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Assessment of Program-wide Curricular Change

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Eva Chi is an Associate Professor in the Department of Chemical and Biological Engineering Department at the University of New Mexico. The research in her lab is focused on understanding the dynamics and structures of macromolecular assemblies including proteins, polymers, and lipid membranes. Undergraduates, graduate students, and postdoctoral scholars are trained in a multidisciplinary environment, utilizing modern methodologies to address important problems at the interface between chemistry, physics, engineering, and biology preparing the trainees for careers in academe, national laboratories, and industry. In addition to research, she devotes significant time developing and implementing effective pedagogical approaches in her teaching of undergraduate courses to train engineers who are critical thinkers, problem solvers, and able to understand the societal contexts in which they are working to addressing the grand challenges of the 21st century.

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Assessment of Program-wide Curricular Change

In this evidence-based, teaching-practice paper, we discuss the assessment methods we have applied to the broad curricular changes implemented within our department. Our department is fundamentally changing the chemical engineering curriculum by threading Community-, Industry-, Research-, and/or Entrepreneurship-based design challenges through the core curriculum, engaging students in writing-across-the-curriculum (WAC), offering faculty professional development workshops, and implementing a digital badging system to help students take ownership of their competencies. Such dramatic changes to department structure and course requirements mandate carefully selected and consistent assessment practices throughout the program. This project has thus far tracked a variety of qualitative and quantitative measures across one year of baseline data and two years of project implementation with numerous student cohorts. The methods used for tracking and comparing student sentiment, confidence, beliefs, skill development, and technical skill performance include: (1) demographics, (2) assessments of conceptual knowledge (i.e., two concept inventories and three faculty-developed proficiency exams), (3) a survey that assesses design self-efficacy and other course-specific assessments, (4) written design skills tests that measure design problem framing ability, and (5) student observations and interviews. These assessment methods are distributed and administered throughout the four-year degree program. This paper outlines and describes these assessment tools and methods and how they are used to measure outcomes. The analysis of some of these methods is also discussed here.

As a “Research Universities (Highest Research Activity)” university, the students in our program are atypically diverse compared to those found at other schools of this type: 43% are women; 33% speak a language other than English at home; 28% are first-generation college attendees; and 52% of students’ mothers and 48% of their fathers have not earned a college degree. On average, 52% of students work more than 10 hours per week while in college, 27% are from lower income families, 45% are Latinx, and 5% are Native American.

We found that students’ performance on conceptual measures neither significantly improved nor declined as a result of curricular changes. This suggests that even as more class time focused on projects and writing, students still learned core content. Overall, based on post-course survey results, students in redesigned courses reported significantly higher design self-efficacy, compared to students in the original courses (t (248) = 2.18, $p < .03$). Compared to baseline results, students who completed design challenges developed a more accurate understanding of the iterative nature of the design process.

The breadth of qualitative and quantitative assessment tools used throughout this program are instrumental in helping us determine the outcome of these faculty and curricular changes, the results of which are used to continuously shape the direction of future programmatic pedagogical changes.

Introduction

Assessment in engineering education is commonly understood as the process of collecting data for the purposes of studying student learning, performing research, and disseminating results, typically with the aim of improving student learning [1-2]. In recent years, universities have been investing in improving the undergraduate engineering experience by revising courses, developing new course offerings—especially at the first-year level, improving department resources and climate, and training faculty in engineering education best practices [3-14]. These initiatives have been undertaken with some faculty or departments obtaining external or internal funding. Other departments have taken the initiative to improve courses and revise expectations of student outcomes and performance based on requirements mandated by ABET [15-16] or because of the changing industrial landscape and foretold global economic requirements, as outlined in publications such as the National Academy of Engineering's "The Engineer of 2020" [17-21]. At the cornerstone of these initiatives, assessment is embedded and used to improve student experience and learning in engineering departments. It is the process of assessment and the application of assessment tools that enables educators and researchers to determine the impact and efficacy of departmental or course changes and determine if educational outcomes have been achieved.

