Creating Value in Engineering Education Through A Master's Level Graduate Seminar Course

Murali Krishnamurthi
Northern Illinois University, DeKalb, IL 60115
Email:mkrishna@niu.edu

Abstract

Seminar courses are common in many graduate engineering programs and they are often used to help students value their graduate education and meet graduate students' needs as well as program goals. In this paper, the efforts made to redesign a one credit hour graduate seminar course in the Department of Industrial and Systems Engineering at Northern Illinois University and their impact are described. After analyzing the background of graduate students joining the master's program and the skills they need to recognize the value of the graduate program, the course topics and course activities were redesigned. Students enrolled in the seminar course were guided through a series of incremental activities that helped them develop and present a research proposal, while recognizing the value of academic integrity, responsible conduct of research, effective writing and presentation skills, and the scientific investigation process.

The redesigned graduate seminar course has been offered several times since 2008, and has made a significant impact on graduate students' skills as well as the graduate program. The course has helped graduate students recognize the value of the graduate program and their future careers. Feedback from students indicates that the seminar course is also improving their performance in other courses in the graduate program and helping them complete theses and industrial projects successfully. The details of the course and its impact, and the opportunities for other programs to adapt the course for their needs are described in this paper.

Introduction

Seminar courses are common in many graduate programs in engineering[1]. They serve a variety of purposes including introducing new graduate students to the program and its expectations[2], arranging a series of presentations on current research by experts in the field, helping students to improve their communication skills[3,4], preparing students to teach[5], training students to conduct theses and projects[6], and teaching students advanced topics[7]. These seminar courses can range from zero to three credit hours per term depending on the purpose of the course and the importance given to it in the program. The organization and delivery of the course can depend on the students' needs and program objectives.

Graduate seminar courses in engineering master's programs generally focus more on preparing students for the graduate program and teaching them research and communication skills whereas the seminar courses in engineering doctoral programs generally focus on exposing doctoral students to state-of-the-art research in a particular engineering field. The doctoral seminar courses often require students to present on their ongoing research work or attend presentations by invited experts. These graduate seminar course can be used effectively to help graduate students value engineering education while meeting their needs as well as program goals.

Industrial and Systems Engineering Graduate Seminar Course Needs

The graduate seminar course in the Department of Industrial and Systems Engineering (ISYE) at the Northern Illinois University was introduced in the early '90s primarily for the purpose of introducing new graduate students to industrial engineering research. All graduate students were required to enroll in this one credit semester-long course, attend presentations by faculty and invited researchers, explore a particular research topic in industrial engineering, and present it to the class at the end of the semester. This approach met the intended purpose but did not prepare graduate students adequately to conduct theses or meet their learning needs. Most importantly, students enrolled in the course did not learn the basic skills necessary for conducting theses or projects, and they did not value the process. Faculty who taught the graduate seminar course assumed the graduate students had learned the necessary basic skills during their high school or undergraduate degree programs. However, when the time came for these students to pursue theses or projects, faculty realized these students were not adequately prepared and faculty had to teach them the basic skills along with helping them conduct theses or projects.

The mismatch between faculty assumptions about graduate students' basic skills and program needs gave the department the impetus to rethink the graduate seminar course and redesign it to meet the needs. As the first step in the redesign process, the university's ISYE graduate students' background and program needs were analyzed, and the following issues were identified:

1. Graduate students' background – At least 80% of the graduate students joining the master's program in ISYE are international students, and they are mainly from India, China, South America and the Middle East. English is the second language for these international students and many of them were not required to write detailed technical reports in English during their bachelor's degrees. ISYE graduate program also attracts many domestic students with bachelor's degrees in non-engineering disciplines such as mathematics, statistics, computer science, etc., and many of them do not know about industrial engineering research.

2. Academic integrity – Discussions with many international students revealed that many of them did not have a good understanding of plagiarism and intellectual property issues, and were not introduced to those issues during their high school or bachelor's degree education in their home countries. Many of them did not also understand the causes and consequences of plagiarism and violation of copyright and intellectual property policies.

