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First-Year Student Design Projects In Engineering Graphics

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Abstract

First-year students at the School of Engineering Technology and the Lowell Institute School at Northeastern University are directly involved in multifaceted projects that have practical applications. This paper will discuss how the presentations are prepared, the expected level of competency, and integration of projects into an introductory design course. Design projects are carefully selected to follow the industrial format and introduce students to architectural, mechanical, and electrical and electronic design. Through the implementation of design projects into the curriculum, students gain fundamental engineering skills, an exposure to on-the-job industrial methodology, an understanding of interdisciplinary work, improved communication skills, and invaluable knowledge that will aid them in making informed decisions about their future careers.

I. Introduction

First-year engineering design projects are an integral part of the education process in engineering and engineering technology. According to Gerard Voland, the design process includes need assessment, problem formation, abstraction, synthesis, and implementation. Our proposed teaching methodology introduces the students to the design process common in the engineering profession and allows the students to experience the practical application of engineering at an early point in their education.

As a problem-based learning approach, the design process incorporates skills such as computer aided design and technical writing with the creative process, all the while developing technical engineering knowledge. In addition, this method of learning frequently aids students in defining their area of interest within the branches of engineering.

First-year design projects vary from short (ten- or twenty-minute) class designs to larger multi-week projects. A major design project requires a written report and the design drawings necessary to illustrate the student's idea. The process used in the design project may be an individual or a group effort, typically limited to three or four students.

An important component of all design projects is communication between the students and their instructor. Group and individual design projects begin with the students' submission of a proposal to the instructor. Upon approval, the student or students prepare a preliminary design report and drawings, which is resubmitted to the instructor for comments. The preliminary project is used as a basis for the final design project. Feedback provided to the students during each step is essential for learning.

The group design project enables first-year students to meet each other and work as a team in the spirit of Northeastern University's Academic Common Experience (ACE). The ACE proposes that students take advantage of previously acquired knowledge to ultimately develop interdisciplinary skills that will transcend the classroom to life experience. The group design project emulates a common industrial design approach, providing a safe environment for students to learn essential skills.

As in all methods of education, each approach has inherent advantages and disadvantages. A disadvantage to the group project format is the temptation for a few students to avoid doing their share of work. Albeit frustrating, such an experience encourages students to develop good strategies for working within groups. Often, group projects utilize the individual strengths of each participant. For example, students who possess strong writing skills will write the report, and those accomplished in drafting will produce the drawings. While this may be efficient and widely done in industry, students seldom work in areas where they need the most improvement. In an effort to fairly determine deserving grades, each student may be asked to write a brief description of their contribution to the project and a percent estimate of each group members' contribution.

II. Design Project Format

Engineering and design textbooks suggest various project formats, many of which are general and may be altered to accommodate specific designs. One such design as suggested by Gerard Voland, is a complete thirteen-part outline developed to familiarize first-year students with the design process and prepare them for advanced upper-level coursework and research. We propose a methodology that focuses on preparing students for working in industry. While the authors familiarize students with Voland's valued comprehensive approach, they utilize an industrial version of the format when working with first-year students. This approach was designed to reflect the type of work typically required by the students' cooperative work employers and in industry in general. Aptly referred to as the industrial format, our method is in keeping with our emphasis on a relevant education. Current formats used in first-year instruction include:

Voland Text	Eide Text	First-Year Design Projects, Industrial-Format
Title Page	Cover Page	Cover Sheet
Contents	Abstract	Table of Contents
List of Figures and Tables	Table of Contents	1.0 Introduction
Abstract/Summary	Body	2.0 Background
Introduction	Conclusions and Recommendations	3.0 Proposed Design
Background	Appendixes	3.1 Design Summary
Alternative Solutions		3.2 Design Criteria
Final Design Solutions		4.0 Required Alterations
Conclusions		5.0 Material List
Recommendations		6.0 Sketches
Bibliography		
Appendixes		

The design project assignments are student directed, allowing students to express their established interest; or projects may be assigned by the instructor to incorporate specific course material. Instructors focus on different training goals in each phase of the project. The dynamic relationship between the instructor and students facilitates learning. For example, instructor comments in the preliminary design phase introduce the appropriate technical terminology of engineering, as opposed to many students' reliance on unprofessional colloquial expressions. Graphic language and symbols required by the particular engineering discipline are taught to the students with "just-in-time" techniques. On average, the first-year student typically completes on average, three major design projects and about twelve small design projects during the Introduction to Engineering and the Engineering Graphics 2 courses.

II. Design Projects Grouped by Discipline

The design projects used in first-year instruction are generally of a broad nature and are selected to give students an overall view of the engineering profession. In keeping with a non-threatening learning atmosphere to facilitate greater learning, the projects are graded on general technical correctness and not on a student's creative ability. Technical correctness encompasses the appropriate language, symbols, and information necessary for a viable, working drawing. Projects are presented to encourage the creative process and begin building confidence in the students' design abilities.

A. Architectural Based Design

Architectural based design projects are required of students in an effort to encourage interest in, and familiarity with the Architectural Engineering and Construction (AEC) industry (the AEC industry is the country's second largest, encompassing approximately ten to twelve percent of its gross national product). Student design projects incorporate the use of the architectural and engineering scales in both sketching and computer aided design. The use of terms relative to the AEC industry is required. For example, students should distinguish the use of terms such as beam or girder, and cement or concrete.