Olds et al. divide assessment methods into two general types [22]. Descriptive studies, which describe the current state of a learning environment or system (such as current student and department climate), are often conducted using qualitative, quantitative, and mixed research methods. Experimental studies, which identify how a learning environment or system changes as a result an intervention (such as assessing the impact of redeveloping a course), are often conducted using quantitative techniques, but can also be assessed using qualitative and mixed methods [22-24]. Methods that are typically used in engineering education to collect qualitative and quantitative data for descriptive studies include surveys [25-29], faculty and student interviews and focus groups [30-36], conversational analysis to examine group dialogue and interaction [37], and observations of students or faculty [38-39]. Experimental studies methods, which track the impact of an education intervention, may include randomized controlled trials (RCTs) that feature treatment and control groups randomly assigned [40-43]; matching, where treatment and control groups are not randomly assigned [44]; baseline data collection before an intervention is implemented [45]; post-test-only design (when baseline or pre-test data cannot be collected) [46], and longitudinal design (studying the long term effects of interventions or initiatives) [47]. Though some journals emphasize the importance and even preference for RCTs and matching over other forms of assessment [48], Borrego and Koro-Ljungberg emphasize the benefits of incorporating qualitative and mixed-methods approaches to create a more holistic and accurate understanding of descriptive and experimental studies [23-24]. Such approaches provide insight into the role context plays in the success of an initiative; this information is useful when transferring an approach to a new setting.

While there have been numerous contributions in the literature regarding assessment of education practices and initiatives across a diverse set of periodicals, the purpose of this current paper is not to present an exhaustive review of assessment methods. Rather, this article will focus on some common assessment practices frequently adopted for the purposes of evaluating the impact of broad curricular and department cultural changes. The approaches shared here can provide suggestions for educational research design and assessment practices for others undertaking curricular revision and development of a student-centered department culture.

Research Questions

Overall, our project seeks to answer the following research questions:

1. How does the deployment of design challenges in core departmental courses, a department-embedded writing-across-the-curriculum initiative, student digital badges, faculty professional development, and other initiatives help support and retain diverse students in our department?
2. What are the impacts of these initiatives and how can they be observed and assessed?

Research Context

Our department is currently one of nineteen across the country which has earned National Science Foundation funding through the Directorates for Engineering, Computing, and Information Science and Engineering program for Revolutionizing Engineering and Computer Science Departments (RED). These multi-year grants, led by department chairs as head PIs, promote groundbreaking, scalable, sustainable, and deployable change in engineering and computer science departments. Our work specifically aims to fundamentally change our undergraduate program and curriculum by threading Community-, Industry-, Research-, and/or Entrepreneurship-based design challenges through the core curriculum, engaging students in writing across the curriculum, offering faculty professional development workshops, and implementing a digital badging system to encourage student ownership of competencies, among other initiatives. This five-year project is currently in its third year, with the first year generally focused on collection of baseline data. Data presented here were collected over a three-year period to track the impact of introducing curriculum revision and faculty development in core chemical engineering courses at a large Hispanic-Serving research university in the southwestern US.

The various assessment methods deployed in first-year to senior level courses will be described first. The analysis and results of assessment practices is intentionally non-comprehensive. More detailed analysis of specific project initiatives' assessment practices has been discussed elsewhere [7-9] and will be discussed in forthcoming published work. IRB approval was obtained before any assessment methods described here were applied and used for program evaluation.

Assessment Methods

The qualitative and quantitative assessment methods presented here overlap across many courses. We selected these assessment methods to lend breadth and depth to understanding how our initiatives and a changed learning environment affect students' learning and self-perception.

(1) Demographics Analysis

Our team has and continues to compare historic student demographics, retention, and graduation rates before and after our project initiatives have been implemented. We seek to determine the effects of our approaches on retention of all students, especially those who are underrepresented. Project researchers have obtained student demographics information in two ways: by obtaining data from the university's enrollment management data office, and by student survey through department-specific courses. Enrollment Management data can be a rich source of information for students' high school background and prior education, their major before and after transferring to the department, and grades in specific courses such as Math, Physics, and Chemistry. These data allow us to identify factors that best correlate to retention and attrition. The surveys students take in courses are both pre- and post-semester, occur 3 times a year, and are assigned points for completion to help ensure a representative data set (though only data from consenting students are entered into the database). Course surveys provide more immediate and up-to-date data on students' backgrounds and preparation, though these data should correlate or consistently resemble the enrollment management data provided by the university.

(2) Proficiency Exams and Concept Inventories

(a) Sophomore Proficiency Concept Test

Our team developed a Sophomore Proficiency Concept Test, based on Concept Inventory questions from high school and first year-level calculus, physics, and chemistry courses. The purpose of this Concept Test is to assess student preparation in these core subjects after their completion but before the first 3 credit hour core chemical engineering course had been completed. The exam consists of 30 questions, with 10 questions devoted to each area: math, physics, and chemistry. Math topics include limits, derivatives, half-lives, and graphing functions. Physics topics include gravity and force balances, acceleration and trajectories, and kinetic and potential energy. Chemistry topics include chemical equilibrium, heat, pH, acids, bases, oxidation-reduction, and phase changes. Faculty developed the test by selecting relevant questions from existing Concept Inventories in the three subjects and excluded items with possible bias. The exam is multiple choice, 4-5 answer choices per question, and students are given 75 minutes of in-class time to complete the test. Thus far, the exam has been administered twice: Fall 2017 and 2018.

