AC 2008-306: INNOVATION VERSUS ANALYSIS

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Innovation versus Analysis
A Case Study in Improving Technology Courses

Abstract

But a few years ago educators were dealing with the implementation of outcomes based accreditation. The Accreditation Board for Engineering and Technology (ABET) started this process with the TC2k criterion in 2000. Since then, other accrediting bodies have also gone to outcomes based assessment. In the intervening years, educators have learned about strategic plans, goals, objectives, outcomes, and a host of other terms. Many faculty and administrators went through periods of confusion, doubt, and even anxiety over outcomes based assessment. Now that there is a general understanding of the process, it seems fair to "assess" outcomes based assessment and see if it delivers what it promises - improved education.

This paper examines the seemingly widely different areas of Computer Graphics Technology and Mechanical Engineering Technology and finds notable similarities in the assessment techniques used. The paper then examines historical assessment data from a course in each area and looks at how the improvements came about. The authors noted many improvements based on the assessment data; however, the most significant changes with the most impact on the students came from innovation, not assessment. So, while assessment plays a key role especially in incremental improvements, innovation still plays an enormous role in improving courses.

I. Introduction

Prior to the 2000 paradigm shift, ABET accreditation was referred to as a "recipe"[1]. Unfortunately, the ingredients of the recipe were never mixed. Imagine placing eggs alongside flour, sugar, butter, and baking soda in a pan next to each other and expecting a cake to result. As educators, that was our response to the old ABET criteria. We simply created a course for each required topic and said the result was an engineer or technologist. Of course, that method did not work well, and many educators recognized that fact. At Purdue University Calumet, the faculty has spent the intervening years learning how to incorporate outcomes based assessment into courses and programs. Even non-accredited programs are going through this same process since most institutional accreditation requirements used to accredit colleges and universities by the Higher Learning Commission (HCL) of the North Central Association of Colleges and Schools (NCA) and other regional associations have gone to outcomes based assessment [2].

One of the first courses converted to outcomes based assessment at Purdue University Calumet was MET 461, Computer Integrated Design & Manufacturing. The initial efforts in this area were published by Higley[3]. Follow on work in Computer Graphics Technology (CGT) was published by Colwell, et. al [4]. Since that time, we have collected considerable data from these and other courses, including the relatively young CGT program. We have found outcomes based assessment very useful for improving courses in some, but not all areas. The remainder of this paper examines our experiences in two courses, MET 461 and CGT 351, Interactive Multimedia Design.

II. Pedagogical Issues

Course Structures: MET 461 is a senior level course in a relatively small program. CGT 351, however, is junior level course in a program of more than 200 students. Although the sizes of the programs vary dramatically, class sizes for both courses tend to be small, usually under 20. This small class size provides tremendous flexibility in course structure, but larger courses should be adaptable with teaching assistants and reasonable lab sizes. Both MET 461 and CGT 351 are structured around a 15 week semester. The original structures for both MET 461 and CGT 351 are shown in Table I and Table II:

Table I - Topics in MET 461

Topic	**Allotted Time**
Parametric modeling	8 weeks
Introduction to rapid prototyping	1 week
Introduction to finite element analysis	2 weeks
Introduction to CAM	2 weeks
Design project	2 weeks

Table II - Topics in CGT 351

Topic	**Allotted Time**
History of Multimedia	1 week
Complex Multimedia Project Design	4 weeks
Interface Design	2 week
Interactive Design	3 weeks
Group Design Project	4 weeks

Teaching Methods: Senior level students in MET 461 should be capable of learning on their own, and the instructor encourages that with his teaching methods. Each week, the instructor demonstrates the current topics while the students observe. The students are encouraged not to take detailed notes, but to observe the process and take rough notes on major characteristics. Then, the students carefully read the instructions in the texts and tutorials and perform the exercises themselves. The instructor then answers individual questions and occasionally interjects comments the whole class might find useful. As one might expect, some students work

much more quickly than others and need little attention. The instructor is then free to assist the slower students. In the class sizes mentioned, this has proven to be an efficient teaching method as high grades on exams indicates. For the reasons stated above, this course has been well suited for the studio format of teaching. All projects are performed in groups of 2-3 students.

