

Developing a Senior Capstone Project Course in Integrating Undergraduate Teaching and Research

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Abstract: In this current study, we will discuss how to develop a course module of senior capstone project as an activity of the NSF STEM grant proposal which has been awarded in the year 2006. The grant proposal was “Metropolitan Mentors Network: Growing an Urban STEM Talent Pool across New York City.” Since the main goal of the proposal was to increase the number of students receiving associate and bachelor’s degrees within science, technology, engineering, and math, we have tried to present a module of a senior capstone project course recently developed in order to meet our goal of a NSF grant proposal. The motivations of integrating undergraduate teaching and research in developing new or advanced knowledge are to provide or inspire students in order to respond and comprehend diverse and fast changing technologies and knowledge in Electrical Engineering Technology education. Since our engineering research requires highly elaborate equipment and expensive materials for students, this would be a very good opportunity to gain the depth of knowledge and experience by planning, initiating, and conducting research in engineering technology principles throughout a firmly structured weekly schedule of a senior capstone project course. Since the primary goal of the capstone project course is to provide an opportunity for students to integrate principles, theories, and skills learned in previous courses to the solution of various realistic engineering technology problems, this course will help students learn how to develop, design, troubleshoot work, effectively in teams, and develop technical writing & presentation skills. Students will also learn and utilize a realistic simulation of the real-world design process in an academic setting for accomplishing engineering technology analysis and synthesis through of their projects. Therefore, we strongly believe a senior capstone project course may be the answer for integrating teaching and research of undergraduate education in engineering technology programs.

Key words: Senior Capstone Project Course, NSF STEM, Undergraduate Teaching and Research, Electrical Engineering Technology.

Background of the Current Study in Integrating Undergraduate Teaching and Research

The central rationale of the proposed activity, “Metropolitan Mentors Network: Growing an Urban STEM Talent Pool across New York City,” is to leverage the close proximity of multiple colleges in the urban academic setting to cultivate a mentor network, enabling CUNY graduate students who are only a subway ride away, to become role models for STEM undergraduates at City Tech. The goal is to increase the number of students receiving associate and bachelor’s degrees within science, technology, engineering and math, by conducting the following activities:

1. Development and institutionalization of two three-credit courses, one in the sciences and math, the other in engineering technologies, that emphasize academic preparation through development of laboratory techniques, communication, team work and creative thinking skills.
2. Academic year mentoring of undergraduates by teaching assistants in STEM, and block programming of the summer cohort in required liberal arts courses such as English Composition linked to a seminar series. These teaching assistants will in turn receive mentoring by experienced faculty at City Tech on class room management, and development of learning outcomes and learning assessment.
3. An annual poster session will display student research and increasing the visibility of STEM activities on campus. Research and employment opportunities will be available to the students.
4. A project website to disseminate developed curriculum assessment results and student work will be established.
5. A senior capstone project course in Electrical and Telecommunications Engineering Technology will be developed.

Introduction to Senior Capstone Project Course

The primary goals and objectives of EET 4212 senior capstone project course which integrates undergraduate teaching and research in developing new or advanced knowledge are to provide or inspire students in order to respond and comprehend diverse and fast changing technologies and open-end design problems in Electrical Engineering Technology field. Since our engineering research requires highly elaborate equipment and expensive materials with analytical and experimental knowledge and skills, it would be a very good opportunity to gain the depth of knowledge and experience to students by planning, initiating, and conducting research in engineering technology principles throughout firmly structured weekly scheduled course such as a senior capstone project course.

The students of senior capstone project course will learn how to apply principles, theories, and skills learned in previous courses to the realistic engineering technology problems. This course will also help students to develop design & troubleshooting methodology, effective teamwork, project management, and technical writing & presentation skills. Students will also learn and utilize a variety of technology for accomplishing engineering technology analysis and synthesis through their project. In addition, each team will meet regularly with their faculty advisors for design review and progress reports.

