Implementation of the Second-year Course in an Engineering Professional Spine

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Abstract – The objective of this paper is to document the experience of developing and implementing a second-year course in an engineering professional spine that was developed in a first-tier research university and relies on project-based core courses. The main objective of this spine is to develop the students’ cognitive and employability skills that will allow them to stand out from the crowd of other engineering graduates.

The spine was developed and delivered for the first time in the academic year 2010-2011 for first-year general engineering students. In the year 2011-2012, those students joined different programs, and accordingly the second-course year was tailored to align with the different programs’ learning outcomes. This paper discusses the development and implementation of the course in the Electrical and Computer Engineering (ECE) department.

Keywords: Engineering Education, Second-Year Course, Electrical Engineering, Course Design, Higher Education.

1. INTRODUCTION

In 2011, Frank, Strong, and Sellens [1] presented a new professional spine that includes a four-year engineering design and practice stream at Queen’s University, in Kingston, Ontario. The spine was designed to develop graduates’ competence to meet the requirements of the Canadian Engineering Accreditation Board as per the Washington Accord. In [1], Frank, Strong, and Sellens discussed the course objectives and delivery for each year of the program, which was delivered for the first time in the academic year 2010-2011 for first-year engineering students, including assessment and evaluation methods.

Moving into second year, students are divided into different departments, as per their aptitudes and preferences. Students transitioning from first to second year students face different challenges as they move to disciplinary courses loaded with novel technical concepts and applications. Instructors of second-year courses also confront with challenges, as their courses have to meet students’ expectations for getting into a specialized engineering arena.

Iqbal was assigned the role of developing the spine second-year course delivered for the first time in Fall 2011. The course provides a project-based learning environment that serves as the context of the communication component of the spine which includes reporting and presentations. He delivered this course multiple times since 2011 with different project themes. The course delivered by him in Fall 2016 is discussed in this paper.

2. COURSE DESCRIPTION

Different active-learning practices were embedded in the course that blend the theoretical and technical training with hands-on experiences, including open-ended complex problem solving, collaborative team work, experiential learning, etc. For the first six weeks of the semester, the course is the same for students in all programs and includes problem scoping; creativity and idea generation; decision making, incorporating technical, economic, societal, and environmental factors; safety; engineering codes and regulations; and engineering ethics. This is in addition to different professional skills required by the engineering job market, such as design methodology and techniques; project management; business practices; and team skills.

2.1. Second-year ECE Course

For the second half of the semester, APSC 200 was tailored for ECE students to incorporate projects based on the theme of Global Positioning System (GPS) and the Arctic region. As Canadians, we know that the Arctic (north of 60° latitude) is a part of the Canadian heritage and vital to the Canadian future [2]. Human activities in Arctic areas are expected to increase as the ice recedes and the demand for energy and minerals will surge [3].

According to the U.S. Geological Survey estimate, the Arctic region has 90 billion barrels of oil and 44 billion barrels of natural gas [4]. The Arctic has the potential to be used for diverse activities such as oil and gas exploration, pipelines, tourism, surveying, mapping, wide-ranging transportation of goods, and fishing. These activities will result in an upsurge of land, marine, airplane and helicopter transportation, and they all need a reliable navigation system.

However, the performance of the GPS in the Arctic region is adversely affected by a number of factors [5] including the poor satellite geometry in the Arctic region that results in poor positioning accuracy and the lack of reliable models needed to compensate for the
randomness associated with the ionospheric characteristics in the Arctic region. These factors and the growing need for reliable navigation in the Arctic area was the rationale behind including this theme in the course.

### 2.2. In-class Lecture Activities

The theoretical component of the course was taught through multiple lectures delivered by both the course instructor and professional guest speakers. Included were the following:

- a) What is GPS? How does GPS work?
- b) Introduction to the Arctic and GPS
- c) Positioning and Navigation in the Canadian Arctic Regions.
- d) Innovation from idea to execution
- e) Strategic Decision – making
- f) Tips for Report Writing

These topics covered basics of GPS’s three segments: (a) the space segment, (b) the control segment, and (c) the user segment, Figure 1 [6,7].

These lectures also provided an overview of Arctic regions; challenges for navigation in the Arctic; how innovation and strategic decision-making is important for a company’s future; the best ways to write a structured and well-documented professional report. These lectures were complemented with six hours per week of lab and discussion activities.

![Fig. 1. Illustration of control, user, and space segments of GPS](image)

### 2.3. Lab Activities

The four labs introduced students to practical perspectives of the course, such as GPS, sensors, and prototyping related concepts. Below is a short description of each lab.

- **Lab 1:** Using MATLAB to acquire accelerometer, magnetometer, gyroscope, and location data from built-in sensors on your iPhone, iPad, and Android device.
- **Lab 2:** GPS Prediction and Observation, followed by exporting GPS data to Google Earth.
- **Lab 3:** Controlling 7-Segment display with Arduino and 74HC595 shift register
- **Lab 4:** Temperature Sensor Circuit (TMP 102 + Arduino LCD)

### 3. PROJECT DESCRIPTION

A design project competition named “Positioning and Navigation in the Canadian Arctic Regions” was launched for this course. The aim of this project competition was to expose students to real-life applications of the course as they reviewed the design limitations of the present navigation system in an Arctic context and to have them recommend a suitable solution for various systems/applications/products that might improve the quality of life and/or the economic development in the Arctic.