Regarding CGT 351, junior level students are coming into the course with a strong foundational knowledge of computer graphics techniques in digital illustration, design and print production. The elements and principles of visual communication are well established in students as it relates to static media. Weekly lectures and demonstrations in CGT 351 introduce students to the core concepts of designing for interactive applications and screen based media. Students are required to perform exercises and demos from required texts to re-enforce material presented in class. The instructor supports the individual pace of student learning by taking on the role of mentor, rather than that of an educator. Students are allowed to investigate topics in a variety of ways; however, unlike MET 461, this is closely monitored by the instructor. The effects are as varied as the students. Some find the self-guided approach frustrating and need significant mentoring. Others excel and progress at varying rates. This method of teaching has been effective in identifying the array of talent and technical abilities of each individual student. In turn, this aids in the formation of diversified student groups for the final projects by allowing stronger students to benefit weaker ones. Evidence of this result in exhibited in the quality of student's final group projects overall.

Course Assessment Methods: MET 461 was one of the first at Purdue University Calumet to use the three-page assessment technique detailed by Higley [3] and Colwell, et. al[4]. This method took several years to develop and has undergone many revisions. These techniques were acceptable in our 2005 ABET visit. The first of the three pages includes instructor and student assessment of course objectives as shown in Table III; the second page of the course assessment contains the student evaluation of the related ABET criteria as shown in Table IV; and the final page of the assessment records changes as shown in Table V. CGT 351 follows the exact format as MET 461, only with different program objectives and course embedded assessments.

Table III - MET461 Course Assessment Page 1

MET461 Comp Integr Dsgn & Mfg Course Assessment Tool – Instructor and Student Course Objective Assessment

Semester: Fall 2007 | **Instructor: Higley**

Course Objective	Supported Criterion	Supported Related Outcome	Course Embedded Assessment of Student Performance						Student Evaluation (%)					
			Assessment Tool 1	Score (%)	Assessment Tool 2	Score (%)	Assessment Tool 3	Score (%)	E	G	A	P	NA	Composite
1. Explain the use and applications of parametric design and finite element analysis (FEA).	a	4.1 BS Technical Proficiency	Midterm Terminology	82.5					64	36	0	0	0	**4.6**
	b													
2. Document engineering designs through written and/or oral communication.	a	4.1 BS Technical Proficiency	Semester Projects	86					45	55	0	0	0	**4.5**
	b													
3. Explain the use and applications of computer aided manufacturing (CAM) systems.	a	4.1 BS Technical Proficiency							45	27	18	0	9	**4.0**
	b													
4. Use parametric design, FEA, and CAM systems to design, analyze, and manufacture mechanical components.	c	4.1 BS Technical Proficiency	Semester Projects	86	Midterm Computer	95	Final Exam Design	91	45	55	0	0	0	**4.5**
	d	4.3 BS Computer Applications												
	k	4.4 BS Open-ended Problems												
Instructor Comments for needed changes: The objectives are covered thouroghly. We didn't do ProManufacture this semester because we spent so much time on design projects.									Number of responses: 11					

ABET a-k Criterion

a. an appropriate mastery of the knowledge, techniques, skills, and modern tools of their disciplines,

b. an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology,

c. an ability to conduct, analyze, and interpret experiments and apply results to improve processes,

d. an ability to apply creativity in the design of systems, components, or processes appropriate to program objectives,

e. an ability to function effectively on teams,

f. an ability to identify, analyze, and solve technical problems,

g. an ability to communicate effectively,

h. a recognition of the need for, and an ability to engage in lifelong learning,

i. an ability to understand professional, ethical, and social responsibilities,

j. respect for diversity and a knowledge of contemporary professional, societal, and global issues,

k. a commitment to quality, timeliness and continuous improvement.

