AC 2007-399: ASSESSMENT RESULTS OF A SENIOR DESIGN CAPSTONE COURSE

Mysore Narayanan, Miami University

DR. MYSORE NARAYANAN obtained his Ph.D. from the University of Liverpool, England in the area of Electrical and Electronic Engineering. He joined Miami University in 1980 and teaches a wide variety of electrical, electronic and mechanical engineering courses. He has been invited to contribute articles to several encyclopedias and has published and presented dozens of papers at local, regional , national and international conferences. He has also designed, developed, organized and chaired several conferences for Miami University and conference sessions for a variety of organizations. He is a senior member of IEEE and is a member of ASME, SIAM, ASEE and AGU. He is actively involved in CELT activities and regularly participates and presents at the Lilly Conference. He has been the recipient of several Faculty Learning Community awards. He is also very active in assessment activities and has presented more than a dozen papers at various Assessment Institutes. His posters in the areas of Bloom's Taxonomy and Socratic Inquisition have received widespread acclaim from several scholars in the area of Cognitive Science and Educational Methodologies. He has received the Assessment of Critical Thinking Award twice and is currently working towards incorporating writing assessments that enhance students' critical thinking capabilities.

Ronald Earley, Miami University

Assessment Results of a Senior Design Capstone Course

Abstract

In *Review of Educational Research,* published by the National Institute for Science Education of Madison, Wisconsin,   Springer, Stanne & Donovan report on a meta-analysis conducted during 1998-1999.   In their paper entitled *Effects of small-group learning on undergraduates in science, mathematics, engineering and technology,* they conclude that small-group learning promotes greater student achievement, increases retention in courses, and promotes favorable attitudes toward the course material. (Springer, Stanne, & Donovan, 1999).   Sharan & Sharan also stress the importance of cooperative learning methods incorporated into the traditional classroom and recommends group investigation. (Sharan & Sharan, 1994).   Many educators believe that in order to lead in a postmodern world, students need flexibility and problem-solving skills more than they need to master any particular body of information (Saxe, 1988; Senge, 1990; Sims, 1995).   In this short paper the authors describe how the above principles have been successfully utilized to conduct the *Senior Design Capstone Course.* This is a very short paper and mainly focuses on the mechanics of assessment.   The authors also provide results of assessment documentation and offer suggestions for continuous quality improvement.

Introduction

Traditional methods of instruction may not be very resourceful in service learning courses pertaining to engineering disciplines.   Student learning styles are completely different and instructors have to accommodate new and different learning strategies (Schmeck, 1988).   The instructor responsible for Senior Design Capstone course is charged with the responsibility of creating an active learning environment.   The instructor may have to utilize some innovative modern technology to design develop and present interactive lecture demonstrations (Sokoloff & Thornton, 1997).   Herein the instructors should utilize Silberman's guide.   He offers several suggestions in his famous book, *Active learning: 101 strategies to teach any subject* (Silberman, 1996). Tom Angelo and Patricia Cross have provided a number of exhaustive and detailed methods as to how classroom assessment can be effectively carried out (Angelo and Cross 1993).   Anthony Grasha (1990) has compared traditional versus naturalistic approaches to the assessment of learning styles and comments about the benefits they offer.   Grasha's 1996 book, *Teaching with Style,* offers an innovative and user-friendly guide to enhancing teaching and learning processes. Further, it provides a unique and comprehensive approach to helping college faculty in all disciplines enhance the quality of their teaching.

New Paradigm

Clifford Young and Laura Young of California State University, San Bernardino argue that a new paradigm for assessment must be constructed to measure the success of new kinds of educational practices.   Their research involved comparing students'

responses to a selected course when taught in two different methods. Young and Young used two survey instruments, the Instruction Model-Learning Model Questionnaire (IMLMQ) and the Student Evaluation of Teaching Effectiveness (SETE) and concluded that neither instrument effectively measured the kinds of learning that needs to be effectively promoting a learning paradigm (Young & Young, 1999). One must recognize the fact that assessment practices throughout the country are in a state of rapid transition. The main goal is to make a difference in the quality of student learning and to help the local civic community whenever appropriate (AAHE Assessment Forum, 1992). Furthermore, it is important to assess this difference *and* document it. Newer assessment practices are being developed and are intended to be more authentic, that is, to involve students in the actual or simulated performance of a task (Linn, Baker, & Dunbar, 1991). Susan Brookhart also discusses the implications of the Art and Science of Classroom Assessment and stresses that instructors should not fail to notice the *missing part of pedagogy* (Brookhart, 1999). However, it is very important to recognize the fact that assessing student learning in these Senior Design Capstone courses presents new problems for the instructor (Magill & Herden, 1995). It is no longer possible to equate the process of education with the product (Barr & Tagg, 1995) and thus to assess learning by giving multiple-choice tests on content. Students wonder whether they are learning anything that actually will serve them in the workplace. It is well known that there is a need to document the successful nature and effectiveness of outcome assessment.

