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Integrating Engineering Design with Humanities, Sciences and Social Sciences Using Integrative Learning Blocks

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Abstract:

The current paper highlights the impact of the National Science Foundation sponsored curriculum project, which has helped the curriculum innovation by design integration throughout the curriculum. This has been achieved by (i) Redesign of the Freshman Engineering course sequence by incorporating Integrative Learning Blocks by involvement of faculty from engineering, mathematics, physics, humanities and social sciences. (ii) Creation of a new Engineering Design course at Sophomore Year and the development of Integrative Learning with a course on Ethics in the Profession (iii) Redesign of a Junior Year Design course with Integrated Learning with Civil, Electrical, and Mechanical Engineering. (iv) Partnership with industry in the creation of real-life engineering projects for all Senior Capstone projects.

The paper narrates the interdisciplinary focus taken by the project, involving faculty from engineering, mathematics, humanities, etc. It has promoted new teaching and learning paradigms and has emphasized team-building and collaborative learning in engineering, mathematics, sciences and humanities. In addition, it has already influenced the complete reshaping of the 4-year curriculum in the College of Engineering. Various parts of the project have addressed engineering curriculum reform from the freshman to the senior year based on a problem based collaborative learning approach. The clustering arrangement experimented in the courses could serve as a models for others to follow and could be transferable to most other institutions. By working on projects, the benefits of students taking greater responsibility for their own learning has resulted in a cultural change. The students have opportunity to work on well-rounded projects sponsored by outside agencies and industries. The project has a significant chance of sustained impact on engineering education.

1. Introduction

In the last decade, there had been several attempts by educational institutions to develop integrated curriculum (Denton[1]). Some of these have focussed on the integration of science and mathematics into problem solving and design, while others had placed emphasis on co-operative learning, assessment, and industry involvement (Everett, Imbrie, and Morgan[2]). Comprehensive

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review of the work of integrating sophomore and junior courses was done by Caroll[3]. There had been a large body of literature on improving the first year education[4,5].

This paper presents the findings of a new curriculum project that dealt with integrating engineering design with humanities, social sciences, sciences and mathematics at the University of Hartford's College of Engineering. The primary aim of this project is to develop and test a model for a innovative curriculum through the integration of inter disciplinary design projects through out the four years of the program, experiential and collaborative learning by both faculty and students and partnership with the industry in the creation of real life engineering projects for students at all levels. The curriculum reform effort was the result of an action agenda NSF grant. The goal of the grant is to incorporate the above-mentioned objectives into all four years of the undergraduate curriculum, in a coordinated effort to expose students to the design process including all ancillary function[6].

2. Curriculum Redesign

The curriculum was redesigned with the creation of unique course combinations where the faculty (engineering, mathematics, science, humanities, and social studies) worked together to define student learning outcomes for project based curricula. This was achieved through several curricular configurations and the clustering of engineering and non-engineering courses into integrated First-Year-Interest Groups (FIGS). The engineering and interdisciplinary courses in the sophomore year and junior year were paved with collaborative projects. The students at the senior level were involved in industry supported Capstone Projects with support from the Outreach Committee.

2(a). Freshman Year – First Semester

In the first semester of the Freshman year, the First Year Interest Group (FIG) was created. It consists of the two courses ES141 (*Principles of Engineering*) and RLC 110 (*Rhetoric, Language and Culture*)

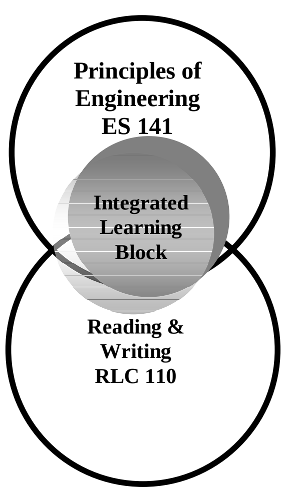

Figure 1 – ***Freshman Year (First Semester)***

Shared Outcomes of First Semester FIG

The faculty of ES141 and RLC110 worked as a team to identify the shared outcomes between the two courses. Then, they worked on identifying the activities, the technology to support those outcomes. They are currently working on the assessment methods.