3. Citations – A majority of new graduate students, both domestic and international, had very little or no exposure to formal citation and referencing styles. They were not required to follow particular citation styles during their high school or bachelor's degrees, and were not given feedback by their professors on the use of citations in their reports and papers. Many of them did not know about citation generators available in Microsoft Word or on the web.

4. Literature review – New graduate students did not know how to search effectively for past work on a topic, identify refereed publications, read the literature, and prepare a critical analysis of the past work and its gaps. A majority of students did not know about engineering databases and resorted to searching for literature only using web search engines. They were not aware of the software and online social bookmarking tools available for literature review.

5. Problem conceptualization – Problem conceptualization is a difficult task for anyone, and new graduate students especially have difficulty formulating the right research questions and scoping a problem appropriately so that it can be solved to address a need. Many students resort to conceptualizing problems that are too broad, trivial or impractical.

6. Scientific investigation – A majority of graduate students did not know about the basic steps in conducting a scientific investigation, and were especially unsure about industrial engineering research methods. They also did not know the difference between a thesis and a project, and assumed that a thesis would always take longer to finish compared to a project.

7. Responsible conduct of research – Even though the Graduate School and federal agencies have placed considerable emphasis on responsible conduct of research, graduate students had no prior exposure to research integrity issues and did not know about IRB (Institutional Review Board) approval or how to protect themselves from research misconduct.

8. Writing techniques – Engineering students generally pay very little attention to writing and tend to focus mostly on problem solving. This is partly due to the training they receive in their engineering courses and the lack of importance given to writing in some courses. ISYE graduate students, regardless of they were domestic or international, did not know some of the basic techniques such as outlining, developing key sentences, proof-reading, etc., and of course, many of them had difficulty with grammar, spelling, and usage.

9. Proposal preparation – Entering graduate students obviously are not expected to know how to prepare a thesis or a project proposal, organize the information into appropriate sections, develop tasks and timelines, and identify resource requirements. This is something that they learn only through a course such as the graduate seminar. Some students who had taken an undergraduate course in project management or had work experience were knowledgeable in developing tasks, timelines and project organizational structures.

10. Formatting – Even though the university's Graduate School has detailed guidelines on formatting theses and dissertations, ISYE graduate students did not pay very much attention to formatting requirements, and many of them did not even know how to make use of the document formatting features in Microsoft Word for creating outlines, table of contents, references, equations, figures, and charts to meet thesis and project requirements.

11. Client projects – As some graduate students pursue theses or projects sponsored by the industry or granting agencies, they needed to understand issues related to completing a project for a client. Many graduate students did not know how to conduct themselves professionally at a client's site and meet client's requirements.

12. Presentations – All the domestic graduate students had prior experience in preparing and delivering presentations but many international students did not. Some of the international students also had difficulty in organizing the information into a presentation format, designing visually appealing presentations, and delivering them effectively. Some also did not know about the commercially available presentation design and delivery technologies.

The issues identified are specific to graduate students joining the master's program in ISYE at Northern Illinois University and the ISYE program needs but may also be applicable to other engineering programs. The graduate seminar course is the only course that all ISYE master's students are required to take, and it is therefore, used in graduate program assessment. New graduate students initially thought of the course as just another requirement to fulfill and neither recognized its importance to their graduate education nor valued the skills gained in the course as necessary technical skills. As the ISYE program prepares its master's graduate students for industrial careers as well as for doctoral programs elsewhere, the ISYE faculty members feel that it is important the graduates value the education they gain during their master's program.

