Assessing Innovative, Project- Based Learning In Drexel's Freshman Core Curriculum

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Introduction

Although ABET and ASEE have cited the importance of innovation in engineering curriculum development, one of the enduring challenges is their assessment. In fact, ABET's EC2000 criteria reflect the program goals initiated by Drexel's E^4 (An Enhanced Engineering Education for Engineers), a program initially funded by the National Science Foundation. That program won ABET's inaugural Award for Innovation in Curriculum Development. The Drexel Engineering Curriculum (tDEC), which grew out of the efforts of E^4, have continued to grapple with the difficult matter of assessing an innovative program which defies standard quantitative measurements. Since E^4's inception, evaluation has included quantitative analysis augmented with qualitative analysis to indicate the positive direction for growth.

The real challenge to maintaining innovation in a curriculum is to answer the question, "When the program is no longer new, by what measures should it be renewed?".

tDEC seeks to educate freshmen engineers who are not only technically proficient but well rounded, individuals who understand the societal impact of their actions. An integrated curriculum provides hands-on experiences with several projects that involve group work and holistic thinking. Because the projects are interdisciplinary team efforts, a single grade to a student or a course evaluation in one discipline fails to convey the learning experience. Quantitative assessment augmented with qualitative assessment is more likely to capture the entirety of the learning process.

While course assessment allows the institution to verify that the course meets some criteria set forth by ABET, a more comprehensive assessment tool is needed to insure the inclusion of broader goals such as life-long learning, the global and societal impact of engineering work, team work and an understanding of the multi-faceted design process. From its inception, the E^4 program actively solicited faculty and student participation in a qualitative assessment process. That culture of continuous quality improvement remains an integral part of the tDEC program. Students are encouraged to become active participants in the education and assessment processes. A weekly quality circle meeting promotes a positive, interactive venue for students, faculty and staff to share concerns and ideas. Therefore, a logical extension of the quality circle

meetings was to implement the focus group as an in-depth qualitative assessment tool. Journal analysis, which had been part of the initial evaluation of E[4], is again being instituted over the entire year.

The Focus Group - A Qualitative Assessment Tool

Focus Group Methodology

Focus group research draws upon the respondent's attitudes, feelings, beliefs, experiences and reactions about a given topic[1]. Focus groups are a form of group interviewing. The primary difference, however, between a group interview and a focus group is that the focus group relies on group interaction and dynamics as a method to generate insight and data while the group interview is simply a series of questions and responses between the researcher and the participants.

The focus group was developed in the 1940s by Merton[5] and has been used primarily in market research. In recent years, the focus group has also been used in medical research[2]. It continues to remain an under-used tool in social and educational research.

The crucial feature of the focus group is the interaction between participants. The interaction allows them to share their view of the world, the language that they use about an issue, as well as their values and beliefs about a situation. This interaction also enables participants to ask questions of each other and potentially re-evaluate and reconsider their own understanding of specific experiences[3,4].

The tDEC Focus Group

Students in the tDEC program experience some commonalities in classroom experience. The focus group format enriches and probes the reflections recorded in the journals and provides a fuller understanding of how tDEC affects the student. Student success results from a multi-faceted process including curricular philosophy, participation in learning communities, student preparedness and motivation, and an understanding of the relevance of course material to engineering applications.

Fifteen students, a representation of students who had earned both high and low academic grades in all three curriculum sequences, participated in the session. In addition to the students, team leaders from the Humanities, Physics, Calculus and Design courses also participated.

TDEC Philosophy and Curriculum Issues ~

The discussion began with a look at the question - *What are some of the characteristics of TDEC that you think of immediately if you were going to describe tDEC to a friend?*

Students shared that tDEC is an integrated curriculum which provides a sense of process and understanding. In addition, students indicated that the tDEC provided preparation for real world engineering and development of the student as a professional. All this is accomplished in a

curriculum that provides “engineering up front”. It is best summed up in following student comment, "tDEC is a way of learning; it gives a different viewpoint of engineering - you are right in there [engineering] from the beginning".

The teaching environment is structured such that courses are taught in components. Lectures provide the forum for introduction and explanation of material. Recitation and laboratory components provide a forum for application of the concepts discussed in lecture. Generally, Ph.D.- level faculty facilitates the lecture portion of the course while recitations are facilitated by either Ph.D.- level faculty or teaching assistants (t.a.'s).

Some of the students indicated that recitation was a worthwhile experience and that the teaching assistant who facilitated that section was helpful. Other students indicated that there needed to be some uniformity and training for teaching assistants.

Most students felt that they learned a great deal from the lectures. Students enjoyed the learning experience when practical examples were used to illustrate concepts. A few students indicated discontent with the faculty, citing a lack of enthusiasm in the classroom.

Student involvement in the learning process was addressed during this discussion. Several students strongly felt that faculty and teaching assistants should not be blamed for poor grades that students receive. Students, they said, need to be pro-active about their education and to participate more fully in the learning process.