The Shared Outcomes are:

- Communicate technical information in written and oral form in a professional manner appropriate to the workplace and the classroom.
- Manage and process information in a variety of contexts and situations
- Gather, analyze, and evaluate data from a variety of sources, including interviews, library materials (books and journals), and on-line sources.
- Organize and manage tasks regarding personal and professional development
- Be aware of university resources and use them
- Work independently and as a member or leader of a small group that performs a variety of writing and analytical projects.

2(b) Freshman Year – Second Semester

In the second semester of the Freshman year, the FIG consists of the three courses ES142 (*Principles of Design*), M145 (*Calculus II*) and PHY112 (*Physics I*).

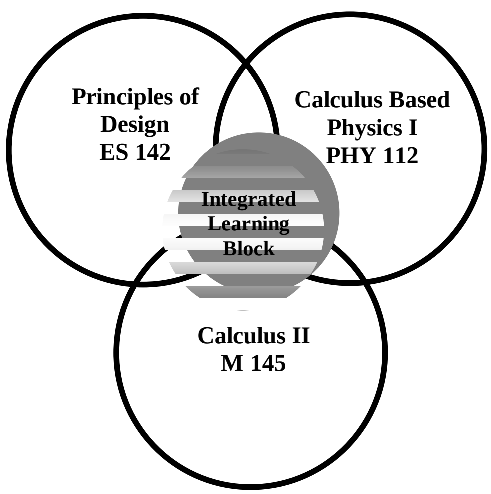

Figure 2 – ***Freshman Year (Second Semester)***

Objectives of Principles of Design

Procedures of Problem Solving, Technology of Engineering Solutions, Team Dynamics, Engineering Presentations, Ethics of the Engineer

Objectives of Calculus II

Integration, Log, Exp., Differential Equations, Trigonometric functions, Integration by parts, Improper Integrals, Infinite Series, Taylor Polynomials, Taylor Series, Polar Coordinates

Objectives of Physics I

Statistics, Graphing, Vectors, Velocity, Acceleration, Centripetal Force, Projectile Motion, Conservation of Energy, Conservation of Momentum, Moment of Inertia, Torque

Shared Outcomes of All Three Courses

- The ability to solve problems utilizing a step-by-step approach independently or as an effective group member
- Utilize technology for problem solving
- Understand basic principles behind problem solving with current technology
- Understand the interaction of math, physics and engineering and be able to utilize techniques from each branch to solve the same problem.
- Present a coherent and concise written and oral presentation of problem solutions and be able to defend the procedures and solutions.

3. Sophomore Year

A new engineering design course (*Engineering by Design*) has been created at the Sophomore level. This new course shares a one-credit integrated learning block (ILB) with a sociology course, *Ethics in Professions*. The ILB mechanism allows for the study of specific ethical issues associated with the design projects being undertaken by the engineering students. In the sociology course, engineering students benefit from wide ranging discussions of ethical issues and non-engineering students and faculty are brought to understand the nature of engineering work and its broad social context.

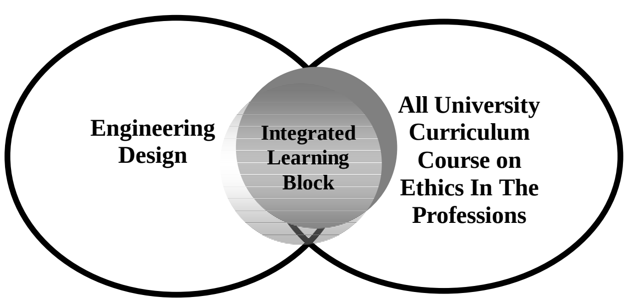

Figure 3 – ***Sophomore Year***

Objectives

- To continue to apply and hone the problem solving skills and basic design concepts covered in the freshman course, *Principles of Design*.
- To learn the skills of being a productive team leader/member.