The Redesigned Graduate Seminar Course

The identified graduate student needs and existing program goals resulted in redesigning the graduate seminar course but still maintaining it as a one-credit, semester-long course so that the total credit hour requirement for graduation remained the same. The redesign process involved addressing four major steps related to the development of:

1. Course Objectives
2. Course Content
3. Course Activities
4. Course Delivery

Course objectives - The first step in the redesign process was to develop course objectives that were "SMART" (Specific, Measurable, Achievable, Relevant and Time-oriented) and demonstrated value in engineering education. This resulted in formulating the following course objectives:

After successfully completing the course, students will be:

1. Familiar with academic integrity and responsible conduct of research issues,
2. Able to explain research, projects, and scientific investigation methods generally used in industrial engineering,
3. Familiar with citation styles and be able to conduct literature reviews,
4. Able to prepare thesis or project proposals.
5. Familiar with effective writing techniques.
6. Able to prepare and deliver effective oral presentations.
7. Aware of issues related to conducting projects for clients.

These courses objectives guided the development of course content and course activities, and provided the basis for course assessment at the end of the semester.

Course content – Considering that the graduate seminar course is for only one-hour per week and that a considerable number of course topics have to be covered during the semester, it was decided that a focused set of class notes should be developed for the course. The class notes were not designed as PowerPoint slides but as comprehensive class notes suitable for self-paced learning. For each of the following topics, class notes were developed by the course instructor and made available freely through the course website to students enrolled in the course:

1. Definition of engineering, industrial and systems engineering, scientific method, industrial engineering research, theses and projects, and problem conceptualization.
2. Academic integrity, cheating, plagiarism, fabrication, falsification, sabotage and protecting oneself.
3. In-text citations and references, citation styles, and citation generators.
4. Literature review process, searching engineering databases, literature review table, critical analysis of past work, and justification of proposed work.
5. Responsible conduct of research (RCR), nine core areas of RCR, and the IRB approval process.
6. Writing techniques including the development of outlines, topic sentences, paragraphs, and transitions. Common mistakes in grammar, punctuation, spelling and usage.
7. Developing thesis and project proposals, tasks and time lines, and resource needs.
8. Conducting projects at client's site.
9. Formatting reports to meet thesis and project requirements.
10. Developing and delivering technical presentations.

Each set of class notes not only covered a particular topic but also related the topic to engineering activities such as product design, manufacturing, quality control, etc., so that students could recognize the topic as part of their engineering education and value it. For example, the impact of plagiarism had to be explained as loss of "intellectual currency" and revenue for their work instead of just saying it is not the right or legal thing to do. The literature review process was explained from the patent search perspective so that students recognized the value of making sure of past work in the proposed area of research. Similarly, the writing process was explained as product design and development as a technical report is often an engineering product.

The developed class notes were assigned as required readings and were also used for delivering the content. All the class notes, except the one for writing techniques, were used for one class period each, and the notes on writing techniques were used for two class periods. Along with the class notes, other learning resources were assigned as required readings or as required course activities and these included the following:

1. Online tutorial on academic integrity (http://www.niu.edu/ai/students)
2. Online tutorial on effective writing practices (http://www.niu.edu/writingtutorial)
3. Responsible Conduct of Research Tutorials (http://www.niu.edu/facdev/resources/)
4. "The craft of research" book by Booth, Colomb, and Williams[8]
5. "Scientific writing and communication" book by Angelika Hoffman[9]
6. "Introduction to the Responsible Conduct of Research" E-book by Nicholas H. Steneck[10]

The online tutorials mentioned above were developed by the author in collaboration with several colleagues, and the free "Introduction to the Responsible Conduct of Research" book was made available through the course website. In addition to these resources, students were referred to news articles (on plagiarism, responsible conduct of research, and writing), videos on technical presentations, and Graduate School guidelines on writing theses and dissertations. Figure 1 shows a concept map of the course content.