(b) Senior Proficiency Concept Test

Our team developed a Senior Proficiency Concept Test in 2017 with the input of departmental faculty, who selected conceptual questions from various concept inventories and the AIChE Concept Warehouse [49]. Hundreds of questions were first curated by a member of the team, then by individual faculty teaching specific subjects. Questions were selected based on subject relevance and question clarity. This concept test instrument was developed to assess conceptual understanding and retention of fundamental concepts from nine general areas: Thermodynamics, Reaction Engineering, Fluid Mechanics, Heat Transfer, Controls, Separations, Mass and Energy Balances, Mass Transfer, and Statistics. The test was first administered late Spring 2018 in the Senior Design course during finals week and will be administered again in late Spring 2019. The exam is multiple choice, 4-5 answer choices per question, 120 minutes, and 54 questions.

(c) Pre- and Post-semester Concept Inventories

Our Fluids and Heat Transfer faculty member administered a 50-minute, 26 question Fluid Mechanics and Heat Transfer Concept Inventory to junior students at the beginning and end of the semester to assess students' prior conceptual knowledge and their gains in understanding at the end of the semester. The TTCI: Thermal and Transport Concept Inventory: Fluids instrument was developed by Miller and Streveler in 2005 [50] and measures conceptual understanding in areas of force and momentum vectors, hydrostatics, the relationship between state variables, viscous fluids, and other topics. This inventory is multiple choice, 4-5 answer choices per question, and was administered Fall 2016, 2017, and 2018, though useable data are not available for 2018.

Our Thermodynamics faculty member administered a 50-minute, 23 question Thermodynamics Concept Inventory to junior students at the beginning and end of the semester. The TTCI: Thermal and Transport Concept Inventory: Thermodynamics instrument was developed by Miller and Streveler in 2005 [50] and measures conceptual understanding in areas of mechanical work, equilibrium vs. steady state, ideal gas law, the relationship between state variables, non-state variables, and other topics. This inventory is multiple choice, 4-5 answer choices per question, and was administered Spring 2017 and 2018.

(d) Free Answer Materials Engineering Pre-test

Our Materials Engineering faculty member developed a 30-minute, 16 question free-answer background materials engineering pre-test to assess students' understanding and retention of chemistry, thermodynamics, heat transfer, physics, and mass transfer concepts as they relate to materials engineering. The test is administered in the compulsory Materials Engineering course to juniors in their Spring semester. The test is meant as a general and broad formative assessment to measure students' ability to identify and describe relationships between engineering variables, describe the reasons for differences in materials, among other concepts. The pre-test is administered in the first week during Spring 2018 and 2019 and is graded and analyzed by a member of the project team.

(3) Surveys of Students in Select First-year through Senior Courses

As described briefly under "Demographics Analysis," students complete pre- and post- semester surveys in most required courses in the program. Surveys change slightly from course to course, but all surveys include items assessing and targeting design experiences and understanding of the design process, students' self-efficacy and beliefs about engineering, students' background and perceptions of engineering before enrolling at the university, as well as demographics. A main objective of these surveys is to observe students' perceptions and understanding of designing, engineering, departmental culture, confidence, and fluency over time across the curriculum. The survey is based on validated items from other surveys.

(4) Written Design Skills Tests

Design skills tests were developed to measure design problem framing ability. We developed three versions of design skills tests based on real world challenges. These tests ask students to solve the problem of foul dishwasher smell, knowing when to change a patient's incontinence product, and minimizing paint splatter during commercial or residential painting. Annually, design skills tests are administered in the first week of class for select courses in our program from the first-year to senior level. The same test is administered in the last week of class. Students are given 15 minutes to work on the designated problem and are told they should not expect to develop a complete solution in a short period of time due to the problem's difficulty. Students gain full credit for attempting the problem but are not provided feedback on their performance. This approach allows our research team to track the development of design problem framing skills across courses and to understand how changes in the course help shape student perception and fluency in design. The results of the design skills tests are coded by a team of students from the learning sciences program and our department, led by a faculty member.

(5) Student Observations and Interviews

To better understand the learning needs and experiences of our students, we collected field notes, video and audio recordings, and artifacts of student writing and work on the design challenges in core courses; interviews with case study students; and focus groups. A faculty member, assisted by two learning sciences graduate students conducted observations of first-year through senior students. Thus far, the graduate students conducted ten interviews with students from our first-year introductory course. These undergraduates will be invited for future interviews as a means to document their longitudinal experiences. The majority of this work is currently being analyzed and some of the results have already been published [7-9].

