An FYE Course Structure for Collaborative Learning in Large Lecture Courses

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Michael Chajes is a Professor of Civil and Environmental Engineering. His research focuses on bridge testing, evaluation, and rehabilitation, as well as engineering education. During his 25 years at UD, Dr. Chajes has served as Dean of the College of Engineering and Chair of theCivil and Environmental Engineering Department. He is a registered Professional Engineer and was named Delaware Engineer of the Year in 2010.

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Michael L. Vaughan is Associate Dean and faculty member at the University of Delaware, College of Engineering. In this role, he is responsible for the College of Engineering academic affairs enterprise. Dean Vaughan manages the College of Engineering academic and educational support processes by developing and implementing policies, programs and interconnections to enhance the College ability to foster successful outcomes. Dean Vaughan is a member of the College leadership team. The College current has over 2442 undergraduate and over 850 graduate students.

For many years, he has served as the Campus Principal Investigator of the NSF funded Greater Philadelphia Louis Stokes Alliances for Minority Participation (LSAMP) Program and the NSF/AMP Bridges to the Doctorate Program, which focus on the success of students traditionally underrepresented in science, technology, engineering, and mathematics (STEM) disciplines. In addition, Dean Vaughan is the former Program Director/PI of the EAA/UD Graduate Preparatory Summer Residential Program funded by the Educational Advancement Alliance (EAA). The program includes up to 40 participants, rising juniors or seniors at Historically Black Colleges and Universities (HBCUs), who have interest in pursuing STEM disciplines at the graduate-level. Annually, Dean Vaughan supervises direction of the 4-week FAME/UD Summer Residential Program for 30-35 high school students, the RISE Summer Enrichment Program for incoming engineering freshmen and, in the past, the HEARD (Higher Education Awareness Response in Delaware) Project, a college awareness program, funded by the Department of Education through Philadelphia GEAR UP for College Network. Globally in the College, he manages academic programs and policies that impact the careers of all engineering students at both the undergraduate and graduate level. Dean Vaughan is focused on enhancing the College's student/faculty interface by fostering

successful academic and professional outcomes in an increasingly multi-cultural and diverse engineering environment.

On campus, Dean Vaughan is past-chair of the University-wide Risk Management Advisory Committee (RMAC), past-chair of the Campus Transfer Student Working Group, a member of the University Community Engagement Commission, the DuPont Scholars Selection Committee, the Assistant and Associate Dean Council and the University Career Services Center Advisory Committee.

Off campus, he is or has been a member of various professional associations and currently sits on numerous boards and committees that focus on engineering education and issues that positively impact the lives of young people. Dean Vaughan served on the National Executive Committee of the GEM Consortium in Alexandria VA which funds graduate degrees in Engineering and Science. Dean Vaughan is a former President and former Treasurer of the Board of the GEM Corporation and past Chairman of the National GEM Investment Committee. Dean Vaughan was former Vice President of the board of directors and Operations Committee Chair of the National Junior Engineering Technical Society (JETS) based in Alexandria, Va. The JETS organization was a leading nonprofit educational enterprise dedicated to promoting engineering and technology careers to America's youth. Of the more than 40,000 students JETS served each year, 53 percent were from groups traditionally underrepresented in engineering and technology and 36 percent of participants were female. Dean Vaughan is a longstanding member of the President's Advisory Committee of the Girl Scouts of the Chesapeake Bay Council which encompasses girl scouting activities in all of the Delmarva Peninsula which includes Delaware, the Eastern Shore of Maryland, and the Eastern Shore of Virginia. In addition, he is a former Board President of Delaware Futures of Wilmington, DE an organization which provides educational, social, and motivational support to high school students with unrealized potential to become successful college applicants. Dean Vaughan is also the convener and member of the External Advisory Board of HBCU-UP SMILE Project at Delaware State University which reports to the institution's president.