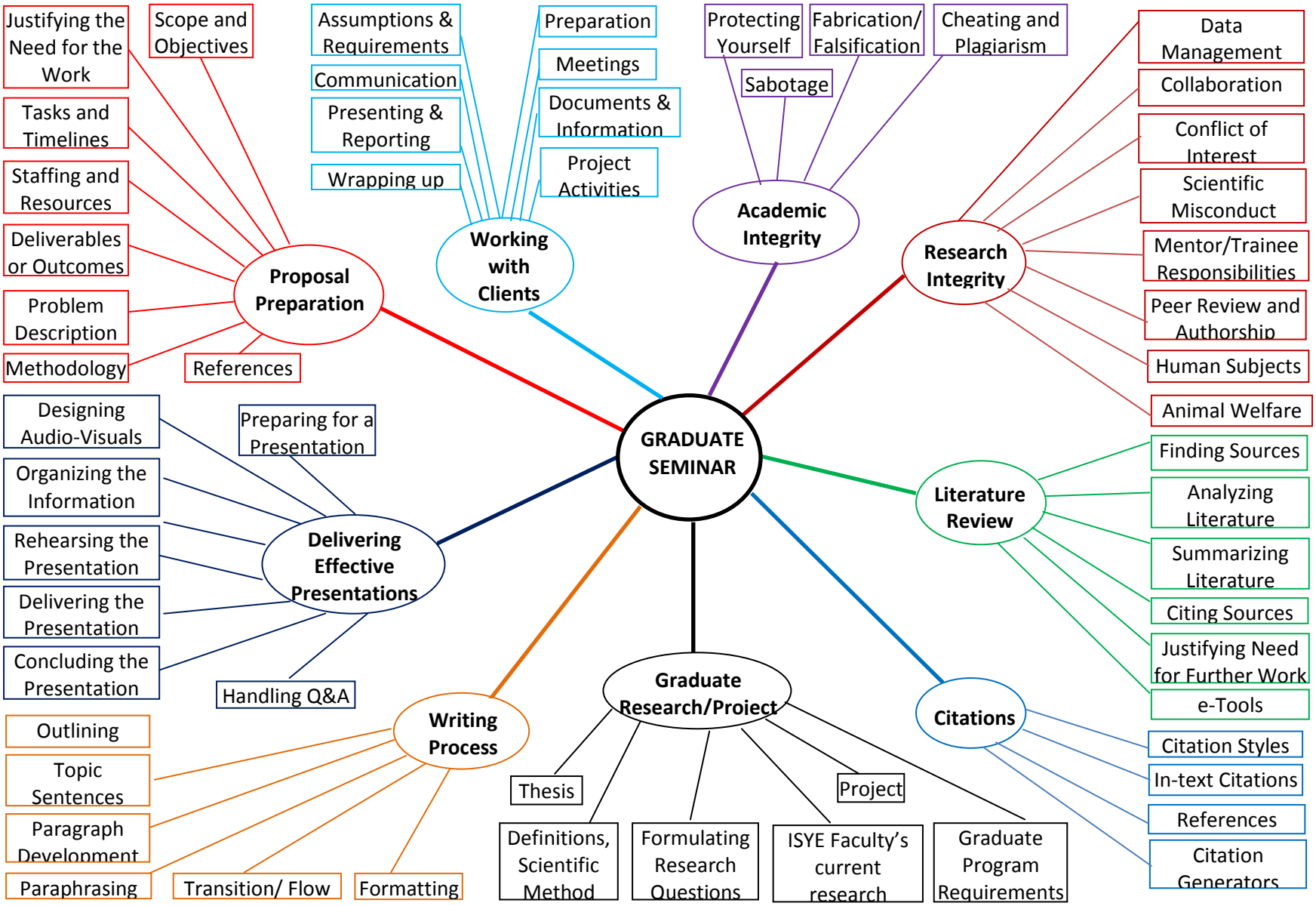

Figure 1. Concept map of major topics covered in the Graduate Seminar

Course activities – One of the lessons learned before redesigning the course was that if students were required just to attend the seminar class each week but not complete any assignments, they did not pay attention to the lectures or the course topics, and as a result, did not gain much from the seminar course. It was realized that even if students were assigned to write papers or proposals as part of course assignments students should be required to incorporate the feedback given for each assignment and improve their work in subsequent assignments. The course activities were designed to accommodate these issues but still meet the one credit hour course requirement and the course objectives.