A faculty member conducted a focus group with seniors, supplemented by a written constructed response survey of 52 seniors, on their impressions of and interest in earning digital badges. The 7-question survey and one hour focus group was geared toward collecting feedback on student interest and willingness in earning a digital badge to convey their unique skills to potential employers or graduate schools. A member of our team coded these results and presented them to the rest of the team to help identify the digital badges which are most in demand.

Limitations of this Study

The analysis presented here is not meant to represent the entirety of our assessment that has been conducted to date, nor is it representative of all potential assessment methods discussed in the Introduction or Assessment Methods section. Instead, we intend to share an overall snapshot of the discoveries from our assessment and analysis practice thus far. In this regard, we only present selected results from the demographics analysis (spanning enrollment data from 2014-2018), concept tests and concept inventory analysis (administered Fall 2016 – Spring 2018), and surveys in core chemical engineering courses (spanning Fall 2016 - Spring 2018). Our results from other assessment practices will be forthcoming in the literature.

Results and Discussion

(a) Demographics Analysis

For our project, course survey data were used to determine the demographic make-up of our students: 43% are women; 33% speak a language other than English at home; 28% are first generation college attendees; and 52% of students' mothers and 48% of their fathers have not earned a college degree. On average, 52% of students work more than 10 hours per week while in college; 27% are from lower income families; 45% are Latinx, and 5% are Native American. To supplement this, Enrollment Management university-wide demographics data provided information on students' enrollment status, current major, former majors, years to graduation, prior STEM course scores, ACT scores, high school attended, in addition to gender, race and ethnicity, and whether a student is the first member of their family to attend college. We used these Enrollment Management data to examine first-year students who took our introductory course in 2014 and 2015 to obtain a recent baseline snapshot of who are students are, how many graduate, and who are more likely to graduate. All data were anonymized by the Enrollment Management office to ensure privacy protection.

Figure 1 below provides a view into the academic outcome of declared chemical engineering majors who took our first-year introductory course anytime in 2014 or 2015. Over 70% of students have graduated with chemical engineering degrees or will soon graduate with a chemical engineering B.S. degree. We observed that 12% most likely dropped out of the university or have not been enrolled for at least two semesters in any major. The 17% of remaining students transferred to other majors, with the most transferring to a science major such as Biochemistry, Chemistry, or Biology.

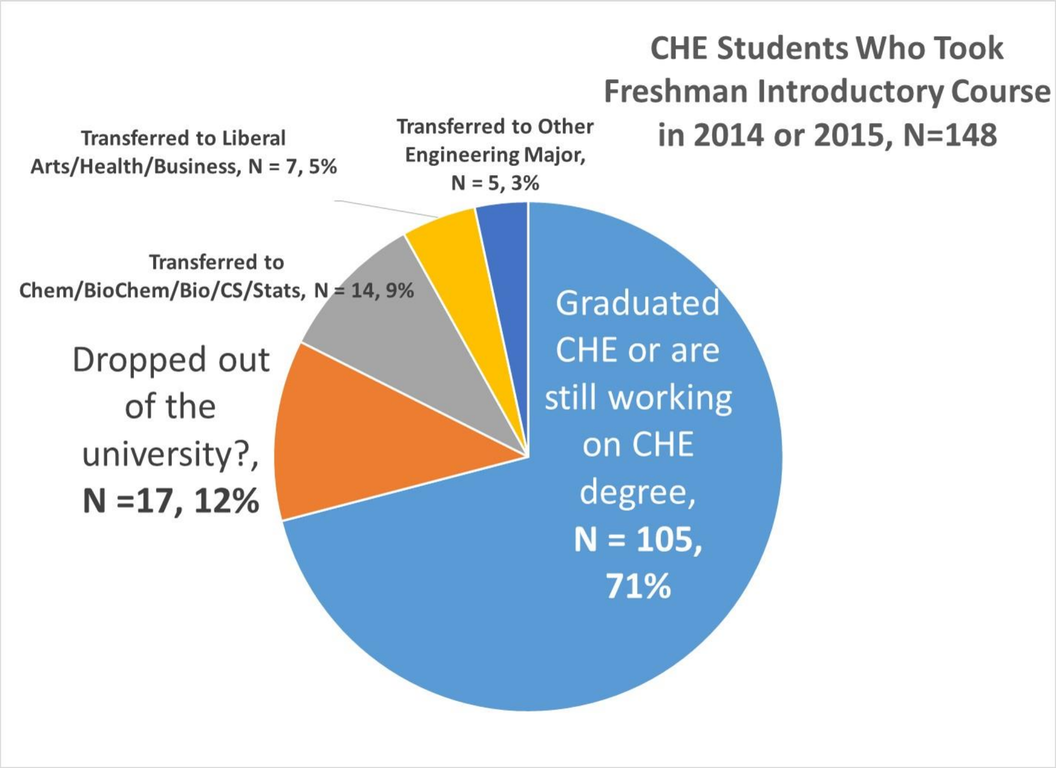

Figure 1: Current academic path outcome of Chemical Engineering (CHE) students who took our first-year introductory course in 2014 or 2015.

