Incorporating Training In Research & Research Methods into the Undergraduate Curriculum in Engineering and Engineering Technology-(E&ET).

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Incorporating Research into the Undergraduate Curriculum in Engineering and Engineering Technology-(E/ET) Lessons Learned.

Abstract

Undergraduate research has been found to provide an essential component of engineering and engineering technology education and therefore belongs in the undergraduate curriculum.
It has a positive effect on individual research programs and the university's research enterprise.
It contributes to the intellectual life of individual departments and the campus as a whole, while it raises the level of research activity, and helps recruit stronger undergraduates, graduate students, and faculty. This paper analyzes the student learning outcomes, for Engineering and Engineering Technology (E&ET) programs, where the curriculum has been tailored to include undergraduate research, as compared to lecture & lab-based curriculum.

Previous research, on which the present work is based, shows that research projects allow students to explore, discover and innovate in a limited period of time and space. The literature reveals that undergraduate research helps to integrate students with the faculty and results in publications which appear in peer-reviewed journals. Thus the student is able to create portfolios that shed light on their learning and skills development in the professions. Through this work, the following several key questions are answered:

1. How do we best incorporate research into the undergraduate curriculum?
2. Does it make a difference?
3. Who is it for?
4. How do we know?
5. What is the evidence for the last 10 years?
6. Why make the transition to project-based curriculum?

Through the analysis of the data on undergraduate course research participation extracted (and summarized) from Faculty Course Assessment Report FCAR, and to no small measure, in agreement with previous research, it can be concluded that undergraduate research apprenticeship allows students to take a project from the beginning, all the way to completion. These, along with presentation/communication skills development, are very important in helping students to identify whether they want to continue their academic experience at the graduate level. Additionally, the undergraduate research in the curriculum provides students with a clearer understanding of career options in the E&ET fields, while producing more informed, committed and better prepared graduate students with greater potential for success in graduate programs. It gives students a deeper and more mature understanding and appreciation of E&ET in general, contributing to students' personal and professional growth. Engineering and Engineering Technology programs with strong undergraduate research produce better prepared and more qualified scientists and engineers

for the coming generations.

Introduction

Bentley and Kyvik, 2012 found in their studies that faculty members spend more than 50 hours of their time every week on the job, out of which only 20 hours are spent doing the actual teaching. Depending on the faculty status, either Tenure-Track or Tenured, or even as a function of the nature of the institution in which one find himself/herself, research oriented or purely teaching institutions as the case may be, these hours can be much higher (Bentley, P.J., and S. Kyvik, S.).
It would be needed to inculcate time-efficient teaching practices into these new courses from here-on in order to give the students the best and facilitate their learning in these new fields. To do these, there is a need to address three basic best practices that can have a positive impact on the way course are presented, particularly in the areas of Renewable Energy (Linda C. Hodges), heretofore:

1. Begin with the end in mind.
2. Generate criteria or rubrics to describe disciplinary work for students.
3. Embed "assessment" into course assessments.

An investment of substantial time up-front enhances the effectiveness teaching of these new courses with a research project focus and this should be encouraged across the board. Spending time on intellectually rewarding exchanges on the subject of Renewable Energy with students, on a regular basis, while current events and news are highlighted on the subject matter, is also recommended. Remember that when a student has learnt and shown understanding, a teacher must have done his or her job well (Covey, S. & Hutchings, P. & Walvoord, B., and Anderson V. J.).
Course development, within the Renewable Energy curriculum, are generally more challenging than core course and/or discipline-specific course development. This unique characteristic is due to the dynamics specific to the field of Renewable Energy and of its cross disciplinary nature.
The Engineering Technology discipline is defined as the part of the technological field that requires the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational spectrum between the craftsman and the engineer at the end of the spectrum closest to the engineer (J. Earnest & http://www.abet.org).