Dean Vaughan joined the University of Delaware in 1992 after prior experience as Assistant to the Dean of Engineering/Adjunct Assistant Professor of Electrical Engineering at North Carolina A&T State University and Senior-level Electronics Engineer at the Naval Underseas Warfare Center in Newport, RI where he also served as the Coordinator of the TIMES2, Inc. program at Rogers High School in Newport. He received both his BS and MS in Electrical Engineering from North Carolina A&T State University in 1982 and 1984, respectively. During his graduate work he was a Micro-Electronics Center of North Carolina (MCNC) Fellow. He is currently completing work for a Ph.D. in Civil & Environmental Engineering at the University of Delaware. He is a member of Alpha Phi Alpha Fraternity, Inc. and President of the Board of Trustees of Bethel AME Church of Wilmington, DE. He is married to Cheryl M. Vaughan, a Private Banking Vice President, and they have been blessed with two children Sterling Michael, Accounting/MIS graduate at UD, and Carter Lynsay, a 14 year old aspiring young women engineer.

Prof. Jeannie S. Stephens, University of Delaware

Jeannie Stephens received her doctoral degree in materials science and engineering from the University of Delaware in 2004. Since then, she has been a National Research Council fellow at the National Institute of Standards and Technology, a post doctoral fellow at Rice University, and a research scientist at DePuy Synthes (companies of Johnson & Johnson). Stephens first joined BME in September 2013 as temporary faculty and is now an assistant professor of instruction and associate director of BME's undergraduate program. In this role, she will strengthen the department's connection with the local medical community, both in clinical and industrial settings, in order to foster undergraduate design projects as well as internship and employment opportunities for our students.

AN FYE COURSE STRUCTURE FOR COLLABORATIVE LEARNING IN LARGE LECTURE COURSES

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Introduction

First Year Experience (FYE) engineering courses at large, research-focused universities present a unique challenge from a curricular and administrative perspective. Prior research indicates large lecture-style courses should be interdisciplinary and highly interactive, while simultaneously presenting enough technical and career-specific content within each engineering discipline to aid or reinforce students' choices of majors [1-5]. These course characteristics are most effectively supported by student-centered pedagogical approaches, such as Problem Based Learning (PBL) [7,8], where experienced faculty instructors provide some course structure with periodic lectures and ample time for break-out sessions for hands-on and group activity in small classes. While ideal from a pedagogical perspective, small class sizes with multiple, experienced faculty instructors are sometimes not attainable given the financial and human resource limitations at large, research-focused universities, particularly state schools that face expectations to keep tuition costs down. The challenge, then, is to design an FYE course that provides students with an intensive collaborative engineering design experience while being maximally efficient in terms of human and financial resources.

This work in progress describes an innovative approach to curriculum design and logistical infrastructure for a First Year Experience (FYE) engineering course that is delivered in a large lecture section format. Beginning in 2014, a team of faculty instructors from our institution substantively overhauled our FYE course, which is a required course for all freshmen engineering students in their first semester and enrolls 650-700 students across two identical sections. This course was historically taught as a survey course, providing high-level overviews of all available engineering majors in a lecture-only format. The course was redesigned to focus on themes and skills common to all engineering disciplines, and these topics were reinforced through a problem-based learning (PBL) approach [7,8] with multiple group design projects and related activities. In redesigning the course, we faced constraints common to most universities with swelling student enrollment and limited human recourses, specifically, that the course must be delivered in two, large capacity sections (300-350 students each) by a maximum of three faculty instructors, who would receive up to half-time teaching release for the course.

This work in progress presents the process and logistical details of the redesign of our FYE course as well as course evaluations from our pilot year (2015) implementing the new course. Our course evaluation focuses specifically on student engagement and retention of core course concepts, e.g., engineering design process [6] and Engineering Grand Challenges [11]. Using historical data from prior year classes, we also examined whether the course preserved FYE "soft" skills such as easing the transition to college and providing structure and support for academic resource-seeking and planning [1,2]. Lastly, we considered the administrative overhead of the course, both in its original format and following the redesign; and we compared our results to anticipated expenditures for a small-section PBL format course.