Need and Necessity

The Accreditation Board for Engineering and Technology (ABET) mandate and require a Senior Design Capstone course as a part of the four-year Engineering or Engineering Technology curriculum. The regional campuses of Miami University have been offering Associate Degree Programs in Mechanical and Electrical disciplines for a long time. Over the last decade, the decision was made to offer four-year engineering technology programs in electromechanical as well as mechanical disciplines. As a result, the Department of Engineering Technology had to design and develop an yearlong four credit hour, two-semester course entitled ENT 497- 498. This was accomplished in 1996, and was designed to conform with the requirements of ABET. (Narayanan, a, b, c, d, e). Later, the Liberal Education Council of Miami University recognized this sequence as an approved Miami University Capstone (MPC) Experience. The actual Miami University Catalog description of the newly designed course is given below:

Miami University Catalog Course Description

MPC 497-498 Senior Design Project (2, 2): Student teams conduct major open-ended research and design projects. Elements of the design process including establishment of objectives, synthesis, analysis, and evaluation are integral parts. Real-world constraints such as economical and societal factors, marketability, ergonomics, safety, aesthetics, and ethics are also integral parts.

497: feasibility studies performed;
498: implementation, testing, and production of design. Includes guest lecturers, team presentations, team building sessions, team meetings, and guided discussions relating to design. The course consists of continuous interaction with faculty and outside professionals. Prerequisite for this course are: senior standing in engineering technology or permission of instructor.

The Development Phase

The first 2-credit hour course, *ENT 497* is normally offered during the fall semester and mainly focuses on exploring various possibilities that may be available to the student group.   New horizons and different venues may offer challenging   opportunities for the Senior Design Project students.   In addition to conducting the necessary feasibility studies, the students are also required to effectively participate in a set of guest lectures and discussions that mainly focus on nine important aspects. Effective participation includes successful completion of relevant homework assignments and submission of appropriate research report. (Narayanan, 1994-2004).

The final 2-credit hour course, that follows *ENT 497* is *ENT 498, and* is normally offered during the spring semester.   This course is mainly devoted to completing the chosen project successfully.   It primarily focuses on design, development, fabrication, testing, and production of a prototype design.   In other cases it may devoted to the actual implementation and execution of the project.

Alexander Astin,   Eyler & Giles,   Honnet & Poulsen, and several other researchers have indicated that service to a community adds value to the learner's educational objectives and accomplishments. (Astin, 1982, 1993, 1996, 1999; Eyler & Giles, 1999;   Honnet & Poulsen, 1989).   Furthermore, it is quite apparent that students learn best when they are provided with an opportunity to utilize their knowledge to help a select community. Some student groups may choose this track. They may take up a Senior Design Project that is oriented towards helping a community project or a high school robotics competition.   Regardless, it will be oriented towards Engineering and Applied Engineering Technology (Johnson and Johnson, 1981).   For example, the community project may involve building a small bridge across a creek.   The success of the project is evaluated three-fold. Appendix A, Appendix B, Appendix C, Appendix D and Appendix E indicate how the project is graded, assessed and evaluated.

Evaluation

The first stage consists of a self-evaluation in the form of a *reflective essay.*   Each student member of the group is required to prepare and submit a separate, individual,   4 to 5-page write-up explaining his or her experience over the four credit hour course.   The student members are expected to identify their contributions as well as comments on the contribution of fellow members of the particular group in question   (Edgerton, Hutchings, & Quinlan, 1991; Forrest, 1990;

Cerbin, 1994).   They are also expected to discuss merits and demerits of the project in additions to strengths and weaknesses of the team members   (Cambridge and Williams, 1998). This is of course evaluated by the instructor and contributes towards the overall grade for the course (Nelson, 1989, 1991 November, Perry, 1970, 1981, 1984).

The second stage consists of external evaluations.   Several different questionnaires have been generated and utilized to obtain feedback from external reviewers and judges on a variety of aspects of the Senior Design Project   (Appendix B, C, D & E). Their comments are again consolidated and tabulated. These may be recorded, reviewed, evaluated, graded or assessed.   (Likert 1932).   These evaluations are based on a review of the Project Design Notebook, Course Portfolio, Oral presentations, and project display.   This also will be graded and subsequently contribute towards the students overall grade for the course.

Finally, the Senior Design Project Report and Portfolio is also examined in detail and graded by the instructor. The instructor assigns different *weights* for each component of the project (Group Dynamics, Member participation, Maintenance of Log Book, Mathematical rigor, Conforming to the principles of Liberal Education, Miami Plan Component, Technical expertise, English composition, etc.) and determines the overall grade based on these data.

