

## **AC 2007-2895: METHODS FOR ASSESSING THE IMPACT OF A DESIGN COURSE ON SELECTED STUDENT TRAITS**

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## **Methods for Assessing the Impact of a Capstone Design Course on Selected Student Traits**

**Abstract** – This paper describes the development of a pilot study to determine the impact of a Capstone Design Course on selected student traits (problem solving, critical thinking, initiative, and transfer) identified by business and industry as necessary for success. Included are a review of the literature, a statement of the research question, the design and methodology of the study, procedures for the study, methods for data analysis, and a summary. The Capstone Design course is a requirement for every Engineering Technology student. The researchers' goal is to determine whether this course enhances, and to what level, the traits. The researchers use four pre-tests at the beginning of the two-semester Capstone Design course and four post-tests at the end of the Capstone Design course to measure enhancement of the traits. These tests form the basis for pilot test assessment of these traits and will become the foundation for future research conducted within the Schools of Engineering & Technology, Education, and Business. Since these four traits, or qualities, are applicable to all areas of successful job placement and job performance, the post-assessment data, which can be thought of as a summative evaluation, of the students' growth will yield a formative evaluation of the merits of the Engineering Technology program. After the students are made aware of their individual growth in these traits they will be given an open ended survey to give their opinion on why they made progress. Researchers from the Schools of Education and Business administer the tests to maintain confidentiality of student responses until after the completion of the courses. The objective of the research is to determine which elements of the design course experience have the greatest impact on these traits.

Aspects of knowledge important to the enrichment of engineering and engineering technology students include problem solving, critical thinking, initiative, and the transfer of knowledge and skills from introductory instruction to working applications. While information and insights into students' learning in other disciplines should not be discounted, research that is done with students working toward different degrees and/or problems not specific to engineering students and engineering problems is not well understood (Turns, Atman, Adams, and Barker, 2005)<sup>12</sup>. Insights into engineering students' learning inherently need to stem directly from experience in course contexts for maximum applicability to success in the job market.

*Keywords:* Problem Solving, Critical Thinking, Initiative, Transfer, Design, Capstone

### **Introduction**

It is important to evaluate the effects of the Capstone Design course on student traits in the four specified areas to promote course re-evaluation for improved instruction and adherence to ABET standards. The research question for this study was generated through workshop on engineering education research conducted at the Colorado School of Mines in August of 2005. The authors participated through a project funded by the Center for the Advancement of Scholarship on Engineering Education (CASEE) and the National Academy of Engineering (NAE). Although the workshop and the literature focus on engineering education, the authors believe they are also applicable to engineering technology.

## **Review of the Literature**

Aspects of knowledge important to engineering students include problem solving, critical thinking, initiative, and the transfer of knowledge and skills from introductory instruction to working applications. While information and insights into students' learning in other disciplines should not be discounted, research that is done with students working toward different degrees and/or problems not specific to engineering students and engineering problems is not well understood (Turns, Atman, Adams, and Barker, 2005)<sup>12</sup>. Insights into engineering students' learning inherently needs to stem directly from experience in course contexts for maximum applicability.

### *Problem Solving*

Problem solving is defined by Killen<sup>7</sup> as a form of inquiry learning where existing knowledge is applied to an unfamiliar situation in order to gain new knowledge. Smith<sup>11</sup> points out that the most common method of classroom teaching and learning in engineering education has been described as where "information passes from the notes of the professor to the notes of the students without passing through the mind of either." In contrast to this type of teaching is problem-based learning which is a process of working toward understanding or resolving a problem. This method of problem solving is suitable for engineering classes because of its ability to help students develop skills and confidence in formulating new problems. This ability is important since most real work problems do not follow the material presented in class textbooks or have a single correct answer. Results from studies on the influence of problem based learning suggest students are better at applying knowledge skills. In addition to this Prince<sup>9</sup> states that while problem-based learning has been used in undergraduate engineering programs "there is very little data available for its effectiveness with this population of students."

### *Critical Thinking*

A report from AC Nielsen Research Services for the Department of Education<sup>1</sup> found that new graduates with university degrees were "particularly poor at critical thinking." As Beder<sup>2</sup> points out it is no longer enough to teach students technical knowledge to carry them through their careers. A broader approach that not only helps students understand engineering principles, but equips them with skills in critical analysis is essential.

Critical thinking skills are necessary for students both during their time in school and their post graduation careers. Within the field of engineering there is typically no one correct solution to most problems. Engineering design involves making assessments and decisions among design alternatives where data may be both lacking and uncertain (Siller<sup>10</sup>). Noting that engineering education usually lacks training in critical thinking, Siller<sup>10</sup> proposes methods developed by King and Kitcheners<sup>8</sup> for developing students' critical thinking skills through engineering problems. These design projects typically show measurable changes over one semester. Siller<sup>10</sup> concludes with the assertion that "other approaches need to be tried and discussed in the literature."