Review of Related Research

Previous research on project-based instruction shows that the ABET required competencies, for engineering technology programs, are better implemented through project based instruction (J. Earnest). It was determined by other research teams, that project based instruction is an extremely effective method of learning the fundamentals and understanding how engineering principles are applied to solve design problems (R. N. Savage, K. C. Chen, L. Vanasupa). Project –based learning approach, implemented at the freshmen level as a comprehensive group project, stimulated the overall interest of the students in the subject

studied, as the project provides a practical application of engineering fundamentals learned in the course (H. A. Hadim, S. K. Esche). As compared to lecture + lab format, project based learning (lecture + lab + project) shows a measurable improvement, shifting the learning process from a teacher-driven to a student needs focus (R. N. Savage, K. C. Chen, L. Vanasupa & H. A. Hadim, S. K. Esche).
Similar to Design-Spine method, project-based learning addresses the set of competencies underline in the ABET accreditation requirement for engineering and engineering technology programs. Both methods emphasize professional practice of communication skills, team work, project management and economic design, enhancing the understanding of science, engineering fundamentals and problem solving skills (K. Sheppard, B. Gallois).

Data Collected and Analysis

Project reports and technical presentations, associated with each individual project, underline the set of skills characteristic to graduates of Engineering Technology programs. This research demonstrates the clear advantage of lecture-lab-project structured courses of Renewable Energy Engineering Technology as opposed to the more traditional method lecture-lab course structure (Misoc F., Okhio C., Asgill A.).