This capstone course is taken by the student groups in their senior year.   They are expected to incorporate their four-year college learning experience in a productive manner.   As such, the senior design project provides the instructors with various assessment data.   Over a period of time, it is possible to consolidate these in a systematic manner. Regardless, even with one student group, it is possible to gather, record, review and report assessments. These seniors may reflect on their educational objectives and may be able to provide constructive feedback to the department and the university as a whole.   The department and faculty may be able revise and remodel their curriculum structure.   A *partial* list of possible assessment areas is given below:

1.   Assessment of oral project presentation.
2.   Assessment of written project report.
3.   Assessment of written communication skills
4.   Assessment of the principles of *Miami Plan for Liberal Education.*
5.   Assessment of reflective essay.
6.   Assessment of instructor or project mentor.
7.   Assessment of the course in general.
8.   Assessment of the entire curriculum structure.
9.   Assessment of educational goals and objectives.

Analysis and Conclusions

In this short paper, only one item is dealt with in greater detail with respect to analysis and conclusions. The other characteristics can be assessed in a similar fashion. The first item on the above mentioned list is selected for detailed analysis.

<u>#1: Assessment of oral project presentation</u>

Appendix B shows the rubric used for assessing oral project presentations.
Appendix C shows a sample how oral project presentation was assessed.
Appendix D shows a consolidated summary of assessment of oral project presentation for student group X.

It can be seen that this particular group X did an excellent job of providing the problem statement. They clearly defined their goals and objectives. They also explained the constraints within which their project was to be carried out and completed. (Item # 1 on the Chart records *Likert Scale Mode Value* 5).

Furthermore it can be seen that this student group X was very professional in their approach and delivered their presentation with very good clarity. Their etiquette was highly regarded and their audio-visual aids were also of very high quality. (Item # 12 on the Chart records *Likert Scale Mode Value* 5).

On the other hand, they could have done much better in four areas. All these recorded Mode Value of 3 on Likert Scale.

11: "Suggestions for future work, outlining ideas for other projects."
9: "Data analysis, calculations, assessment and conclusions."
5: "Technical expertise, utilization of resources and knowledge."
4: "Modeling, application of engineering science and mathematics."

In the future, the project mentor or faculty member could watch for these signals from other student groups and probably would be able to guide them towards improvement and accomplishment of their goals and objectives more effectively.

Finally this particular group recorded an acceptable mode value of 4 on Likert Scale in 6 other areas.

2: "Literature survey, feasibility studies, evaluation of hypothesis."
3: "Documentation of the use of engineering methodologies."
6: "Gantt charts, Fishbone diagrams, Statistical data, Graphs."
7: "Relationship to other courses, combining pre-requisites."
8: "Cost-benefit analysis, consideration of different solutions."
10: "Group dynamics, brainstorming sessions, teamwork."

It will be excellent if all student groups can accomplish mode value of 5 in all the 12 areas, however this may be unrealistic. It should also be noted that the above mentioned example is valid for student group X only. Another student group, for example Y may record a chart that may be significantly different than the one shown in the above example. There may be a variety of reasons for the deviation. Examples include complexity of the project, group dynamics, non-availability of funds and resources, improper guidance, etc.

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http://www.idea.ksu.edu/

http://www.abet.org

APPENDIX A (Source: http://ent.ham.muohio.edu/ent%20497%20498)

SENIOR DESIGN PROJECT: Assessment of Written Project Report

Project Name and Names of Students

Graded by: Instructor/Project Mentor/Industrial Advisor

Grading Details	Maximum Points Possible
Title Statement, Table of Contents, Goals and Objectives	12
Weekly Journal, Narrative, Descriptive Details	30
Scope, Design Methodology, Adherence to Miami Plan (Appendix C)	30
Documentation of Findings, Comparison to Expected Results	30
Conclusions, Remarks, Comments, Recommendations for future work	30
References, Appendices, Charts, Diagrams, Pictures and Drawings	18
Use of Engineering Analysis, Mathematics, Derivations and Equations	30
Individual Student's Contributions, Quality of Participation, Teamwork	30
Reflective Essay about the project and its impact on educational objectives	30
Successful Completion of the desired project and Effective Demonstration	30
Oral Presentation of completed project (Evaluation from Appendix B & C)	30

Grand Total	300

Percentage grade earned by the student will be based on 300 Points.

LETTER GRADE DEFINITION:

The students are to be evaluated on classroom participation,
project write-up and presentation, homework assignments and examinations
using the standard letter grading system as follows:

A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
100> X 97	>93 X 96.9	90> X <92.9	87> X <89.9	83> X <86.9	80> X <82.9	77> X <79.9	73> X <76.9	70> X <72.9	67> X <69.9	63> X <66.9	60> X <62.9	<60

SENIOR DESIGN PROJECT: Assessment of Oral Project Presentation

Participants recording assessment data:

External Judges, Selected faculty members, Industrial Advisors,
Project mentors, Invited experts, Peers

Assessment of the entire group and not individual student.

