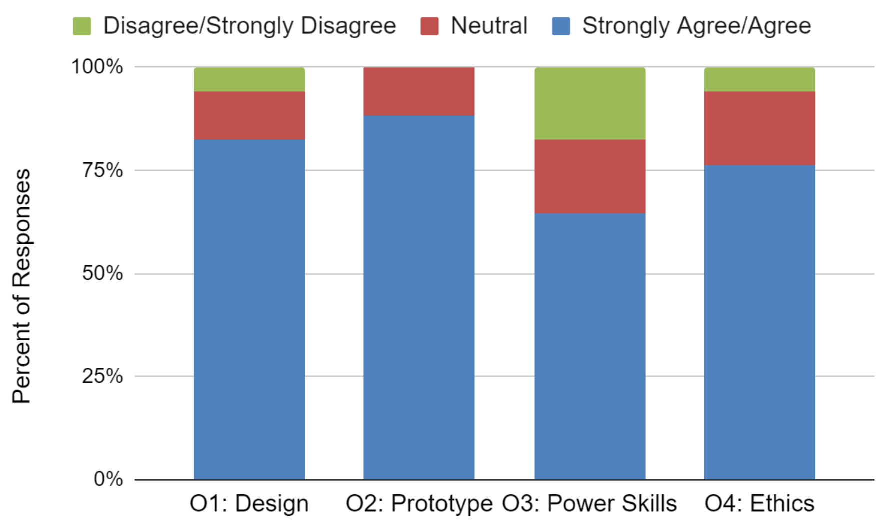

Figure 1: Faculty responses to the appropriateness of each of the four course outcomes (n=17)

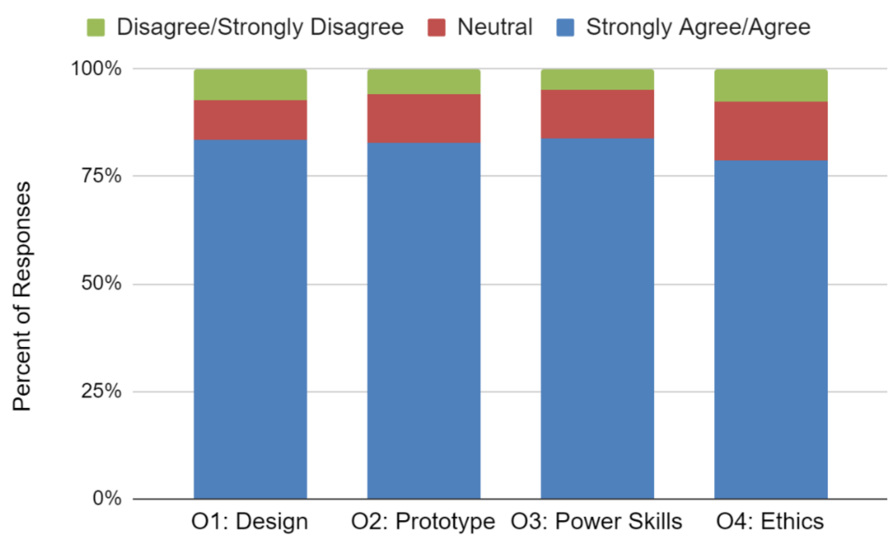

Figure 2: Student responses to the importance and relevance of each of the four course outcomes (n=168)

Specific interventions were implemented to address each of the four learning outcomes as demonstrated in Table 3. It is believed that these interventions contributed to the high self-reported achievement of these outcomes in the course shown in Table 2. The achievement of almost every outcome increased in each iteration of the course thus far. The implementation of each intervention was improved by collecting feedback from the team during our biweekly meetings to inform the improvement of course materials for the subsequent iteration.