MET Program Educational Program Outcomes

1.1.Students will demonstrate proficiency in mechanical design, materials, manufacturing processes, mechanics, and fluid power. (a, b, c, d, f)

1.2.Students will demonstrate proficiency in applied mathematics and science. (b, c, f)

1.3.Students will demonstrate proficiency in computer applications. (a, d, g)

1.4.Students will demonstrate proficiency in solving open-ended problems requiring multiple areas of knowledge. (a, b, c, d, f)

2.1.Students will demonstrate a level of effectiveness expected by employers when they produce written documents, deliver oral presentations, and develop, prepare and interpret visual information. (a, g, i)

2.2.Students will be exposed to the value of professional societies in their careers. (h)

2.3.Students will demonstrate proficiency in managing projects. (e, f, g, i, j)

2.4.Students will understand the advantages of self-learning. (h, k)

3.1.Students will have exposure to situations that develop a sense of personal responsibility and accountability for one's individual actions and performance. (i, k)

3.2.Students will have exposure to situations that develop their philosophy and appreciation for human differences. (i, j)

3.3.Students will be able to demonstrate the ability to communicate in individual and team settings. (e, g)

3.4.Students will demonstrate proficiency in assisting others in a group. (e, g)

4.1.Students will demonstrate proficiency in mechanical design, materials, manufacturing processes, mechanics, fluid dynamics, and heat and power.(a, b, c, d, f)

4.2.Students will demonstrate proficiency in applied mathematics and science.(b, c, f)

4.3.Students will demonstrate proficiency in computer applications.(a, d, g)

4.4.Students will demonstrate proficiency in solving open-ended problems requiring multiple areas of knowledge.(a, b, c, d, f)

Table IV - MET461 Course Assessment Page 2

MET461 Computer Integrated Design & Mfg Course Assessment Tool
MET Program Educational Outcome Assessment

Instructor: Higley | **Semester: Fall 07**

Educational Program Outcome	Student Evaluation (%) E	G	A	P	NA	Composite	Evidence that Supports the Educational Program Outcome
2.1 Students will demonstrate a level of effectiveness expected by employers when they produce written documents, deliver oral presentations, and develop, prepare and interpret visual information.	36	36	18	0	9	**3.9**	A report and presentation is required for the semester project.
2.3 Students will demonstrate proficiency in managing projects.	36	36	27	0	0	**4.1**	The students decide how to handle the project.
2.4 Students will understand the advantages of self-learning.	64	27	9	0	0	**4.6**	The course is intentionally set up so the students teach themselves much of the material.
3.1 Students will have exposure to situations that develop a sense of personal responsibility and accountability for one's individual actions and performance.	64	27	9	0	0	**4.6**	"
3.3 Students will be able to demonstrate the ability to communicate in individual and team settings.	45	36	18	0	0	**4.2**	A report and presentation is required for the semester project.
3.4 Students will demonstrate proficiency in assisting others in a group.	45	45	9	0	0	**4.3**	The students work together in fulfilling 2.4.
4.1 Students will demonstrate proficiency in mechanical design, materials, manufacturing processes, mechanics, fluid dynamics, and heat and power.	40	50	10	0	0	**4.3**	This is primarily a design course with some manufacturing processes and mechanics.
4.2 Students will demonstrate proficiency in applied mathematics and science.	36	45	18	0	0	**4.1**	Finite element analysis is applied science and math.
4.3 Students will demonstrate proficiency in computer applications.	36	55	9	0	0	**4.3**	The entire course uses computers.
4.4 Students will demonstrate proficiency in solving open-ended problems requiring multiple areas of knowledge	36	64	0	0	0	**4.4**	The project and the final are open-ended.

Instructor Comments: Since this is the senior level MET design course, the high scores are expected and appreciated. It seems the course covers most outcomes very well.

Table V - MET461 Course Assessment Page 3

MET461 Instructor Update Information			
Date Submitted: 12-14-07		**Date to be Reviewed: 08-15-08**	
Responsible faculty for the review: Higley			
Type of Update			
☐ New Edition of the Text	☐ New Text Adopted	☐ New Software	☑ Teaching Method
☐ New Laboratory Equipment	☐ Lab Material Update	☐ Teaching Initiative	☐ Other
Description of Condition Prior to / After Update: I changed the order of the course to introduce FEA much sooner. I increased the number and complexity of open ended projects. The students seem to have a much better understanding of stress analysis now. I'll continue this format next time.			
Assessment Method Used to Evaluate Short or Long Term Results: I finally figured out how to get them to read - make the tests open book. They will then read the text to answer the questions.			

III. Evaluation of Results in MET 461

Currently, we have six years of assessment data on MET461. Each year the faculty evaluate the assessment results and decide what action should be taken to improve the course. In these six years, several items became evident:

1. The textbooks must match the software version being used in the course. Mismatched text and software versions cause considerable confusion to the students.
2. These students rarely read information sections of the textbooks. Test results confirm this. The simple solution that took many years to discover was simply giving open book tests. The students learn the material during the test if they do not already know it.
3. After significant course projects, a final exam is not needed, and the time can be better spent on open-ended projects.