Methods

Description of Prior Version of the Course

Our FYE engineering course, *Introduction to Engineering* (EGGG101), is a 2-credit, 14 week course, with two lecture sections of 325 to 350 students. The course is open to all students, with 98% of enrollees being first-semester freshmen engineering students (all majors), excluding the recently launched Biomedical Engineering major. Prior to the course revision, a single faculty member taught and administered the course with no assigned undergraduate or graduate teaching assistants. The core instructor's lectures, which composed approximately 50% of the course, were mostly focused on common first-year topics such as use of on-campus learning resources, career planning, and future course selection. There were also extended guest lectures (3-4 lectures) from appointed faculty in each of five engineering departments, specifically, Civil and Environmental, Mechanical, Chemical, Electrical and Computer Science, and Biomedical; and these lectures provided a broad overview of each discipline with some discussion of educational and career opportunities. There were brief (2-6 hr) out-of-class time activities, mostly involving online research or simulated laboratory exercises, that were associated with each disciplinary lecture. Approximately 30-50% of these activities depending on the year involved collaborative work, in teams of 3-4 students.

Description of Revised Course

Beginning in Winter 2015, the FYE engineering course was redesigned by a team of four experienced faculty-level instructors who represented several engineering disciplines. The course curriculum was modified substantively while maintaining the original course logistics (2-credits, 14 weeks, two lecture sections of 325-350 students). Revised course curricula were framed with the following core concepts: (1) a 4-phase engineering design process [6]; (2) collaborative learning in small teams, specifically, "Project Groups" of 4-5 students from multiple engineering majors; and (3) the NAE Grand Challenges for Engineering [11]. Technical and career development topics, such as energy concepts, mathematical modeling, statistical analysis, prototyping, technical writing, and oral presentations were introduced through small group activities and 3 major (3-4 week) design projects. These activities were intended to scaffold the skills needed for three substantive engineering design projects centered on: (1) Joy of Living and User-Centered Research; (2) Sustainability; and (3) Cybersecurity.

Three of the four faculty members who redesigned the course served as course instructors during its pilot year in Fall 2015. These faculty members co-taught nearly all lectures and co-supervised a team of 28 undergraduate "Peer Leaders," who individually mentored cohorts 5-6 Project Teams (25-30 students total). Students worked in their Project Teams for all three engineering design projects and most out-of-class time activities. Peer evaluations were administered upon completion of each design project and were factored into the grading [10].

Course Evaluation

To determine the impact of the substantial revision of our FYE course, we completed a multifaceted course evaluation focused on three areas of interest. First, we compared student outcomes on the university-administered end-of-course survey for all FYE courses for the year immediately prior to the course redesign ("Pre-Redesign") to the outcomes in the pilot year following the redesign ("Redesigned"). Survey questions focused primarily on how well the FYE course helped students transition to college as well as their comfort level utilizing university resources. The survey was administered electronically (Qualtrics v0.248s), with survey questions on a common 4-pt Likert scale. Pre-Redesign versus Redesigned outcomes were compared using one-way ANOVA (JMP Pro v12).

Second, we considered whether students retained core concepts from the revised course that were not emphasized in its prior version, e.g., The Engineering Design Process. To do this, we designed an anonymous online survey (Qualtrics v0.248s) administered it to all students online as part of the first (Pre-Course) and last (Post-Course) individual assignments in the course. This survey consisted of six questions that were more focused on core course concepts (Table 2), again measured on a 4-point Likert Scale. Pre-post results were compared using repeat measures one-way ANOVA (JMP Pro v12). These pre-post survey data were further supplemented by a two-question end-of-course evaluation that focused on perceptions of the overall value of the course, assessed on a 5-point Likert scale and presented using descriptive statistics in our report.

Lastly, we evaluated the administrative overhead associated with the prior version of the course (Pre-Redesign) and the redesigned version (Redesigned). Specifically, we considered the costs of faculty workload, undergraduate and graduate teaching assistant stipends, and course supplies and equipment. For comparison, we also projected costs for the course were it to be administered strictly as small-group (25-30) course sections, instead of large sections (325-350 each) with out-of-class small group time. All costs were determined using 2015 salary and student enrollment numbers.