Table 3: Deliberate interventions intended to support each course outcome

Outcome:	Intervention:
Outcome 1: Develop creative solutions for problems facing our world by applying engineering design principles, math and science, and data analysis in a sustainable manner.	Real-world projects that related to the "Sustainability on Campus" theme. Students identified a problem and developed a solution which was required to follow the engineering design process, incorporate at least 1 math/science concept, and collect or analyze data.
Outcome 2: Construct an effective prototype or model utilizing appropriate technology and tools	All project teams were required to develop a prototype or model (physical or virtual) that was used to communicate their design.
Outcome 3: Demonstrate improved proficiency with "power skills" such as communication, teamwork, information literacy, and professional development	Common course material was presented in each section and linked to the design project at hand: ● Communication: interpersonal communication within a team as well as public facing, persuasive communication for culminating Expos ● Teamwork: Team agreements, microaggressions, and strategies for conflict resolution were introduced ● Information literacy: Finding, assessing, and referencing information from a variety of sources, including AI ● Professional development: Opportunities to meet with career center and other on-campus resources were provided during Expos; Headshots for LinkedIn or similar were provided at no cost to the student
Outcome 4: Employ the NSPE code of ethics to examine ethical case studies and extrapolate principles for other situations	Common course material, activities, and assignments were utilized for ABET accreditation including case study examples, live-action simulation [9], and final assessment of a hypothetical ethics scenario related to sustainability.

Specific interventions were implemented to address *some* of the desired attributes of the redesigned course as demonstrated in Table 4. When asked which activities contributed to the achievement of that attribute, the students often identified activities that corresponded with the interventions implemented by the coordination team.

Table 4: Deliberate interventions intended to support each desired attribute

Attribute:	Faculty-identified Intervention(s):	Students perceived these interventions to contribute most significantly to this attribute:
Design-focused	Design project-based learning strategy for the entire course	Project-based Learning Design Expos Benchmark Assignments/Deliverables
Hands-on Projects	Projects were required to have some data collection/analysis, experimentation, and prototype development	Project-based Learning Design Expos Benchmark Assignments/Deliverables
Transferable Power Skills	Interventions related to course Outcome 3 apply	Design Expos Project-based Learning Benchmark Assignments/Deliverables
Transferable Technical Skills	Data analysis was performed using spreadsheets; Poster/slide creation demonstrated at least one plot/graph and demonstrated best practices; Skills appropriate to their design session prototype/model/experiment	Benchmark Assignments/Deliverables Project-based Learning Design Expos
Engineering Ethics Considerations	Interventions related to course Outcome 4 apply	Individual HW Assignments Classroom Activities
Bucknell 's Engineering Identity	No specific interventions	Project-based Learning Design Expos Orientation Event
Excitement for Profession of Engineering	No specific interventions	Project-based Learning Design Expos Orientation Event
Create an Inclusive Community	Engineering Quest to enhance team bonding; Course materials on microaggressions and diversity	Orientation Event Design Expos Project-based Learning
Professionalism	Individual contributions/assignments; Intermediate benchmark deadlines across all sections	Design Expos Benchmark Assignments/Deliverables Project-based Learning

It was anticipated that Bucknell’s Engineering Identity and Excitement for the Profession would develop naturally through the course of the hands-on, real world projects. However, the student survey results indicate that these two attributes were achieved at a lower level than all of the other attributes as shown in Figure 3.