Student Preparedness and Issues of Success ~

While students may enter the university with varying levels of preparedness, it is fair to say that most, if not all, students have a common desire to succeed. Success for most students is equated with good grades. The section deal with the issues of success and preparedness.

The goal of suitable academic progress generated conversation about the merit of the math placement exam. Math placement testing occurs in the spring of the student's senior year and is designed to provide the tDEC faculty with a clearer understanding of the student's readiness for a calculus-based curriculum. Students take this exam during the spring following acceptance to the university.

Students did not seem to realize the impact of the math placement examination with regard to placement within the curriculum and subsequent academic success. A few students shared that they understood the value after the fact, when it was “too late”. One student recommended that students be allowed to review the exam and subsequent placement in the curriculum with an advisor.

Summer Orientation is intended to provide students with information and provide an understanding of what to expect in the fall. Students indicated that orientation did not help them to feel more prepared. Rather, they felt that orientation was overwhelming; too much information and a lack of personal connectedness.

However, students who participated in the pre-term, materials course offered by the department of materials engineering, felt that they had a good opportunity to acquaint themselves with the campus and settle in. This course is intended to educate students about the materials engineering discipline.

Advanced placement credit is another area in which preparedness for academics at the university can be impacted. Students indicated that how placement can and should be used is not made clear to them. There needs to be a more comprehensive explanation of Advanced Placement Credits.

Regarding success in the freshman year, students had a great deal to say about examinations in the Physics, Calculus and Chemistry/Biology courses. How and when students are tested is an area of great concern. The common exam period needs to be modified; of primary concern - the time of the exams and the days of the week when exams are given. Exams are given too early on Monday morning and too late on Friday afternoons, creating problems for some students.

Of equal concern seemed to be the proximity of one exam to another. During the common exam period on Monday both a math and physics exam is given. Some students felt that the exams were given too close together. However, there were a few students who did not feel that the proximity of one exam to another to be a problem. Rather, these students expressed concern about learning concepts and not just memorizing information in order to pass the exam or quiz.

The issue of progress and attainment of student goals - primarily, the desire to do well on exams prompted a discussion on the issue of cheating. It would appear that cheating occurs on many levels.

The Learning Community ~

How does one attain success as a student? Is the student on a solitary journey or are there others who contribute to the learning community? Who are the members of the community and how does the community impact the student. Is the community created by the physical space or by the individuals in the community?

Students had divergent opinions about dorm living. Some students felt that there was a ready-made learning community in the dorms. Others indicated that there was no quiet place for students to study.

Commuter students face a different set of obstacles for inclusion in the learning community. Some students felt isolated because they could not participate in night study groups. They also felt it was harder for commuter students to know his/her professors. It does appear that the university supported commuter student lounge is a source of support and provides inclusion in the community.

The openness of the faculty as well as access to faculty via the university email system creates a community that exists beyond a typical 9:00 to 5:00 day. Students shared that there was a great deal of communication between themselves and the faculty. The faculty communicate about

grades, weekly course updates and study helps. Students who cannot access a faculty member during office hours can always contact the faculty member by email.

The Office of Student Services is another component of the learning community, although it appears from student commentary that the office needs to develop an awareness of the services, which augment the curriculum.

The freshmen meeting (Quality Circle Meeting) is yet another component of the learning community. A team - the director of tDEC, professional staff from the Office of Student services and team leaders for each of the freshmen courses - meet weekly with the students to address concerns. Students suggested that more emphasis and awareness be made regarding the value of the quality circle meeting. Some students did not appear to understand that the meeting was an open forum. Students commented, positively, that it gave them an opportunity to meet and talk with faculty on a different level.

The Internet has also become an integral component of the learning community. Students shared that the course websites provided a lot of information that enable the student to focus. It was suggested that lecture notes and quizzes from previous years be posted as "helps" for students.

Classroom Learning, Content, and Integration ~

As success weighs heavily on the mind of students, there is concern as to what they are learning in class.

The matter of course integration or rather the perceived lack of course integration is an issue. Students feel that there is no integration between the physics course and ED&L (the laboratory course). Students indicated that it would enhance the learning process if more physics concepts were integrated into ED&L.

Students also commented on learning itself; does learning occur for understanding or just to complete the exercise or exam? Overall, there is an appreciation for the learning process in ED&L. Hands-on experience is an important factor for the students, they shared that such learning prepares them for the cooperative education experience.

The freshmen design project is an intense experience, which allows students to put into practice some of the learned fundamentals. The project allows students to see relevant application of coursework. The project spans two terms and is an integrated class assignment in ED&L and Humanities. Students indicated that the experience afforded them the opportunity to learn and develop public speaking and presentation skills. In addition, being reviewed by one's peers was a key element.