Results

End-of-course survey response rates for both Pre-Redesign and Redesigned years were 66% and 85%, respectively. The redesign of the course seemed to have a significant but insubstantial effect on common FYE student outcomes, including connecting with other students and faculty and academic goal setting ($d<|0.5|$, see Table 1). The course redesign modestly and negatively affected propensity to seek guidance from one's academic advisor ($d=-0.54$); and there was no substantial effect on likelihood of remaining in the engineering discipline ($d=-0.12$).

Our course-specific student assessments yielded interesting findings regarding student perceptions of group-based engineering design projects, which formed the backbone of the course. A total of 572 students completed both the pre and post-course online survey (85% response rate). Respondents showed substantive and statistically significant gains in "understanding the engineering design process" ($p<0.001$, $d=0.5$; see Table 2). Interestingly, students matriculated to college with relatively strong understanding of the engineering field, interdisciplinary collaboration, and the importance of ethics; and the course had a trivial effect in these areas (see Table 2). The two-question supplemental end-of-course assessment ($N=445$, 66% response rate) showed that students were overall likely to "use the skills learned in this course" (3.78 ± 1.23 on 5-pt Likert Scale with 5=Very Likely to 1=Very Unlikely); and they rated the total volume of course content to be equivalent to other courses during their first semester as engineering students (2.68±1.26 on 5-pt Likert Scale with 5=A lot more content to 1=A lot less content).

Course revision led to no major increase in administrative overhead for the course (Table 3). Total course costs, including salary, teaching assistant stipends, and supplies and equipment, were on the order of $160k for both the Pre-Redesign and Redesigned versions of the course. For comparison, estimated administrative overhead for a version of our FYE course taught in small sections were nearly 2.5 times greater than the revised course, which incorporated PBL elements but maintained a large lecture section format.

Table 1: Results for general First Year Experience (FYE) course survey for year prior to course revision (2014, Pre-Redesign) and pilot year following course revision (2015, Redesigned). All responses scored on 4-pt Likert Scale with 4=Strongly Valuable/Comfortable/Likely to 1=Not At All Valuable/Comfortable/Likely. Historical vs. Revised outcomes compared using one-way ANOVA with $p<0.05$ for significance.

	Pre-Redesign	**Redesigned**	**Effect Size (d)**	**p**
Please indicate how valuable you believe the following will be/was in helping you [with the transition to college]:				
Connecting with other freshmen in my FYE	3.17	3.00	-0.17	0.001
Connecting with my FYE faculty	3.15	2.90	-0.25	<0.001
Learning about the UD academic resources in my FYE	3.35	3.00	-0.35	<0.001
Meeting with my academic advisor	3.44	2.90	-0.54	<0.001
Learning about cultural activities on campus in my FYE	2.59	3.10	0.51	<0.001
Exploring how my personal decision making impacts my ability to attain my academic goals	3.23	3.10	-0.13	0.006
How comfortable are you doing the following?				
Getting faculty to help me when I get stuck on schoolwork	2.91	2.70	-0.21	<0.001
Getting help from other college academic resources when I get stuck on schoolwork	2.75	2.60	-0.15	<0.001
Working with a group of students in my engineering courses	3.34	3.20	-0.14	<0.001
Working with a group of students outside of my engineering courses	3.32	3.20	-0.12	0.014
How likely are you to remain an engineering major and graduate with a degree in engineering?	3.62	3.50	-0.12	<0.001

Table 2: Results for course-specific survey administered before (Pre) and after (Post) completion of the Redesigned course. Responses to prompt, “Please indicate your level of agreement with the following statements,” with 4-pt Likert responses as 1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree. Pre vs. Post outcomes compared using repeat-measures ANOVA with $p<0.05$ for significance. Effect size reported for significant differences between Pre and Post.