Figure 2 below shows the percentage of majors that transfer into our program, by general category. The majority of students who transfer from within the university are transferring from Biochemistry, Biology, or Chemistry. This information allows us to be more cognizant of the academic needs and interests of students within these majors and to target our recruiting efforts accordingly.

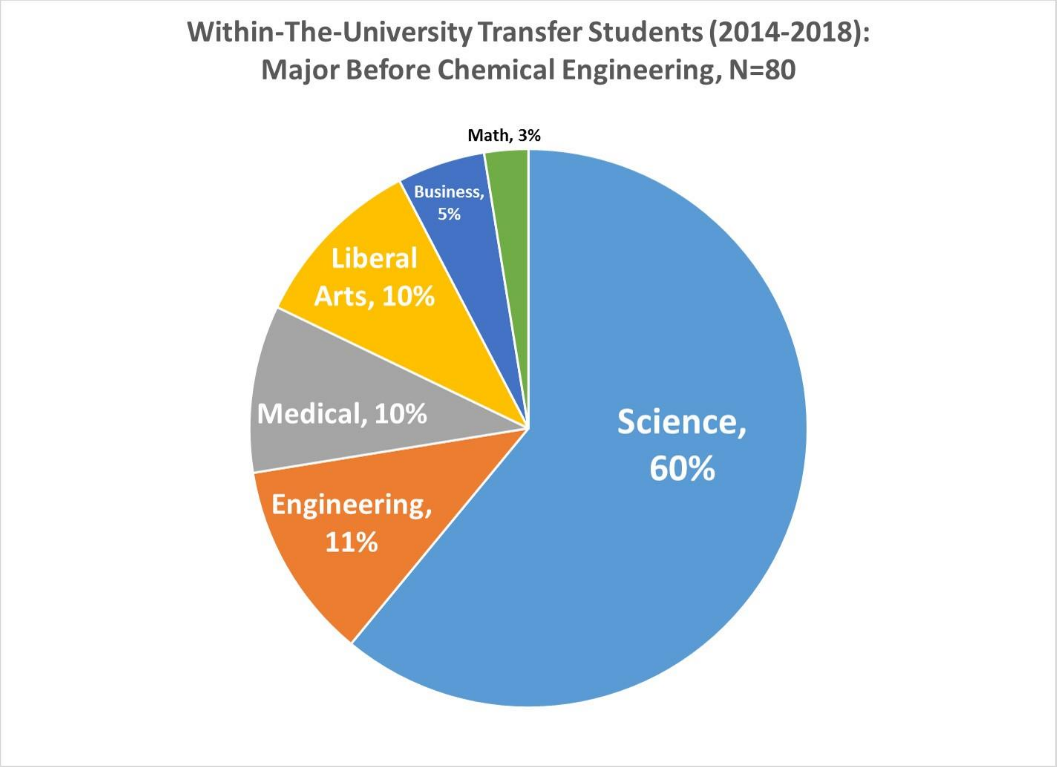

Figure 2: Transfers from within the university to our program, based on type of major. The term “Medical” is used to encompass majors such as Nursing, Emergency Medical Sciences, Medical Laboratory Science, Exercise Science, Doctor of Pharmacy, etc.

Students who transfer out of our program often move to similar majors, as seen in Figure 3. Students appear to transfer to Biology, Biochemistry, Business Administeration, and Chemistry most prevalently.