Hence, assessment and evaluation of the assessment results has definitely improved the course. The students consistently rate the course objects as being met very well (typically >4 out of 5).

However, these are not the only changes that have come about during the last six years of MET461. The course schedule has changed considerably as shown below in Table VI:

Table VI - MET461 Current Structure

Topic	**Allotted Time**
Parametric modeling	6 weeks
Introduction to finite element analysis	2 weeks
Introduction to CAM	1 week
3 Open-ended Design projects	6 weeks

As originally taught, the course spent half the semester on solid modeling, several weeks on finite element analysis, and then performed one open ended project. After teaching this course several times, the instructor decided the design and analysis portion of the course was more important than the small nuances of solid modeling. Hence, finite element analysis is introduced in the fourth week instead of the ninth week, and projects are implemented much sooner in the course as well. This gives the students more time working in groups and experiencing the creative design process rather than simply reproducing solid models. The authors find it somewhat satisfying to hear students discussing each other's finite element convergence graphs and how to improve them when just a few weeks earlier they did not know what a convergence graph was. Many students go on to use these techniques to good effect in their senior design courses.

When reviewing changes made to MET461, some incremental improvements came about through the normal assess-evaluate model. Significant changes that have greatly improved students ability in the design area came about not because of assessment techniques but upon careful reflection by the course instructor.

IV. Evaluation of Results in CGT 351

CGT 351 has been assessed using the ABET criteria over the course of two years, respectively [4]. Identical to MET 461, each year the faculty evaluate the assessment results and decide what actions should be taken to improve or enhance the course. Since January 2006, several items have become evident:

1. After significant course projects, students should write a complete scope and definition document detailing their final project from proposal to delivery.
2. Significant time needs to be allocated to applying and enhancing techniques which enable students to become more proficient with the tools and methods demonstrated in weekly lectures.
3. Introduce the tools and applications used in the course to students early to facilitate more interest in the discipline of interactive design and in turn increase group project quality and diversity in general.
4. Major exams needed to be incorporated for assessment of concepts and terminology, allowing projects and assignments to assess technical skills and methods.

Again, assessment and evaluation of the assessment results has definitely improved the course. The students consistently rate the course objectives as being met very well (typically >4 out of 5). As in the case of MET 461, CGT 351 course schedule was also changed considerably as shown below in Table VII:

Table VII – Current Topics in CGT 351

Topic	Allotted Time
Interactive Design & Production: Techniques and Individual Projects	10 weeks
Complex Multimedia: Definition and Group Project	4 weeks

In the beginning, CGT 351 focused on topics relative to the history, design and production of interactive multimedia on an overview level only. Emphasis was placed upon theoretical concepts on how to scope and define a project rather than actually designing and building one. Course assessments and student feedback indicated the course needed to be reversed and focus on techniques and project work in place of conceptual topics.

In response, the course was completely redesigned to place a stronger emphasis on techniques and applications of skills. Tools and techniques are introduced in the first week of the term, and projects are implemented in stages over the entire course. Theoretical topics were not completely abandoned, however, but incorporated into project specifications as purpose and approach

criteria. The authors now see students discussing each other's individual projects and how to improve them well before defining a large-scale group-based complex multimedia project as required in the later stages of the course.

As found in MET 461, revisions made to CGT 351 came about through the normal assess-evaluate model. Redevelopment of the course has greatly improved students ability in the production and technical areas primarily because of the integration of topics related to project-focused techniques.

V. Conclusion

Assessment and evaluation is a simple fact of technology programs now. Most faculty and programs originally found the change to outcomes based assessment difficult, but as it completes its first decade of use, most of us have accepted it and found it quite useful. Frequent assessment gives a faculty member the tools needed to find problems in a course and correct them. Based on the similar results we obtained in two widely differing courses, we maintain that assessment techniques provide a good method to incrementally improve a course. However, true innovation in a course still comes from a dedicated faculty member evaluating the course with an open mind. Assessment techniques do force faculty to consider their course more often, and perhaps this helps with innovation as well.

Bibliography

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