### *Initiative*

The significance of students' ability to take the initiative to seek out solutions and answers to problems should not be underestimated. Initiative may be a concept more easily defined, yet difficult to teach. An instructor cannot completely assess a student's understanding with assignments and tests alone due to the many factors which may influence test scores (mental and physical condition of student, amount of time preparing for assignments and tests, etc.). If students do not show initiative, the learning process may not produce the full potential of the process. Yet, given the importance of student initiative, it is surprising that the scholarly research is minimal.

### *Transfer*

An important component of engineering competency development is the ability to extend what has been learned in one context to other, new contexts. This ability is known as transference, or transfer of knowledge and skills (Dym, Agogino, Eris, Frey, and Lei)<sup>4</sup> and (Byrnes)<sup>3</sup>. The inability to transfer between problems is a significant cognitive difficulty that can have a profound effect on successful learning. The inability to transfer is frequently marked by functional fixedness, the perception that a particular object or concept has only one use. According to Keller<sup>6</sup>, functional fixedness handicaps the transfer process since "successful transfer may require seeing a familiar concept or procedure in a new way."

The transfer of acquired knowledge is essential for critical thinking and problem solving. The researcher van Gelder<sup>13</sup> asserts that critical thinking is especially vulnerable to the problem of transfer because critical thinking is intrinsically general in nature, i.e., the skills apply in a wide range of contexts. "The closest thing we have to a solution to the transfer problem is the recognition that there is a problem that must be confronted head-on" claims van Gelder<sup>13</sup>.

Likewise, problem solving research has consistently found that students have a great difficulty applying concepts and principles discussed in texts and lectures. The transfer of knowledge often remains hidden from students because instructors normally use transfer skills automatically and fail to emphasize them in lectures (Grossman)<sup>5</sup>. Scholars have suggested various methods for helping students learn to transfer problem solving skills (Grossman)<sup>5</sup>. It is generally agreed that students do not have the necessary skills as they begin their post-secondary education and there is a need to develop procedures and teaching techniques to help students learn to apply what they are taught.

### **Statement of the Hypothesis**

The curriculum of the Capstone Design course will:

- enhance the problem solving traits in the students
- enhance the critical thinking traits in the students
- enhance the initiative traits in the students
- enhance the transfer traits in the students

## **Design and Methodology**

The subjects in the study are seniors majoring in Engineering Technology who are required to develop a proposal, construct an item, and demonstrate its function.

The instruments utilized in both the pre-test and post-test are:

1. Tests of Adult Basic Education, Form 8, Level D.
2. Cornell Critical Thinking Tests, Level X and Level Z.
3. Trainers Assessment of Proficiency.
4. Achievement Motivation Profile.
5. Open-ended self assessment post test survey.

## **Procedures**

In the beginning of the Fall Semester, the students will be given four pre-tests designed to measure problem solving, critical thinking, initiative, and transfer. Then the students will be exposed to the Engineering Technology curriculum, teaching strategies of the course, and the instructors. At the end of the Spring Semester, the students will be given the same four tests to measure their progress in each of the four areas.

The individual's profile scores of the pre-test and post-test will be compared and the results will be reported to each student in accordance with the Buckley Amendment guidelines. At a class meeting each student will be given an open-ended survey in order for him/her to indicate what aspects of the course influenced the differences between his/her pre-test and post-test.

Professional educators from the Schools of Education and Business will administer both the pre-tests and the post-tests and conduct the survey in order to protect the confidentiality and anonymity of the subjects and the responses. They will be the only ones with access to the pre-test and post-test scores, and will code the raw data for each test.

The technology faculty will use the data as feedback for the continued assessment of the program's course curriculum. Researchers from the Schools of Education and Business will utilize the findings of the study to determine the effect of internships on the four traits.

## **Methods of Data Analysis**

Individual scores on the pre-test will be compiled using a Pearson correlation of performance based on Z and T-scores. Individual scores on the post-test will be compiled using a Pearson correlation of performance based on Z and T-scores and measures of central tendency will also be calculated and charted as they were on the pre-test. The data and responses on the student self assessment will be compiled and presented to the Chairman of Engineering Technology after the grades are submitted to the Registrar. This time schedule is a two semester assessment of the merits of the Capstone Design course.

## Summary

This study is valuable in that it will yield objective and subjective factual data gained from the Capstone Design course. In order for a department to meet the competencies that industry desires in engineering technology graduates, a program must constantly assess its curriculum components and the faculty who are responsible for instilling these competencies. Since the Capstone Design course is the culmination of the courses, the student must utilize the skills and the knowledge gained in previous courses. This study has allowed one Engineering Technology department to begin an on-going yearly assessment of the quality of its instruction. From this modest start, growth is sure to be made in both the department and the quality of instruction of the students. This research will inspire other areas of study at the university to take an objective look at the programs that lead to both ABET and NCATE continued accreditation.

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