- To recognize and offer solutions to potential ethical problems. (Expanded discussion of ethics problems will be covered in *Ethics in the Professions*, taken as a co-requisite).
- To refine written and oral presentation skills, including the use of computer presentation hardware/software.
- To recognize the interdisciplinary nature of most design projects

4. Junior Year

During the Junior Year of the curriculum, a new course has been introduced, tentatively titled, *Engineering Practice*. The course is a one-credit course for all junior engineering students that is closely linked with a discipline specific course and loosely linked with All University Course, *Introduction to Western Heritage*, a required course for all engineering students. This course is being modified to include readings and discussion on the societal impact of technology, and how our heritage has evolved to consider the rights of the individual versus the rights of the society, ownership of natural resources and intellectual property.

The main goal of *Engineering Practice* is to introduce engineering students to factors such as impact on society, political concerns, and cultural concerns that significantly affect their designs, but are not part of traditional engineering design. The course is structured around a large overarching engineering project that involves all engineering disciplines. The students are assigned to multidisciplinary teams of 4-6 students to perform two group projects, which corresponds to various design assignments. The choice of projects includes projects on feasibility studies, environmental impact, financial viability and cultural concerns. The course is taught concurrently with a discipline specific, design-oriented junior level course offered by the Civil, Electrical and Mechanical Departments.

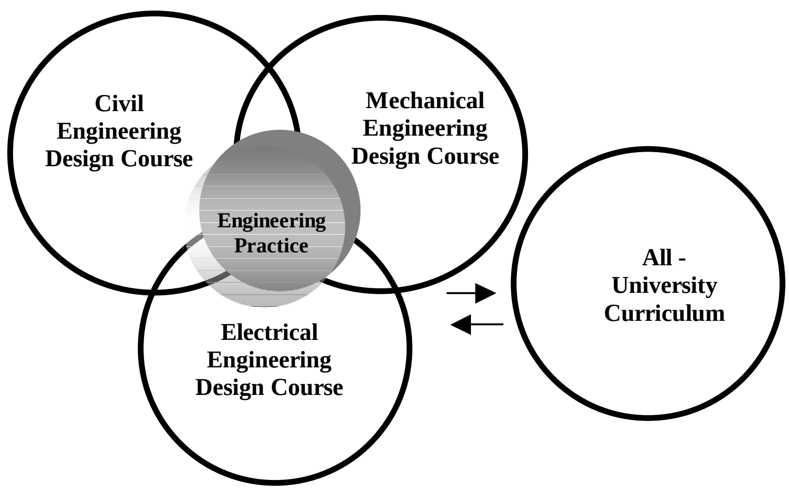

Figure 4 – ***Junior Year***

The course outcomes include: understanding the structure and development of a large engineering project; being able to work to a common goal with students of other disciplines;

being able to complete a project involving public health and safety; understanding the role of presenting engineering design and analysis to the general public; applying skills and techniques for earlier and co-requisite courses to a major design project; and understanding the social-economic, financial, and economic aspects of engineering design. Each of the above outcomes was then mapped into one of the elements of ABET Criteria to both further define the course and illustrate its position within the entire engineering curriculum.

5. Senior Capstone Projects

Central to the curriculum reform effort is the strengthening of undergraduate research and problem solving capabilities and the forging of strong ties between undergraduate engineering education and industry. Our business/industrial partners are involved in the development, re-development, and presentation of courses throughout the four years. The Senior Year of curriculum culminates in a capstone project with significant interdisciplinary components supervised by engineering faculty with consultation from a business/industrial counterpart. Students have been prepared by the previous years of integrative, interdisciplinary work to solve engineering problems taking into account the larger context. Students are required to demonstrate their mastery of oral and written communication skills by presenting their results to an audience of peers, faculty, and business/industry representatives and submitting a final written report. These final presentations and reports include sections on the social, political, economic and cultural dimensions of the completed design projects.

The Senior year design projects are assessed according to the student outcomes defined for this curricular revision project. The Capstone Project represents the result of that interaction as senior student design teams work under the supervision of faculty and an industrial partner and engage in hands-on problem solving.