The course activities included assigned readings, a two-minute quiz at the beginning of each class on the course topic for that class, a five-minute in-class exercise at the end of each class on the topic covered during the previous class, online discussion board postings, and homework assigned at the end of each class to be completed by the following class. The homework assignments were carefully designed such that students were able to recognize how the assignments contributed incrementally to completing a thesis or project proposal, and value the engineering education process. Homework assignments covered academic integrity, research integrity, citations, problem formulation, literature review, project tasks and timelines, proposal preparation, and proposal presentation. In-class exercises covered problem conceptualization, citations, paraphrasing, responsible conduct of research, outlining, grammar, work break down structure, and presentation feedback. There were no midterm exams or final exams as this is a seminar course.

Course delivery – Due to the one-hour per week only class time constraint, the course delivery had to be limited to lecture and course activities (two-minute quiz at the beginning of the class and five-minute in-class exercise at the end of the class as mentioned earlier) for each class. The lectures included presentations on the course topic, class discussions, demonstration of software tools and features, such as citation generators, engineering literature databases, social bookmarking, SafeAssign™ (for plagiarism checking), document formatting techniques, etc.

One of the important aspects of the course delivery was the instructor's effort in conveying the value of the course topics and activities, and how they contributed to engineering education. For example, the process of writing was related to the process of designing, developing and testing a product, and that students should exercise the same care in writing as they would do to design a product. This helped students to see the writing process in a different light, recognize the value of doing it right, and understand its impact on their engineering education and careers.

The redesigned course balanced students' workload as well as the course instructor's workload. Students had a clear understanding of how each week's topic and assignments contributed to the overall effort needed for completing an engineering thesis or project, and the course instructor had to grade only smaller assignments of not more than two pages per student each week instead of having to read and grade lengthy reports at the end of the course from all the students enrolled in the course. The last three weeks of the semester were designated for student presentations on their thesis or project proposals. As the course enrollment averaged around 20 students, each student was given approximately 10 minutes to present his or her proposed work and receive written feedback from all their classmates as well as their instructor.

Analysis of Results

The redesigned graduate seminar course has been offered seven times since fall 2008, and the redesign process has also been gradual due to the time needed for developing the course content and course activities, and experimenting with the various aspects of the course. The impact of the course redesign was assessed using pre and post surveys, students' feedback, and instructor's analysis of students' work. Table 1 shows a summary of results from the pre and post surveys completed by 21 students enrolled in the fall 2012 offering of the course.

Table 1. Summary of Results from the Pre and Post Surveys Conducted During Fall 2012

	Very High %		High %		Satisfactory %		Low %		Very Low %		None %	
Topics	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Scientific investigation	0	28.5	0	52.4	23.8	19.0	33.3	0	33.3	0	9.52	0
Academic integrity	0	57.1	9.52	38.1	47.6	4.76	33.3	0	9.52	0	0	0
Citations & Referencing	4.76	42.9	9.52	52.4	14.3	4.76	19.0	0	38.1	0	14.3	0
Literature Review	0	42.9	0	47.6	42.9	4.76	19.0	0	28.6	4.76	9.52	0
Research integrity	0	23.8	0	42.9	14.3	28.6	28.6	0	23.8	4.76	33.3	0
Writing techniques	0	28.6	14.3	52.4	42.9	14.3	28.6	0	9.52	0	4.76	0
Proposal preparation	0	33.3	0	52.4	28.6	14.3	23.8	0	19.0	0	28.6	0
Formatting techniques	0	47.6	4.76	42.9	14.3	9.52	42.9	0	23.8	0	14.3	0
Technical presentations	4.76	28.6	14.3	47.6	42.9	23.8	33.3	0	4.76	0	0	0