Senior Design Capstone Courses Assessment of Oral Presentation	5 Strongly Agree	4 Agree	3 Undecided	2 Disagree	1 Strongly Disagree
1 Problem statement, definition and specifications of constraints					
2 Literature survey, feasibility studies, evaluation of hypothesis					
3 Documentation of the use of engineering methodologies					
4 Modeling, application of engineering science and mathematics					
5 Technical expertise, Utilization of resources and knowledge					
6 Gantt charts, Fishbone diagrams, Statistical data, Graphs					
7 Relationship to other courses, combining pre-requisites					
8 Cost-benefit analysis, consideration of different solutions					
9 Data analysis, calculations, assessment and conclusions					
10 Group dynamics, brainstorming sessions, teamwork					
11 Suggestions for future work, outline of ideas for other projects					
12 Presentation clarity, etiquette, visual aids and professionalism					

SENIOR DESIGN PROJECT: Assessment of Oral Project Presentation

A sample of how assessment was administered

Assessment Recorded by: A Selected Peer

Assessment of the entire student group X and not individual student.

Senior Design Capstone Courses Assessment of Oral Presentation	5	4	3	2	1
Student Group # X	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1 Problem statement, definition and specifications of constraints	√				
2 Literature survey, feasibility studies, evaluation of hypothesis		√			
3 Documentation of the use of engineering methodologies		√			
4 Modeling, application of engineering science and mathematics			√		
5 Technical expertise, Utilization of resources and knowledge		√			
6 Gantt charts, Fishbone diagrams, Statistical data, Graphs	√				
7 Relationship to other courses, combining pre-requisites			√		
8 Cost-benefit analysis, consideration of different solutions	√				
9 Data analysis, calculations, assessment and conclusions		√			
10 Group dynamics, brainstorming sessions, teamwork	√				
11 Suggestions for future work, outline of ideas for other projects			√		
12 Presentation clarity, etiquette, visual aids and professionalism	√				

SENIOR DESIGN PROJECT
Consolidated Summary of Assessment
Oral Project Presentation for the student group X

Participants recording assessment data:

External judges, Selected faculty members, Industrial advisors,
Project mentors, Invited experts, Peers

Assessment of the entire student group X and not individual student.

Summary using "Mode" Likert Scale (1 to 5)

SENIOR DESIGN PROJECT: **Addressing the principles of**
Miami Plan for Liberal Education

Participant: Individual Student (*Self-reflection*)
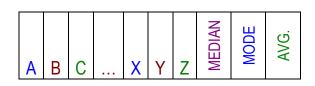
LIKERT SCALE ANALYSIS

Senior Design Capstone Courses
Assessment of Miami Plan Objectives

Source: http://ent.ham.muohio.edu/ent%20497%20498

Student # A

		A	B	C	...	X	Y	Z	MEDIAN	MODE	AVG.

I **CRITICAL THINKING SKILLS : This course has :**

		A	B	C	...	X	Y	Z	MEDIAN	MODE	AVG.
1	enhanced my abilities to think critically.										
2	assignments designed to sharpen critical thinking skills.										
3	stressed logical thinking and not just memorizing.										
4	problem solving techniques that utilize critical thinking.										
5	writing projects that encourage critical thinking.										

II **UNDERSTANDING CONTEXTS : This course helped me :**

		A	B	C	...	X	Y	Z	MEDIAN	MODE	AVG.
6	understand the positive and negative consequences of a design.										
7	appreciate some of the ethical issues faced by engineers.										
8	determine the cost/benefit analysis of a design project.										
9	rationalize the manner is which design engineers think and act.										
10	become sensitive to the consequences of implementing a design.										

III ENGAGING WITH OTHER LEARNERS : This course has :

11	class activities to promote engaging with other learners effectively.									
12	improved my ability to work and solve problems with other learners.									
13	stressed the importance of group work for engineers.									
14	helped me learn things I did not know by working with my peers.									
15	helped me to improve my communication and listening skills.									

IV REFLECTING AND ACTING : This course :

16	is structured so that I can reflect upon the concepts I have learnt.									
17	helps me to reflect upon the concepts & apply them judiciously.									
18	helped me understand the need to reflect before implementation.									
19	helped me account for multiple aspects of an engineering design.									
20	helped me to reflect before acting in other areas of my life as well.									

V CHARACTERISTICS WAYS : This course has me understand :

21	the need for problem definition, before actually solving it.									
22	the advantages of well-structured design methodologies.									
23	the importance of meeting users needs while designing a project.									
24	the safety rules and O.S.H.A. regulations in design practice.									
25	the value of logic and the power of reasoning.									