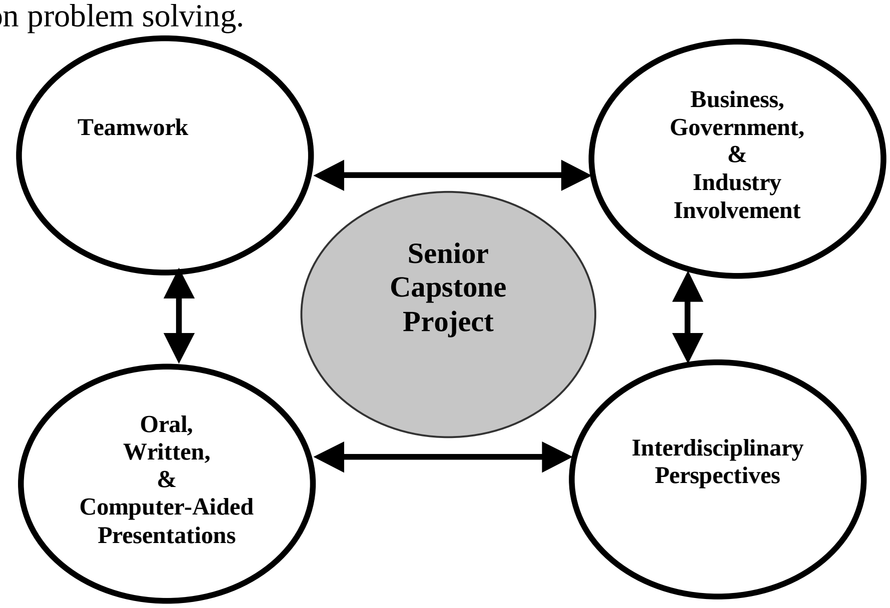

Figure 5 – ***Senior Year***

Senior Capstone Project

- Students work in groups with the guidance of a faculty member and a liaison from the sponsoring organization
- Projects are selected on the basis of quality of educational experience provided as well as student interest. Each team submits an initial proposal to the client, plus periodic reports culminating in a final report.
- Depending on the project, the student team visits the sponsoring company or institution for a mid-semester review.
- Students are required to make oral presentations to the class as well as to the sponsoring agency. They are also required to submit final written reports and summary presentations to the sponsoring agencies at the end of the project.

6. Evaluation

A series of evaluation tools are under various stages of development.

- Development of tools for the evaluation of Integrated Learning Blocks.
- Development of assessment tools for the new courses introduced in the sophomore year and junior year.
- Development of assessment tools for the evaluation of the senior capstone projects
- Assessment of the faculty workshops

As an example, Figure 6 depicts the evaluation results done to measure the impact of changes made in the freshman year ES141 course. The students were provided with a questionnaire asking them to grade on a five-point scale from 1-disagree to 5-strongly agree. The selected parameters were grouped under six basic types of skills namely, ‘Engineering skills’, ‘Communication Skills’, ‘Computer Skills’, ‘Resource Utilization skills’, ‘Management Skills’, and ‘Connection and linkage to other courses’.