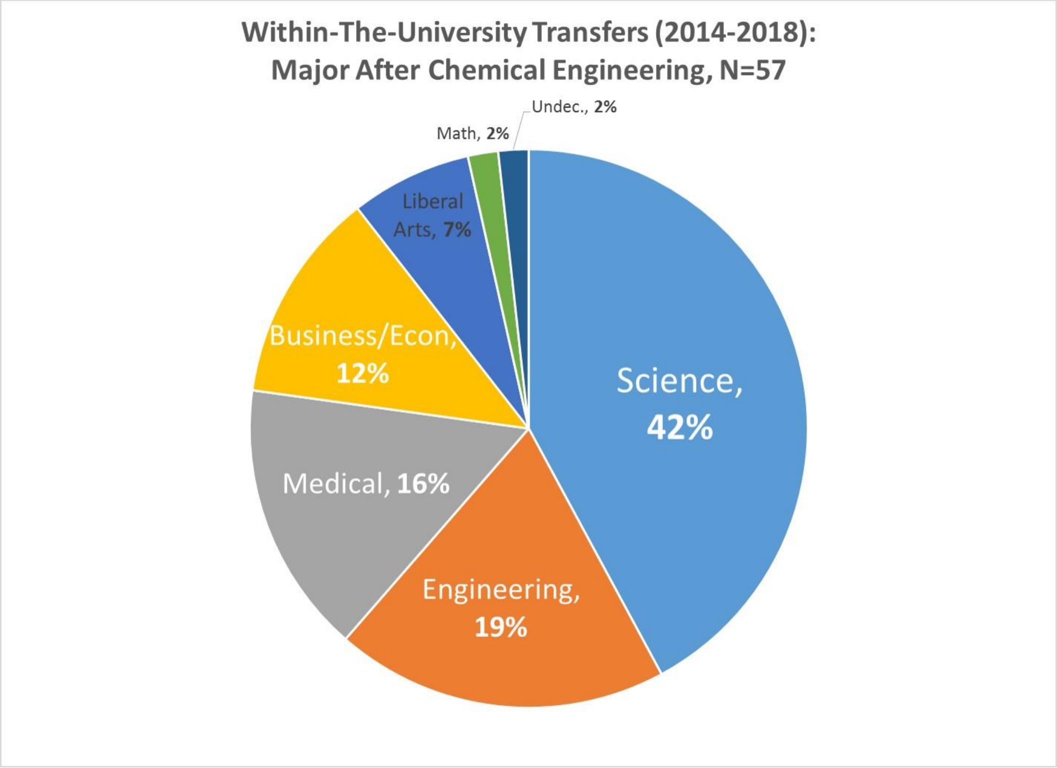

Figure 3: The majors to which our students transfer, based on type of major, 2014-2018.

Finally, Figure 4 shows the demographics of chemical engineering students who have already graduated, or will soon graduate, with chemical engineering degrees. Our students are 45% Hispanic, 33% white, 7% Asian, 5% American Indian, 5% two or more races, and 5% international, described as “Non-Res Alien” by Enrollment Management.

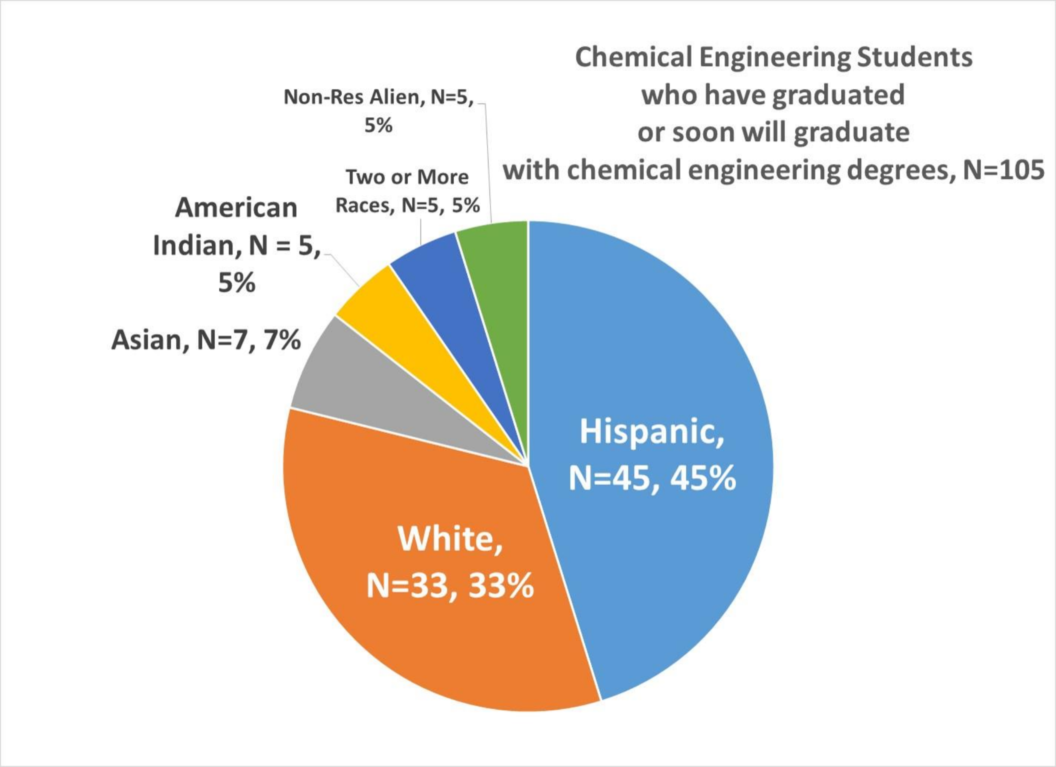

Figure 4: Race demographics of chemical engineering students who have graduated or will soon graduate, among those who took our first-year introductory course in 2014 or 2015.