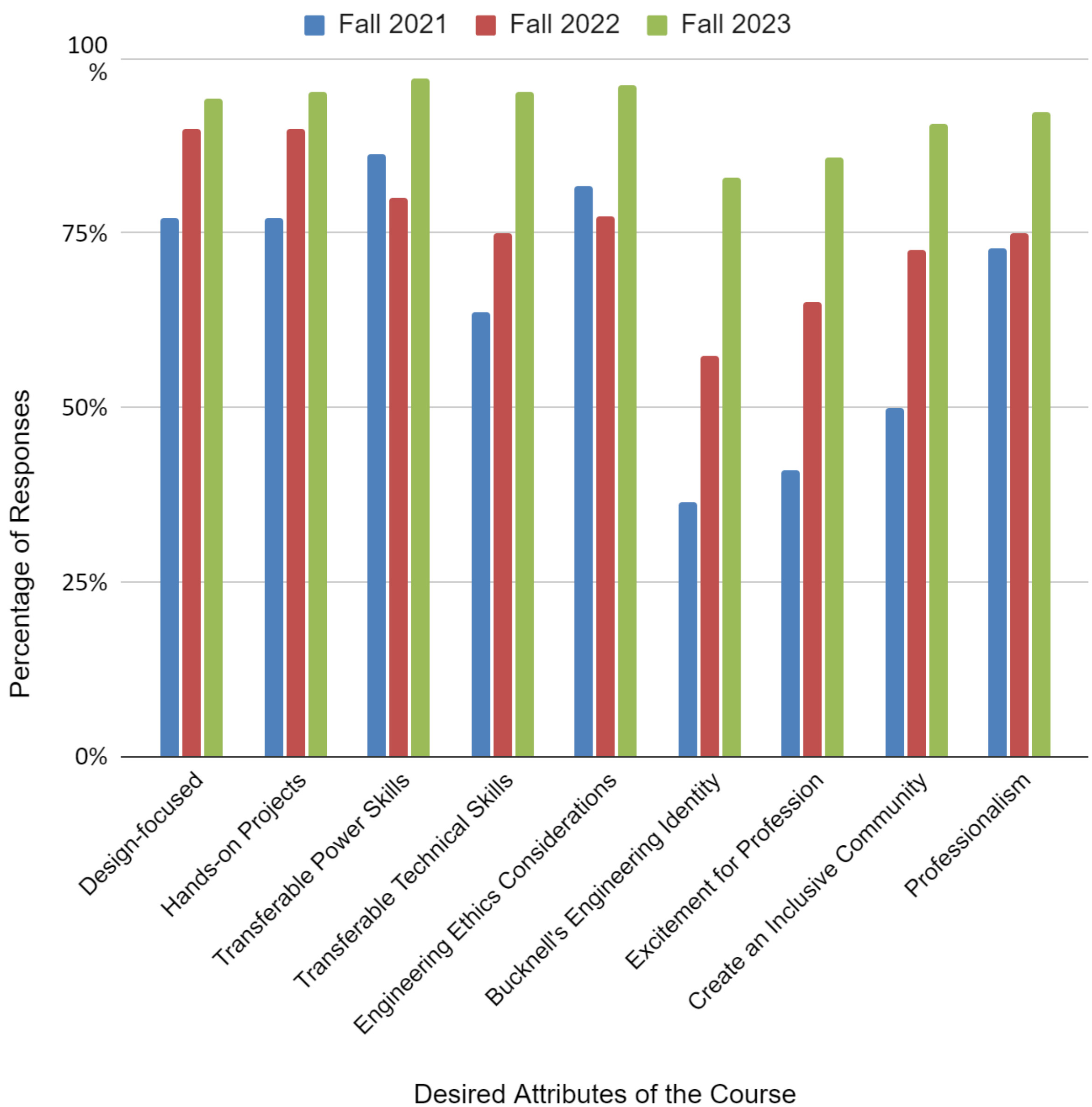

Figure 3: Student survey responses positively affirming that the ENGR 100 course delivery achieved each of the desired attributes

In retrospect, these two attributes were identified as more aspirational goals than characteristics identified through focus groups.

> *"Aspirationally, the course could 1) fully reflect Bucknell's engineering identity nested in the liberal arts, 2) generate excitement for the engineering profession and the remainder of the engineering education at Bucknell, 3) build community and inclusive behavior, and 4) emphasize professionalism."* [1]

The coordination team unintentionally prioritized the attributes that drew from the focus groups and college input, leaving room for improvement on these more aspirational goals.

Theme 3: Tensions continue to exist

As mentioned in the previous themes, the coordinators consistently sought input from colleagues and communicated plans throughout the four-year course redesign process (one year of planning and three years of delivery). Despite these efforts at least two overarching tensions still exist. One is mostly a local issue based on the more than 30 year history of previous versions of the course and the other tension is likely to exist on nearly every college campus.

The local tension is providing opportunities within the course for students to explore different engineering disciplines in order to help them choose their engineering major, which occurs at the midpoint of the first semester. Prior to the redesign, this aspect was highlighted to prospective students during pre-college visits and on the university website. It was a stated outcome of the previous versions of the course and became firmly entrenched in the minds of faculty and students [2], [3]. The coordinators deliberately left out opportunities for students to explore different engineering disciplines in the redesign. The previous version of the course had become disjointed with a variety of topics (including the disciplinary explorations) that eroded the unifying purpose in the eyes of students. Therefore the redesign focused exclusively on the four academic outcomes stated previously and omitted topics that were not directly relevant to these outcomes. The coordinators were aware of the tension from the beginning and observed the following after running the new course for one year [1]:

> *"Many student course evaluations criticized the lack of coverage of disciplinary introductions and individual major information in ENGR 100, partly because the former versions of the course had done so for over 20 years. These comments are in direct conflict with the intention of the redesigned interdisciplinary format of the course to de-emphasizes disciplinary information in class. We plan to work with relevant campus partners to address this misunderstanding and discuss with the co-instructors to overcome this tension."*

The coordinators worked to improve the issue by meeting with Admissions Department staff multiple times to clarify information provided to prospective students, as well as developing an Engineering Quest team-based activity [5] performed by students outside of class to provide some information about the engineering disciplines. The College of Engineering Dean's Office also introduced a peer mentoring program and organized events for the first-year students to promote engineering discipline exploration. Despite these efforts the tension still exists, as evidenced by continuing comments from students on course evaluations as well as comments from students and faculty in the open-ended questions on the surveys. Reducing the expectation that the course will provide opportunities for students to explore different engineering disciplines will require more time as discussed in Theme 1.