	Pre	Post	Effect Size (d)	p
I understand what it means to be an engineer.	3.2	3.2	0	0.511
I understand the diversity of the engineering disciplines.	3.3	3.4	0.1	0.026
I understand the engineering design process.	2.7	3.3	0.5	<0.001
I feel comfortable working on team-based projects.	3.3	3.2	-0.1	0.003
It is important that engineers work on interdisciplinary teams to solve engineering problems.	3.7	3.5	-0.2	<0.001
Ethical decision-making is an important part of being an engineer.	3.6	3.5	-0.1	0.001

Table 3: Administrative overhead for three versions of our FYE course, namely, prior to course revision (Pre-Redesign), the revised course (Redesigned), and a hypothetical version of the course taught in small groups (PBL Small Groups).

Course Version	Instructor Salary	TA Stipends	Supplies & Equipment	Total
Pre-Redesign	$112,118	$31,710	$20,000	**$163,828**
Redesigned	$89,694	$68,800	$6,200	**$164,694**
PBL Small Groups	$328,878	$68,800	$6,200	**$403,878**

Discussion

In this work in progress, we present an innovative approach to a First Year Experience (FYE) engineering course taught in a large lecture session format. This approach incorporates PBL elements during out-of-class-time activities and group projects. There were three key findings from this multifaceted evaluation of our first year implementing the course. First, although "soft" FYE themes such as transitioning to college and seeking academic advisement were not emphasized heavily following course redesign, student outcomes in these areas were comparable to the prior version of the course, where upwards of 50% of the lecture content was focused on these themes. Second, the redesigned course, which challenged students with three substantial group-based design projects, led to significant concept retention in the Engineering Design Process. Students also perceived that they were likely to use the skills developed in the course during their academic careers. Lastly, the administrative overhead associated with the revised course was comparable to the prior version of the course and approximately 2.5 times less than a small-section PBL format.

Interestingly, there was a contrary finding from our multifaceted evaluation that should be explained in the context of the course implementation. Student perceptions of the importance of group work or interdisciplinary collaboration in solving engineering problems shifted slightly but significantly in the negative direction following course redesign (Pre-Redesign vs. Redesigned, see Table 1) and also over the course of the semester in the redesigned course (Pre vs. Post, see Table 2). This may be explained by the substantive level of group work required in the redesigned version of the course as compared to other required engineering courses as well as the previous version of the course. Students were assigned to teams to maximize interdisciplinarity and creativity styles [9], and even the best functioning teams experienced some level of discord during this learning process. Thus, we attribute the decline in perceptions about collaboration to be a consistent outcome in this course, as students are normalized to the level of collaboration that is expected to solve engineering challenges. We plan to investigate this effect in more detail in future studies.

There are several strengths and some caveats to the work presented in this paper that should be addressed. The major strength of our approach is the novelty of our course structure. PBL has long been advocated for FYE courses [1,2], and it has largely been presented in the literature for small class sections [3-5]. We found ourselves in a unique position, largely due to resource constraints, to adopt PBL in a large class section format. This was primarily accomplished by implementing a group-based activity-project model and relying on undergraduate teaching assistants to provide guidance to student groups during out-of-class time hours. We were largely successful in meeting the learning objectives and logistical constraints of the course, although there are some caveats to the multifaceted course evaluation presented in this work in progress report. Specifically, the learning objectives for the redesigned course were so vastly different from the prior version that it was difficult to find a baseline from which to measure our impact. The university-administered FYE survey, which was our only multiyear assessment, was by its very nature discipline-neutral and therefore failed to detect differences between the course versions that were specific to engineering theory and practice. We attempted to mitigate this gap by providing a pre vs. post course assessment that was more targeted towards course objectives; however, as was discussed, we believe that incoming student misconceptions about group work and collaboration may have skewed our outcomes. Our future work will focus on a more detailed analysis of the impact of the course on student collaborative practices as well as concept retention related to other key themes in the course, e.g., Grand Challenges [11].

Overall, the results of this work in progress suggest that our large lecture section FYE course is effective in advancing student understanding of core engineering principles, such as the Engineering Design Process. Our course may serve as a model for other universities that face similar administrative constraints in providing small section FYE experiences for large incoming freshmen cohorts.

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