The pre and post survey results (rounded to the nearest decimal) clearly indicate students' positive perceptions on the impact of the course on their comprehension of the various course topics. While the pre and post survey results are primarily student perceptions of their own learning and performance, the course instructor's analysis of student performance in their homework assignments and in-class exercises revealed the following by the end of the course:

1. A majority of students who did not even know about citation styles and paraphrasing were able to demonstrate them in their writing after a few weeks of the semester.
2. Students were able to search engineering databases instead of just using the web search engines, distinguish between refereed and non-refereed work, find refereed work, and complete a thorough literature review.
3. All the students' final proposal documents were screened through SafeAssign™ plagiarism checking tool in Blackboard, and none of the proposals were found have plagiarized work.
4. Students demonstrated awareness of research integrity issues through the case studies they analyzed and the responses they posted on the online discussion board.
5. Students were able to demonstrate by the end of the semester, the steps necessary for writing and presenting a formal proposal for a research project.

Students' unsolicited comments were positive overall, and many of them wrote that they did not even know how to conduct a literature review or how to write a research proposal before taking the course and that taking the course had improved their performance in other courses. This was the real valuing of engineering education that was the expected outcome from the redesigned course. Finally, the impact of the course was evident in the theses and graduate projects completed by those who had taken the redesigned graduate seminar course, and the quality of their work clearly demonstrated what they had learned in the graduate seminar course.

Along with the positive outcomes of the redesigned course, some challenges were also experienced, but these challenges may not be necessarily unique to this graduate seminar course:

1. Getting students to read and follow instructions was one of the biggest challenges even though the course instructor provided detailed instructions and examples. In the future offerings of the course, a greater emphasis will be placed on relating "reading and following course instructions" to "reading and following engineering product design requirements".

2. Even though students spend a considerable amount of time online and on social media, they do not explore learning resources and experiment with online or software tools available for learning purposes. The course instructor had to demonstrate even simple features in Microsoft Word for generating citations or formatting a document. The value of independent learning and exploration will be emphasized more in the course in the future.

3. A majority of students, when left on their own, did not take pride in their work and were content to submit mediocre work. Students had to be taught to monitor the quality of their work and the course instructor had to provide students with check-lists and teach them the importance of proof-reading their work before submitting it. The value of quality control will be emphasized explicitly in every aspect of the future offerings of the course.

The mentioned challenges will be addressed by designing new or refining existing course activities in the future offerings of the course to help students overcome the hurdles.

Conclusions

Graduate seminar courses, when designed properly to meet students' needs and program goals, can help students value engineering education. As seminar courses are usually taken by graduate students during the early phase of their graduate programs, the seminar courses can prepare students effectively for performing well in their other courses, and help them value in engineering education. If students can be shown that the engineering research methods, technical writing, and formal presentations are similar to engineering product design and development, they will relate better to the engineering education process.

The redesigned master's level graduate seminar course being offered by the Department of Industrial and Systems Engineering at Northern Illinois University is helping to create value in engineering education. New graduate students entering the graduate program are better prepared to succeed in the program, and graduating students are producing better theses and graduate projects. Due to ISYE graduate students' positive comments about the course, graduate students

from other engineering programs at the university that do not have such a course have also started enrolling in the graduate seminar course. Faculty members from other programs at the university, who heard about the redesigned graduate seminar course, have also adopted some of the course materials for their graduate seminar courses. ISYE graduate students can still be exposed to current research through graduate colloquia arranged outside the seminar course.

The framework of the redesigned graduate seminar course is a generic one and it can be easily adopted by other engineering programs and tailored to suit their students' and program needs. Finally, it should be recognized that the redesign of one course or the efforts of one faculty member alone cannot create lasting value in engineering education but it can motivate other faculty members to explore the same and contribute collaboratively to accomplishing this goal.

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