The EET 4212 senior capstone project course consists of one semester and is the follow-up course to EET 4112 Mechatronics which is a combination of 'Mechanics' and 'Electronics' with emphasis on analog electronics, digital electronics, sensors & transducers, actuators, and microprocessors. It combines mechanical engineering, electronic engineering, control engineering, systems design engineering, and computer engineering to create useful products. The capstone design course will provide an opportunity for students to integrate principles, theories, and skills learned in previous courses to the solution of a realistic electrical engineering technology problem.

Each team in senior capstone project course will consist of 3 to 5 students open to other engineering technology disciplines. Each team will develop team rules and select a project after consulting with their faculty advisor. This course requires each team submitting one preliminary

report and two written reports as a progress report and a final report. The preliminary report will present the information of the project outlines, specifications, design approach, budget, and plan schedule. The progress report will include design method and problems, list of changes in their project plan, and the preliminary analysis and design. The final report will be submitted at the end of semester after adding their evaluation of their capstone experience, role, contribution, results, conclusions, and future works to previously submit the progress report. Students will finally have an oral presentation after an informal practice presentation in order to evaluate and refine their presentation and demonstration. In attendance are clients and representatives from the department industrial advisory board members, peers, faculty, and the general public. These presentations are evaluated by the student team peers and technical advisory faculty.

Instructional Objectives and Assessment

The senior capstone project course requires students to demonstrate proficiency in various essential skills. Students will exhibit skills in classes, labs, homework assignments, laboratory exercises, and a designed operational project. Effective writing, effective oral communication, and use of technology are also addressed and assessed through reports, presentation, and demonstration. For the successful completion of this course, the students should be able to:

Objectives	Assessment
<ul style="list-style-type: none"> • Identify an appropriate and manageable topic of team project that can be designed, built, and tested. 	<ul style="list-style-type: none"> ➤ Students will illustrate an ability to identify an appropriate manageable topic for a team project.
<ul style="list-style-type: none"> • Apply current knowledge and adapt to emerging applications of mathematics, science, and engineering technology. 	<ul style="list-style-type: none"> ➤ Students will demonstrate ability and skills using various scientific and technical tools to formulate a problem statement, analyze design requirements, and implement a solution.
<ul style="list-style-type: none"> • Design, simulate, and construct experiments, as well as to analyze and interpret data. 	<ul style="list-style-type: none"> ➤ Students will display an ability to apply creativity in design, simulation, and construction of systems, components or processes appropriate to program objectives.
<ul style="list-style-type: none"> • Identify and evaluate the references and standards applicable to the team project. 	<ul style="list-style-type: none"> ➤ Students will illustrate the knowledge in understanding the patents, references, and standards.
<ul style="list-style-type: none"> • Demonstrate writing and oral communicating techniques effectively among team members, with technical advisors and peers. 	<ul style="list-style-type: none"> ➤ Students will develop a written design report and oral presentation for faculty and peers.
<ul style="list-style-type: none"> • Understand the importance of professional and ethical behavior. 	<ul style="list-style-type: none"> ➤ Students will demonstrate the importance of professional and ethical behavior in their written and oral presentations.

Course Deliverables

Each team is required to prepare several documents, presentations, and the prototype of the designed system. The main deliverables are

- Midterm progress design report and team notebook
- Final written report
- Final oral presentation and demonstration

Textbook and Other Required Materials

There is a text required for this course. Additional handouts will be distributed by the instructor throughout the semester. Students are required to have a USB storage device and a hard-covered lab notebook for their capstone project notes.