Students were required to work in teams to determine the opportunity and need for an application/system/product in the Canadian Arctic region that requires positioning and navigation and to describe how they would approach finding a solution to providing the positioning accuracy required by their chosen application. Through this process, students should identify the potential stakeholders for their application, determine prerequisites for the application, and list the requirements of each stakeholder. Detail of the project assessment plan was presented in the following section.

### 4. PROJECT ASSESSMENT

This section describes the details of the assessment plan of the course, which included a project proposal, two progress reports, a final report, and an oral presentation. The final grade of students in a team is not unified but dependent on individual efforts as demonstrated throughout the project progress reports, peer and instructor assessments. A short description of these assessment activities and the team responsibilities is outlined below.

**Proposal** (submitted 8th week of the semester): The proposal’s purpose is to persuade a company to award a contract to the team. Each team, acting like a professional team, was encouraged to have a commercial identity and a logo. They should identify
one specific research problem that they would like to work on, pertaining to positioning and navigation in the Canadian Arctic region; they may choose a revolutionary idea or an evolutionary/incremental idea. They must clearly describe the objective of the project. It is important that the proposed solution addresses at least one specific limitation of the selected application/system/product and enhances its capabilities in the Canadian Arctic.

**Progress Reports** (submitted 9th and 10th weeks of the semester): Brief progress reports summarize the progress that the team is making. The reports should justify any deviations from the original proposed plan and should describe the new features added to the project proposal. Reports should include and describe a functional flow block diagram to illustrate the functionality required of the solution. This block diagram helps the students to understand the requirements and key assumptions for the system, and how well the solutions have met the design requirements.

In the progress report, students document their current state as per the proposed schedule with regard to various aspects of their design, and their anticipation of the next steps in the project using a Gantt chart. They should also discuss the challenges and issues they experienced in this phase of the project and how they plan to mitigate them.

**Final Report** (submitted 12th week of the semester): As design engineers, they are required to approach the problem by following engineering design principles, considering the available resources, local population needs, and global issues. They need to employ creative thinking, sound decision making, and a rapid analytical and prototyping approach to arrive at an innovative solution for this project. These aspects should be considered when the students are preparing the report, which is the culminating document for the project, and should include the following elements:

- A cover page describing the project, clearly highlighting the team design process, accomplishments, innovation, and creativity.
- A one-page executive summary
- A statement of originality
- Introduction: problem statement and motivation for the project
- Project Details: technical design elements, specifications, solution, environmental aspects, design criteria, implementation issues, functionality/performance, robustness, design process, schematic and illustrative figures and block diagrams, and considerations about health, safety, cost, and economic issues.
- Project Summary
- Suggestions for future work and ideas for enhancing the project
- Brief description of the demonstration of the solution concept, implementation, execution, time line, simulation, etc.

**Oral Presentation** (delivered 12th week of the semester): The final presentation takes place at the end of the semester, where the students, as a team, orally present their research, innovative ideas, and solution to a panel of judges and senior faculty members. Presentation time is divided equally among team members. The final presentation should clearly address:

- The significance of the application selected to research
- The design requirements of the application/system/product proposed
- The innovative idea proposed for the solution
- The technical components and designed methodologies used to solve the problem

**5. SAMPLES OF STUDENTS’ DESIGN PROJECTS**

In Fall 2016, students’ projects included initiation of new start-up companies to simulate application of their technical skills to a real-world environment, which include the customer needs; applying critical-thinking skills to develop prototypes, evaluate and communicate; and testing; and iteration. To evaluate the performance of each team and individual members a system of instructor, TA and peer’s feedback was established.

The aim of the course project was to enhance the positioning and navigation capabilities in the Arctic region for different applications. Student project ideas extended to cover different aspects of the project, such as: navigating System for the Transpolar Sea Route; commercial shipping - Canada’s Northwest Passage; Environmental impact of the Mining Industry in Arctic; Iridium, GPS, and phone in Arctic; helicopter navigation system - Arctic Oil Rigs; border security In Canada’s Arctic; web-based application for caribou herds in Taloyoak’s; GPS-based wildlife tracking in the Canadian Arctic region; Search And Rescue (SAR) system for the Arctic region; Automated Arctic Fishing Regulatory System (AAFRS); Mapping System in Norilsk; Alert Emergency Response Services for the Arctic; Drones and Arctic; Ground Based Augmented System (GBAS) to enhance positioning; Arctic icebreaking logistics; and Arctic oil-spill positioning system; and tourism.
Conclusions

This paper documents the development of a second-year engineering professional spine course in Electrical and Computer Engineering. The course implemented project-based learning and focused on GPS applications in the Arctic region. The course was carried out in a professional way where students demonstrated their cognitive and employability skills. Students’ feedback on the course both formally and informally showed great satisfaction with the content and the implementation of the course, which also demonstrated the diversity of the projects implemented by the students of this course. The skills and knowledge acquired by the students in this course enhance their preparedness for the ensuing third-year courses, which require higher levels of design and professional skills.

References