Exploring further the demographics of these graduates or soon-to-be-graduates, we observed that 58% are male, 54% are first generation college students, and 70% attended public schools with an average rating of between a B+ and B [51]. They also earned an average 25 composite ACT score, have an average of 27 transfer credits, and an average overall 3.4 university GPA.

The 12% group from Figure 1 that dropped out of the university on average had a significantly lower university GPA (2.7), which is not surprising nor revealing. Though the cause is not often known, low GPA is frequently a reason for college attrition and is commonly seen with students who drop out of universities. We observed from the analysis these students are disproportionately Non-resident Alien and Hispanic males, generally attended lower-rated high schools, and are usually not first-generation college students. Understanding these findings has allowed us to identify students who may need additional departmental and campus support as well as resources to bolster course grades and prevent attrition.

Comparing these results to available literature on chemical engineering student retention has been difficult because of lack of published findings on enrollment and demographics for these students. The literature for large U.S. engineering schools such as Clemson, Ohio State, and Iowa State suggest that 60-75% of students who are enrolled in an engineering program at some point graduate from the university, though not necessarily with an engineering degree [52-55] and only about 35-42% of students stay in engineering [52-54]. It is difficult to compare these results with our own because universities count engineering students differently depending on when they declare their major. In our case, the students included here are specifically declared chemical engineering majors, or ones with a specific interest in chemical engineering based on their enrollment in the first year introductory course. Therefore, it should be expected our chemical engineering retention rates should be higher compared to other universities where enrollment in engineering is counted differently or more generally.

(b) Concept Test and Concept Inventory Analysis

A summary of the results from our Fluids Concept Inventory is shown in Table 1, the Thermodynamics Concept Inventory results are shown in Table 2 and performance on our three Concept Tests is shown in Table 3. Student performance on the Fluids TTCI is significantly improved between pre- and post- exams, though there is no significant improvement seen between pre- and post- exams with the Thermodynamics TTCI.

Table 1: Student performance on TTCI: Thermal and Transport Concept Inventory: Fluids Concept Inventory conceptual assessment instrument. Two samples *t*-test assuming unequal variances was performed, $\alpha = 0.05$.

Administered	Pre-test			Post-test			Statistically Significant difference between pre- and post- test?
	Mean	S.D.	n	Mean	S.D.	n	
Fall 2016 (baseline)	35.8	13.3	81	47.7	16.5	75	**Yes**, $t(142) = -4.95$, $p < 0.0001$
Fall 2017	33.3	10.7	51	43.8	14.3	47	**Yes**, $t(85) = -4.09$, $p < 0.0001$
Statistically significant difference between 2016 vs. 2017?	**No** $t(122) = -1.21$, *n.s.*			**No** $t(108) = -1.40$, *n.s.*			

Compared to baseline performance, student scores did not significantly improve or decline with either Concept Inventory after program changes and initiatives were implemented, suggesting that even though more class time was focused on projects and writing, students still learned core content. However, since only two years' of data were collected, it remains to be seen if a significant improvement in scores will emerge in the future.

Table 2: Student performance on TTCI: Thermal and Transport Concept Inventory: Thermodynamics Concept Inventory conceptual assessment instrument. Two samples t-test assuming unequal variances was performed, $\alpha = 0.05$.

Administered	Pre-test			Post-test			Statistically Significant difference between pre- and post- test?
	Mean	S.D.	n	Mean	S.D.	n	
Spring 2017 (baseline)	41.3	14.1	47	41.8	14.9	46	**No**, $t(91) = -0.172$, *n.s.*
Spring 2018	43.8	16.4	55	46.5	19.0	39	**No**, $t(74) = -0.716$, *n.s.*
Statistically significant difference between 2017 and 2018?	**No** $t(100) = 0.838$, *n.s.*			**No** $t(72) = 1.26$, *n.s.*			

Likewise, student scores appear to be consistent, neither significantly improving nor decreasing with any of the three concept tests administered (sophomore, senior, and Background Materials Engineering). The Senior Proficiency Exam is the only concept test for which we collected baseline data and after program changes and initiatives were implemented. Differences in scores for this test are marginally significant, but like the concept inventories, will require further evaluation when more data are collected in subsequent years.