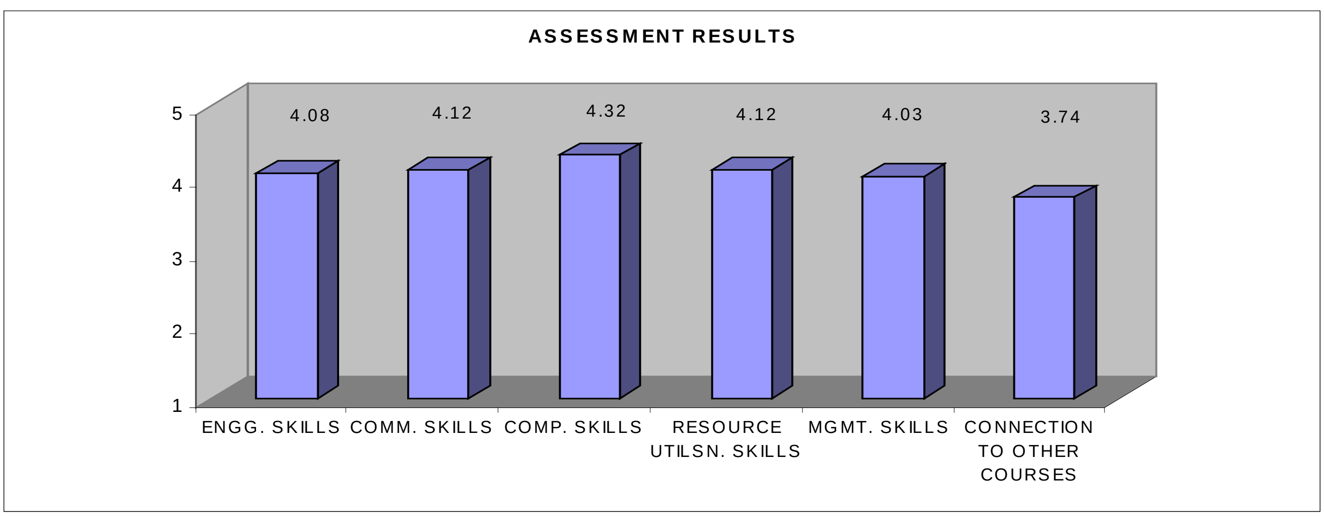

Figure 6 – ***Evaluation Results***

Further evaluation work on other courses as well as on the whole curricular modification and its impact on student learning is under progress.

7. Conclusion

The NSF sponsored project at the University of Hartford's College of Engineering has helped the curriculum enhancement by design integration throughout the curriculum. The contribution of the grant to the field of engineering education is as follows.

- Redesign of the Freshman Engineering course sequence by incorporating *Integrative Learning Blocks* (ILB) by the involvement of faculty from engineering, mathematics, physics, humanities and social sciences.
- Creation of a new Engineering Design Course for the sophomore year. This activity is supported by the creation of integrative learning along with a course on Ethics in the Profession.
- Redesign of a Junior Year Design course with Integrated Learning with Civil, Electrical, and Mechanical Engineering and inclusion of a course on "Engineering Practice."
- Partnership with industry in the creation of real-life engineering projects for all Senior Capstone Projects
- The Faculty involved has gone through a training program in the area of active and collaborative learning and useful pedagogues. A new design laboratory for interdisciplinary, integrated student learning has been created. Further efforts are in progress to create measures to assess the effectiveness and outcomes of the new implemented methodologies.

Various parts of the project have addressed engineering curriculum reform from the freshman to senior year based on a problem based collaborative learning approach. In addition, the curricular reform is very relevant to the new ABET accreditation guidelines with focus on outcomes. The projects have taken an interdisciplinary focus, involving faculty from engineering, mathematics, humanities, etc. The project has emphasized team-building and collaborative learning in engineering, mathematics, sciences and humanities. The students have an opportunity to work on well-rounded projects sponsored by outside agencies and industries.

The clustering arrangement experimented in the courses could serve as models for others to follow and could be transferable to most other institutions. The projects have a significant chance of sustained impact on engineering education. In addition, the project's collaborative learning approach will also have sustained impact on other schools of the University of Hartford.

Acknowledgements

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References:

1. Denton, Denice D. " Engineering Education for the 21st century: Challenges and opportunities", Journal of Engineering education, January 1998, pp. 19-22.
2. Everett,L., Imbrie,P., Morgan, J, " Integrated Curricula: Purpose and design", Journal of Engineering Education, April 2000, pp. 167-175.
3. Carroll, D., " Integrating design into the sophomore and junior level mechanics course", Journal of Engineering Education, July 1997, pp. 227-231.
4. Pendergrass, N.A. and et al, " Improving first year engineering education", 29th ASEE/IEEE Frontiers in Education committee, Nov'1999.
5. Smith, L. and Shetty, D., " Principles of Engineering and Design: a Multidisciplinary First Year Course". ASEE Zone I meeting – Spring 1997 Middle Atlantic Section, New England Section, St.Lawrence Section, West point, New York 1997.
6. NSF Grant Award Number 9872433, " Integrating Engineering Design with the Humanities, Social Sciences, Sciences and Mathematics", 1998.
7. Alnajjar, H., " Getting Freshman to Make the connection Between Courses Through Integrative Learning Blocks (ILB's) ", Presented at the ASEE Annual Conference and Exhibition, June 18-21, 2000, St.Louis, MO.,
8. URL: http://www.asee.org/conferences/search/20263.pdf
9. URL: http://uhavax.hartford.edu/~leone/ES242.htm

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