The second tension that is more common across all campuses arises from the priorities of individual engineering departments versus larger academic units such as the college and university. The discipline-agnostic approach adopted in the redesign increased this tension compared with the previous version that contained more discipline-specific content. In the following observation was made after one year of running the redesigned ENGR 100 course:

> *"ENGR 100 successfully became one of the few classes offered in Bucknell College of Engineering where the faculty or student discipline/department/major was not the focus of lessons or discussions. Rather, the course emphasized one single identity as an*

engineer, and students undertook the same assignments, deliverables, and goals regardless of declared major." [1]

After running the redesigned course for three years, tensions still exist among students and faculty in the College of Engineering stemming from the discipline-agnostic approach. Tensions are inevitable between some departments that would prefer to reclaim the ENGR 100 curricular spot in order to provide more disciplinary content, versus the broader needs of the college and university to protect curricular space for incoming students to adjust to college life and learn what it means to be an engineer. The college and university benefit from the discipline-agnostic approach, and departments benefit indirectly, although some departments disagree and think discipline-specific content is more valuable than activities that more broadly support the overall institution and student development. Leadership from the Dean and Provost to promote the common good for the institution are important to tamp down these tensions as much as possible.

Ideally all faculty would view the overall curriculum through both a "college hat" and their "department hat." In the early focus groups at the start of the redesign the coordinators found that most faculty were wearing a college hat in proposing course outcomes and desired attributes. However, over the years, the coordinators were members of a smaller group of faculty that continued to wear a "college hat" while many others shifted to a "department hat" in their views. The coordinators conducted a survey of engineering faculty after the second offering of the redesigned course and this shift was evident in the results and comments, where lack of disciplinary content was by far the dominant complaint. Similar results also appear in the faculty survey conducted in December 2023. However, a notable feature in the more recent survey is a sharp contrast between faculty that have taught in the redesigned course and those that have not. As noted in Theme 1, more time will be required so that more faculty can teach in the redesigned course and see first-hand the value of the discipline-agnostic approach (15 out of 91 faculty or 16.5% have taught in the redesigned course). The benefits of this approach are not immediately apparent to faculty that meet students in subsequent courses, instead they tend to notice a lack of discipline-specific knowledge. The results of the student survey conducted in December 2023 show considerable improvement in student perceptions over the three years, but faculty perceptions change much more slowly. However, as an example of the transformation in faculty perception after teaching the redesigned course, this is a quote from an instructor after one year: "I was never opposed to ENGR 100 or the redesign of the course, but I couldn't understand the desire to teach design before the students had learned some core engineering science concepts. I see now that I underestimated what first-year students can prototype and what they are motivated to try. There is certainly value in experiencing the design process even with minimal expertise. In sum, I have been transformed from a lukewarm supporter to a vocal advocate for ENGR 100."

Student Reflections

At the conclusion of the survey, students were asked two open-ended questions: "What advice do you have for future ENGR 100 instructors and coordinators?" and "What advice do you have for future first-years who will be taking ENGR 100?" A review of the comments indicated that the impact on students was mixed. Some students clearly understood and valued the course's primary focus on transferable skills, while others did not. Some students from the first and second iterations of the course even commented how the skills introduced in this course are utilized in subsequent courses.

"Enjoy it! Really get to know your group members and make a project you can be passionate about. You learn a lot, but can also have fun with it too. This course gives you room to mess up, but also gives you so much room to grow. I still use the skills from this course today, and have met some of my closest engineering friends from ENGR100."

- *Student comment from first iteration of redesigned course*

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"Don't focus too much on the actual logistics of the project because you do not have all the information that you need to actually complete the project at the level that is needed. Instead, takeaway the overall design process and certain skills like making a professional poster, working in a team, and acting professional."

- *Student comment from first iteration of redesigned course*

"This class will teach you how to use the engineering design process and how to properly communicate with a group. Do not expect to learn much about specific engineering topics but rather the inherent interpersonal aspect of engineering."