Table 3: Student performance on Concept Test conceptual assessment instruments. Two samples *t*-test assuming unequal variances was performed, $\alpha = 0.05$.

Name of Instrument	Administered	Mean	S.D.	n	Statistically significant difference between test averages?
Sophomore Proficiency Exam	Fall 2017	49.9	19.1	57	**No** $t(120) = -1.05$, *n.s.*
	Fall 2018	53.7	20.5	65	
Senior Proficiency Exam	Spring 2017 (baseline)	47.0	9.19	52	**Marginally** $t(102) = 1.84, p < 0.10$
	Spring 2018	43.6	9.75	52	
Background Materials Engineering Exam	Spring 2018	51.6	15.8	40	**No** $t(68) = -1.04$, *n.s.*
	Spring 2019	54.6	10.6	42	

Published data on student performance on the Fluids TTCI and Thermodynamics TTCI, especially overall exam performance, are lacking in the literature. The TTCI concept inventory developers Miller et al. have published some findings on specific question and topic performance four different schools to identify specific, persistent misconceptions [56]. They determined that 10 percent or more of junior and senior engineering students tested did not appear to understand how internal energy and temperature are related, some believing that a change in temperature equates to an equal change in internal energy. Students also showed a lack of understanding of how heat capacity and temperature together can be used to estimate changes in a system's stored internal energy. We observed on average that around 65% of students we tested through these exams also did not understand these thermodynamics concepts, which is significantly higher than the ~10% average observed at the four other schools.

Additionally, according to Miller et al., approximately 10-15% of the students do not have a clear conceptual understanding of the difference between steady-state and thermal equilibrium processes [56]. These students appear to believe that processes in which heat transfer is occurring can never come to steady state nor reach equilibrium, and a similar number confused the rate of heat transfer with the total amount of energy. We observed some of the same findings, though on average 35% of students we tested did not understand these concepts, a marked increase from the 10-15% observed at other schools.

Survey Data

Our pre-and post- course surveys provide a plethora of candid and valuable feedback and data for analysis. Much of these data for numerous courses throughout the curriculum still require detailed analysis. However, thus far we have observed that our first-year introductory course shows some of the greatest gains in learning outcomes and improvements in student perception of designing and engineering. At the end of the course, compared to the beginning, when asked about the process of design, most students perceptions aligned to those of expert designers, understanding that design is an open-ended process with constraints and goals, design is an iterative process, designers of equal skill and experience usually do not come to the same design solution given the same initial design problem, design problems have multiple possible solutions and multiple ways to get to the solution, an expert designer is usually not right on the first try when designing, and significantly more students stated that they were confident they could evaluate and test a design solution to an authentic engineering design problem. Overall, students in redesigned courses reported significantly higher design self-efficacy, compared to students in the original courses, $t\ (248) = 2.18$, $p < 0.03$.

Most promising was that students rated the statement "I intend to complete a major in engineering other than Chemical engineering" far lower than at the beginning of the course. The statement, "The faculty and staff make engineering feel like a welcoming place for me" was significantly higher at the end of the course. Another outcome was that students significantly changed their opinion about working in teams versus working by themselves. Students rated their preference to working in teams more favorably than at the beginning of the semester.

Conclusion

This paper outlines many qualitative and quantitative assessment methods and instruments which have helped us in the process of answering our research questions, specifically, tracking and measuring the outcomes of broad curriculum and departmental changes and elucidating valuable and diverse knowledge about students and their learning environment. We have examined the demographic make-up of the students who complete our degree program and how they differ from students who drop out of the program and those who drop out of the university. This allows us to focus recruiting and course topics more appropriately for students who have broad interests in science, business, and other subjects, as well as identify the students who may need more course assistance and campus support. We observed ostensibly higher rates of retention than observed at other schools, though this may be because of how enrollment and engineering college acceptance is counted and administered. Though conceptual instrument assessment has shown student test performance is consistent year-to-year, we have measured conceptual learning gains in at least one course when comparing pre- and post- semester scores. We have also observed significantly lower performance on concept inventories compared to some published results from other schools. Through surveys we have also observed significant self-reported gains in students' perceptions of their teaming and engineering design abilities as well as comfort level within the department, suggesting students come away from the course motivated to persist in chemical engineering. Data continue to be collected and analyzed to support these conclusions and build a richer understanding of the outcome of these faculty and curricular changes, the results of which are iteratively applied to guide more effective pedagogical changes.

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