- Tools and Tactics of Design, First Edition (2000) by Peter G Dominick.
Publisher: John Wiley & Sons, ISBN-13: 978-0-47138-648-3
- Lecture Notes (will be distributed as handouts)

Grading Policy and Criteria

Each design review team will generate written appraisals for several different senior projects assigned team. Each design review team will evaluate the functional description, complete system, and documented report, and oral presentation and demonstration. The final grade will be given based on the following components:

- Class Participation: 10 %
- Preliminary Proposal: 10 %
- Midterm Progress Report: 20 %
- Final Report: 20 %
- Final Oral Presentation: 20 %
- Final Demonstration: 20 %

Final Letter of Grades

Of all team performance will be graded by the senior capstone design course instructor and the final grade will be awarded based on the percentage of the total points earned as follows:

<u>Letter Grade</u>	<u>Numerical Grade Ranges</u>	<u>Quality</u>
A	93-100	4.0
A-	90-92.9	3.7
B+	87-89.9	3.3
B	83-86.9	3.0
B-	80-82.9	2.7
C+	77-79.9	2.3
C	70-76.9	2.0
D	60-69.9	1.0
F	59.9 and below	0.0

Course Outlines

The course contents for EET 4212 senior capstone project course is a mixture of class presentations by students and instructor and individual and team meetings with instructor. The weekly tentative schedule including the series of lectures and laboratories will be the following:

Weeks	Lecture	Laboratory Work
Week 1	Orientation: Structure, overview of senior capstone project, and grading policy.	Introduce project ideas proposed by members of the EET faculty.
Week 2 – 4	Design Phase: Top-down design approach to the senior capstone project including functional description, design specification, library research, planning, detailed block diagram, and functional requirements with a list of quantitative performance specifications.	Develop a preliminary design including experimental, analytical, computer simulation and research, and identifying and ordering parts on the chosen project as directed by the faculty advisor. A preliminary design report including the project budget is due at the end of this period.
Week 5 – 8	Intermediate Design Phase: Conceptual and detailed design of block diagram and building & troubleshooting prototype circuits and devices.	Develop an intermediate design including experimental, analytical, computer simulation and research, and identifying and ordering parts on the chosen project as directed by the faculty advisor. An intermediate design report including the project budget is due at the end of this period.
Week 9 – 13	Comprehensive Design Phase: Further design review and evaluation.	Acquire and analyze final results of the team project. A comprehensive design report is due at the end of this period.
Week 14 – 15	Final Design Phase: Final testing, tuning, and evaluation of team project.	Prepare and demonstrate a team project in both an oral presentation and a written final report.

List of Potential EET Senior Capstone Projects

The senior projects are the culmination of the Electrical Engineering Technology, which involves the students in professional level engineering design problems. The main areas completing a significant project that reflects their Electrical Engineering Technology Program are:

- Biomedical applications
- Embedded Systems and Control Applications
- Network Based Control Systems and Applications
- VHDL, and Hardware-Software Co-Design
- Alternative, Renewable Energy Sources, and Green Technology Electronics
- Sensors and Instruments

- Network Security Simulations and Design
- A Real Time Wireless Data Acquisition System
- Microprocessor and Applications
- MATLAB Modeling of Control Systems
- Remote Sensing
- Digital Signal Processing Applications

Conclusions

Since the primary goal of senior capstone project course is to provide an opportunity for students to integrate principles, theories, and skills learned in previous courses to the solution of a realistic engineering technology problem, this capstone project course will help students to develop design & troubleshooting methodology, effective teamwork, project management, and technical writing & presentation skills. Students will also learn and utilize a realistic simulation of the real-world design process in an academic setting for accomplishing engineering technology analysis and synthesis through their projects. We strongly believe our senior capstone project course will contribute to the education of the next generation of professionals and help students in integrating undergraduate teaching and research with interdisciplinary environment.

References

[1] Bergman C. A.: "Senior Design Projects with Industry." Frontier in Education Conference, 1998.

[2] Jang S.: "Senior Capstone Project", NY City College of Technology, 2009.

[3] Brackin P., J. Gibson D.: "Capstone Design Projects with Industry: Emphasizing Teaming and Management Tools", Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition, 2005.

[4] Goldberg J., Ropella k.: "Senior Design Projects", Marquette University College Engineering, Biomedical Engineering, Milwaukee, WI 2009.