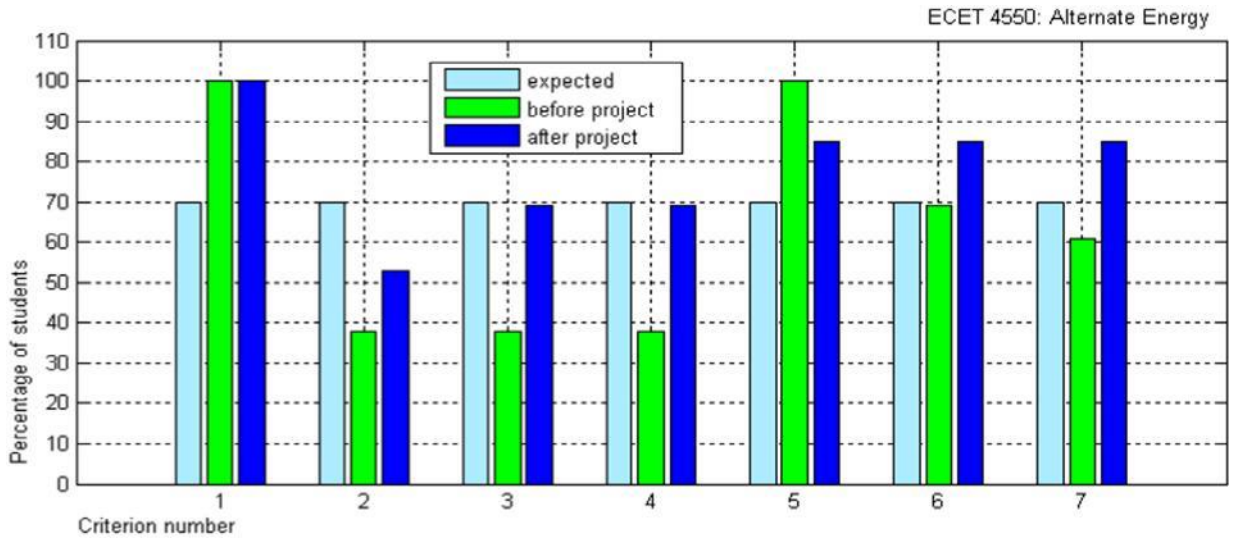

Figure1: Comparative results of pre and post research project learning outcomes

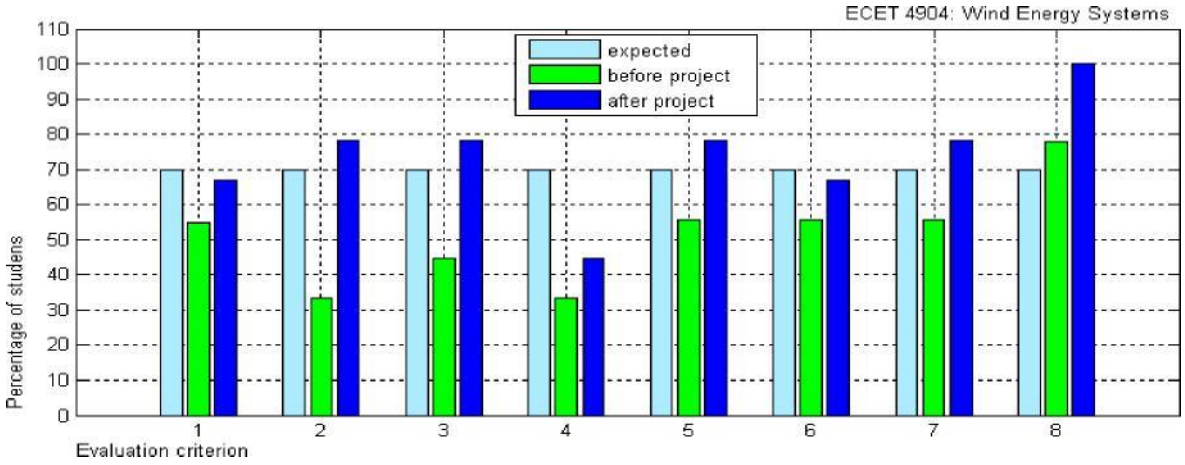

Figure 2: Comparative results of pre and post research project learning outcomes

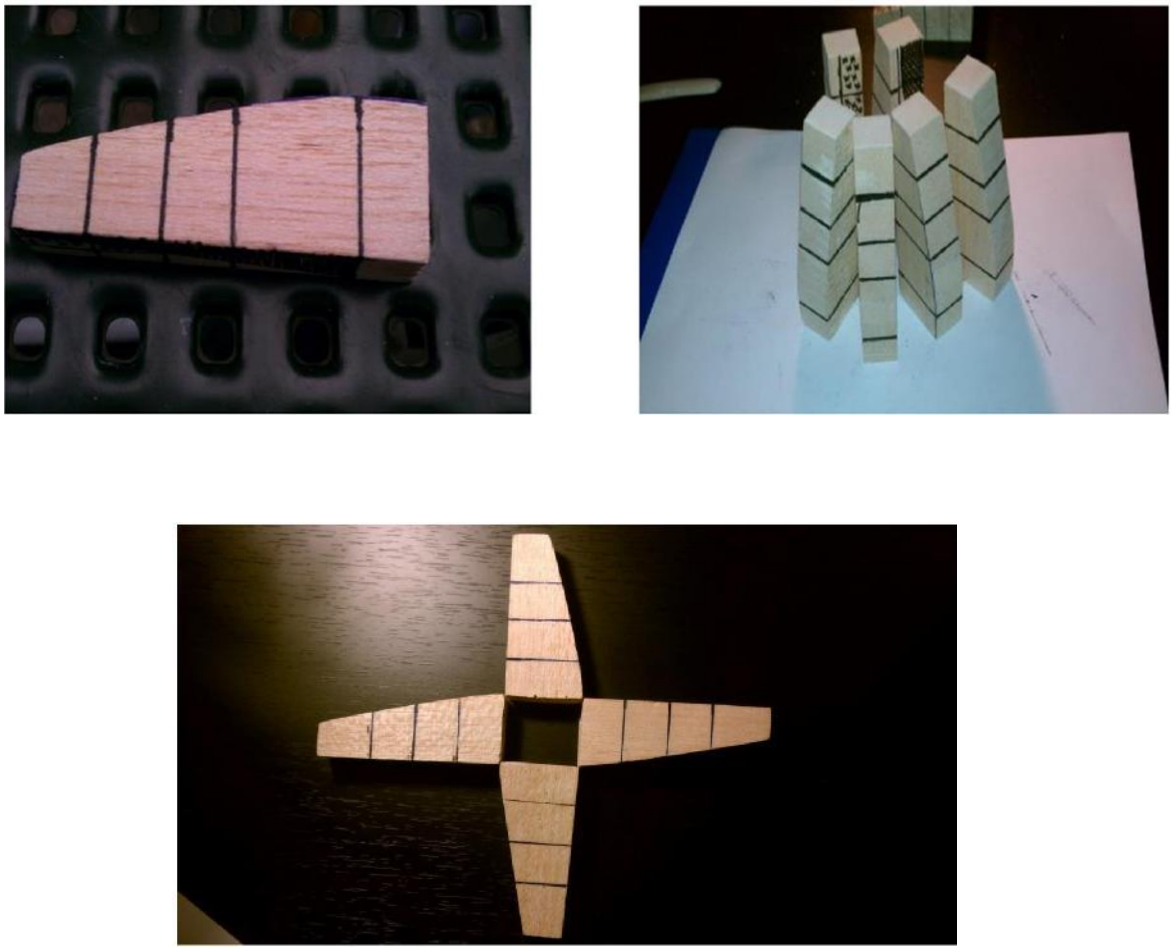

Figure 3: Research Progression from Blanks to 4-Bladed Design.