Student design projects may be broadly divided into the following topics:

1. surveying – site layout
2. furniture/ building equipment
3. design of spaces/ arrangement plans
4. design of building systems, for example, lighting (electrical), pipe (mechanical), and heating ventilation and air conditioning (HVAC-mechanical)
5. building structural design

Several first-year classes were recently involved in the redesign of a university laboratory site to fulfill the requirements of an architectural based design project. This project is a working example of how an interdisciplinary relationship between the Physics Department and the School of Engineering Technology provided an ideal opportunity to support the practical goals of both the ACE (Academic Common Experience) and the industrial format. To provide real-life experience, students benefited from visits to the site of the proposed physics laboratory and a presentation by the laboratory director. Following the industrial model, student developed preliminary design drawings based on the architect's existing multi-layered AutoCAD working drawings. These preliminary laboratory arrangement plans and reports were submitted to the instructor for comments, then returned to the students. As students refined their work through making design changes, they increased their technical knowledge. The knowledge they gained through their practical experience directly reflected curriculum requirements. Therefore, their final design projects were graded to reflect these requirements. During this unique interdisciplinary project, students benefited from feedback from both their instructor and the physics laboratory director. The project was extended for those students participating in the honors program, who developed laboratory manuals regarding the proper use of the equipment that they included in their design projects (c f Hoop et al). Area high-school students using the new laboratory may use some of the proposed experiments.

B. Mechanical Based Design

Mechanical based design projects are frequently the most popular of student selected projects. The expectations for technical correctness in mechanical based, first-year, student design projects include:

1. An understanding and computer use of the architectural, engineers and metric scales. This includes proper dimensioning of detail and assembly drawings.

2. The use of mechanical based engineering terms and language. Student design projects may be broadly divided into the following topics: case or housing designs, mechanical devices, instrumentation design or mechanical systems.

Students frequently choose a case or housing design as their first mechanical based design. Popular projects include designing: cellular phone cases, usually with extra features; instrument panels; motor housings; study lamps; various containers; computer, and peripheral devise cases. To broaden their knowledge and encourage awareness of industrial needs and opportunities, students are instructed in basic layout and design of pipe and ventilation systems, including material take offs. A systems design is often assigned to acquaint students with a typical industrial project.

C. Electrical and Electronic Based Design

Frequently there is a substantial amount of confusion among first-year students as to what constitutes an electrical/electronic design project. Many of the design projects that students think are electrical or electronic are actually mechanical. For example, they will design a case and not the components. Most first-year students do not have the specialized technical background for electrical/ electronics design. Therefore, students generally do not choose design projects in these disciplines.

Comprehensive curricula should assist the students in becoming familiar with all engineering disciplines, including the electrical/electronics (which is engineering's largest discipline). The authors advise that first-year students be required to become familiar with electrical and electronic symbols as they relate to basic devices and wire coding. Assigned student design projects include the circuit mapping of a building (electrical) and designing a circuit board (electronic). Other projects may include changing a dual/ backup electronics system to a single system including material take offs and various power diagrams.

D. Design Projects Across Disciplines

In industry, when a project is electrical, and the electrical section is the lead design group, the design is frequently dependent on the "as built" structure and the location of mechanical equipment and systems. This may result in electrical engineers and designers needing to understand the basics of structural and mechanical engineering or the structural and mechanical design to be knowledgeable about electrical design. Common lack of knowledge across disciplines causes communication problems in the design office. Comprehensive curriculum should assist the students in becoming familiar with all engineering disciplines, including the electrical/ electronics (which is engineering's largest discipline).

In an integrated curriculum, design projects often overlap engineering disciplines. Concurrent engineering, just-in-time, total design and turnkey projects illustrate industrial approaches to these design overlaps. Students experience this overlap by selecting or being assigned design projects that span the disciplines. Student projects including the design of a telephone, toaster, electric shaver and many other projects are clearly in the electro-mechanical field. Other projects, such as outdoor lighting, involve electrical and civil design. Foundation design for various types of equipment may involve many engineering disciplines concurrently.

The physics laboratory project, previously described, is an example of an integrated design project. Typical first-year integrated design projects attempt to emulate the ideal learning experience. For example students may be assigned to design a floorplan for a computer room and the following assignment may be circuit mapping the same space. Students may then be required to generate equipment, materials or other take off-lists. Through these assignments students not only experience the satisfaction from seeing a design project through to completion, but also gain an appreciation and understanding of the complexities of design overlap.

Conclusion

Utilizing an industrial format in instructing first-year engineering students better prepares them to design and build, basic goals in the engineering profession. Unfortunately, most first-year students have limited exposure to practical engineering and few opportunities to design within and across disciplines. At minimum, design projects presented in the industrial format using just-in-time teaching techniques acquaint students with the various architectural, mechanical, and electrical/electronic languages and symbols. Well-structured assignments also encourage growth and self-confidence in the creative thinking process. In addition to providing this essential foundation of knowledge, employing the industrial format greatly assists students in their career development. Given multi-step projects, they become keenly aware of the importance of communication among specialists and the need for a general understanding of all engineering disciplines. This exposure to multiple disciplines through real-life projects affords them the opportunity to evaluate their strengths and interests to make informed decisions about their future careers. Introducing the industrial format during students' first year provides a safe environment for students to gain fundamental technical knowledge and invaluable lessons in career development.

References

1. Eide, A., Jenison, R., Mashaw, Log and L. Northup, Engineering Fundamentals and Problem Solving, McGraw Hill Companies, 1997, pp. 434-435.
2. Hoop, B., Hansberry, E., and Voland, G., Student-Centered Science Activities in Lay Science Disciplines, 2000 ASEE Conference.
3. Voland, G., Engineering by Design, Addison-Wesley Longman, Inc., 1999, pp. 4-8, 14-16.

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