- *Student comment from first iteration of redesigned course*

It was apparent that some students expected more of a technical focus for the course. The perceptions and experiences shared by students in previous versions of the course may have contributed to the development of unrealistic expectations for incoming students. However, this type of comment was only from students who took the first and second iterations of the redesigned course, suggesting that passing time has already begun to minimize the carry-over from the previous version of the course.

"You won't learn any technical skills from this class that you'll need in future classes. I advise you to learn these on your own because the curriculum made for you will not teach you these skills.

- *Student comment from second iteration of redesigned course.*

Comments from students in the third iteration of the course were more specific to the logistics of the course itself, as the survey was completed within a month of them completing the course.

"Be open-minded and flexible in your idea of how the team is going to function. Do something out of your comfort zone; if you usually are a follower try leading instead. If you are a leader try following. Be on time to all classes and team meetings, punctuality is part of professionalism and respect for your teacher and team. Also hand-in all assignments on time. Things snowball, stay on top of it."

- *Student comment from third iteration of redesigned course*

"Utilize all tools in the makerspaces, although they may seem difficult to learn at first, they are great to know how to use for all classes."

- *Student comment from third iteration of redesigned course*

"It is probably not what you expect it to be but you will appreciate it at the end"

- *Student comment from the third iteration of redesigned course*

Conclusions

Reviewing the longitudinal data on the three-year redesign of the ENGR 100 cornerstone course, the course outcomes and attributes that saw gradual, consistent improvements over the redesign period were those involving targeted interventions by the coordination and instruction team. While the thematic takeaways were developed from this course-specific redesign, the spirit of the underlying notions are applicable for the redesign of other similar courses (college-wide, introductory, multiple sections/instructors, significant redesign).

References

[1] K. Salyards, B. Wheatley, and K. Wakabayashi, "Redesigning an Introduction to Engineering Course as an Interdisciplinary Project-Based Course," Presented at *2022 First-Year Engineering Experience*, East Lansing, Michigan. Available: https://peer.asee.org/42246

[2] S. Velegol, R. Ziemian, R. Zaccone, R. Kozick, J. Baish, and M. Vigeant, "Exploring Engineering At Bucknell University: A Seminar Approach To The First Year Engineering Experience," in *2003 Annual Conference Proceedings,* Nashville, Tennessee: ASEE Conferences, Jun. 2003, p. 8.561.1-8.561.14.

[3] M. Vigeant, K. Marosi, and R. Ziemian, "Evaluating The Seminar Model For First Year Engineering Education," in *2007 Annual Conference & Exposition Proceedings*, Honolulu, Hawaii: ASEE Conferences, Jun. 2007, p. 12.698.1-12.698.11.

[4] B.B. Wheatley, K. Wakabayashi, and K. Salyards, K., "Integration of ethics in sustainability in a first-year design course," in *2023 Annual Conference Proceedings,* Baltimore, Maryland: ASEE Conferences, Jun. 2023. Available: https://peer.asee.org/43791

[5] K. Salyards, K. Wakabayashi, and R. Kozick, "Engineering Quest: A Puzzle Adventure for Building Teamwork," *Engineering Unleashed*, Jan. 16, 2024. Available: https://engineeringunleashed.com/card/3958

[6] J. Dong and H. Guo, "Effective Course Redesign Strategies to Integrate Collaborative PBL in Senior Computer Engineering/Computer Science Courses," in *2014 ASEE Annual Conference & Exposition Proceedings*, Indianapolis, Indiana: ASEE Conferences, Jun. 2014, p. 24.454.1-24.454.14.

[7] N. Tsuchiya, P.M Nissenson, and M. Jawaharlal, M., "A Student Assessment of the Value of a Redesigned First Year Mechanical Engineering Orientation Course," Presented at *2017 Pacific Southwest Section Meeting*, Tempe, Arizona. Available: https://peer.asee.org/29200

[8] T.-H. Shih and Xitao Fan, "Comparing Response Rates from Web and Mail Surveys: A Meta-Analysis," *Field Methods*, vol. 20, no. 3, pp. 249–271, Aug. 2008.

[9] C. Beal and J. Orbison, “An Interactive Professional Ethics Case Simulation,” in *2017 ASEE Annual Conference & Exposition Proceedings*, Columbus, Ohio: ASEE Conferences, Jun. 2017, p. 27575.