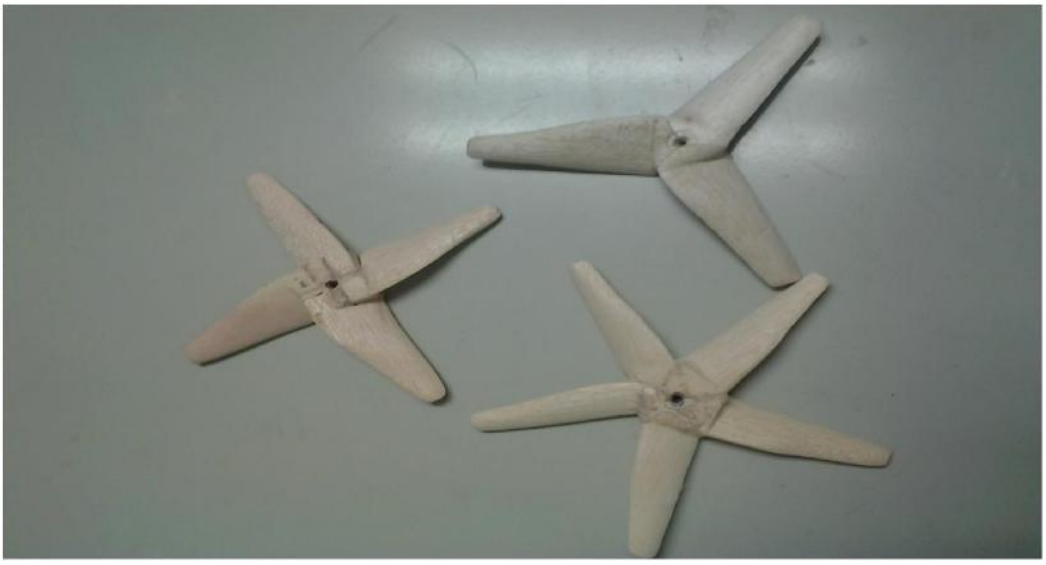

Figure 4: Final Outcome of Figure 3 Design Exercises.

Observations

All student engineers who aspire to professional status should read widely and make use of libraries, including that of the institution. While they may extend their reading in the engineering and scientific fields, it is important that they should study the principles of management and the underlying social sciences. They can, in this way, acquire an understanding of the elements of economics, law, trades union history and practice and the behavior of man both as individuals and as groups.

As has been mentioned, broad communication potential and an ability to express himself/herself clearly should be the attributes of a successful student engineer. Student engineers should be encouraged to become familiar with a foreign language at least. Such knowledge would encourage overseas industrial exchange program that will help both student and industry to be aware of technical developments abroad, and later enable them to play a more expert part in the development of the nation and overseas trade.

Any graduate engineer wanting to undertake postgraduate training by research in a University, Polytechnic or acknowledged research organization without having first completed his industrial training program can be specially considered by professional bodies. Such a research student will normally or frequently undertake a great deal of work involving design, construction and development of quite complex pieces of equipment. Such high quality research periods that involves work that is not predominantly of a theoretical nature is usually recommended as fulfilling professional training requirements.

Conclusions

The student engineer's enterprise and initiative should always be stimulated and maintained to the fullest. A research project training, in which a student engineer is given an actual

engineering or organization problem to explore, can be of the greatest value. Such a project affords an outlet for the exercise of ingenuity and fosters a sense of achievement; useful ideas can often stem from it. Research Projects are appropriate during each stage of training. An ideal research project would involve the following:

(I) the application of knowledge and experience gained
(II) the exercise of a sense of judgment
(III) cost appreciation and human effort and supervisory requirements
(IV) the need for compromise

Where possible, the project should demand some technical and supervisory ability and competition with other individuals will provide an additional stimulant. It is encouraged that research projects are completed and tested by the end of the period.
Several students commented on the value and the importance of research projects. They tended to emphasize the employment opportunities associated with some projects. Comments from most students indicated the difficulty in completing all the tasks associated with sponsored research project in such a limited time frame, as well as the constructive aspects of their respective projects, such as: proper materials, machining of critical parts, etc.

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