Findings

The session provided a great deal of information for consideration. Following the focus group session, the Director of Student Services and the course team leaders met to debrief. It is evident that there are areas of clear concern for the program.

It appears from the insights gained during the focus group session that the program has maintained many of the original characteristics set forth in the original E^4 model. Students indicated that the primary characteristics continue to be promoted in tDEC. It (tDEC) is an "integrated curriculum" and students experience a "sense of process". The design and laboratory course introduces the student to engineering. The student feels as if he/she is "treated like an engineer". Students indicate that they understand and are able to see the integration of coursework. Students appreciate the hands-on aspect as it "helps you to get ready for a coop job - in particular, freshmen design and research are helpful". Students appear to have a deep-seated appreciation for the faculty teaching within the program; indicating that faculty are willing to help and are accessible.

While the program appears to have maintained many of the original characteristics, it is the implementation of various program aspects that are cause for concern. Continuous quality improvement is a necessity for the longevity of the program. The concerns are detailed and categorized for consideration.

Student Preparation prior to freshmen year

- A lack of understanding on the part of students as to the importance of the math placement exam with regard to course sequencing and success in the tDEC program
- A lack of understanding by students regarding advanced placement credits and how such credits may be used within the tDEC program

Cheating as it deals with academic preparation and the freshman year curriculum

- The issue of cheating; from the earliest aspect (cheating on the math placement exam) to what appears to be consistent cheating on weekly quizzes and exams as well as plagiarism in the humanities course

Course Content

- Providing a better explanation of the laboratories within ED&L

Administration of Courses and Exams

- The preparedness, reliability and effectiveness of the teaching assistant in the classroom
- The administration of the chemistry course (during academic year 1999-2000)
- Rescheduling of exam times - not conducive to have two exams on the same day; Friday afternoons and Monday mornings can be difficult for some students
- Concern about the consistency of faculty supervising the freshmen design project; providing training for those individuals

Course Integration

- The possibility of providing better integration of the physics and ED&L course [better integration of particular course topics]
- Creating a closer integration of the lecture and laboratory segments of ED&L

The Learning Community

- A need to provide a greater awareness (to both students and faculty) of the support services provided through the Office of Student Services (Curtis 261)
- Creating an awareness of the importance of the weekly Quality Circle Meeting to the students
- Creating a better method to integrate transfer students to the program

The following areas of concern involve departments or programs that are not within the realm or responsibility of the faculty and staff working within the tDEC program. Those areas of concern include:

- A need for better study space on campus
- Providing quiet space within the dorm environment
- Creation of a better climate/program for commuter students
- Creating a more cohesive orientation program that prepares a student for the fall term

The specific areas of concern that were addressed within the focus group session should be shared with the tDEC council (a team of faculty and administrators dedicated to the principles of tDEC, continuously seeking new challenges for curriculum development and delivery) the tDEC freshman teaching team (team leaders for the faculty teaching the freshmen courses) and the Office of Student Services (professional staff of collegiate administrators who support the program through advising and counseling students).

Many issues could have been better addressed with improved and consistent communication between the faculty, staff and students. The faculty and staff must be proactive in reaching students; faculty and staff must recognize that until now, many students have not considered themselves an active partner in the education process. The concept of a learning community in which students are integral members must become inherent. This learning community is critical to maintaining the principles of tDEC.

The information gained through the focus group is a valuable element in the assessment process. Continued implementation of the focus group session provides a more comprehensive view of the total program. Yearly implementation provides a benchmark by which to evaluate progress. A qualified individual within the College Administration should be assigned the task to implement a yearly focus group session. This individual should be familiar with the program and capable of interpreting the focus group comments within the curricular context, i.e., someone capable of discerning appropriate comments from "petty gripes."

The value of the focus group can already be seen in the changes that have been made since the focus group session in July of 2000. At the onset of this academic year (ay 2000-2001), many changes occurred. The administration of examinations has been changed for this year; physics, calculus and chemistry exams are now given on three separate days at 8:00 a.m. The Office of

Student Services has established a new advising system whereby students are "linked" with an advisor within the first half of the fall term to ensure that students receive advising in an accurate and timely fashion.

In addition to input from focus groups, we have been successful in gathering data from student journals that, among other things, reflect on the interdisciplinary Freshman Design Project. Faculty in Engineering, Science and Humanities interact in guiding students and in evaluating their efforts. Students bring to bear information and skills they have learned from all their courses to the Freshman Design Project. The journals record their growth and development into members of a learning community. Detailed analysis of the journals provides evidence to students and faculty alike, the importance of interdisciplinary projects in engineering.

Journals - A Formative Assessment Tool

E^4 has been recognized in the Fund for the Improvement of Post Secondary Education (FIPSE) sponsored registry of Learning Communities as an unusual model of a learning community, a community of faculty from Science, Engineering and the Humanities dedicated to educating the professional engineer. To meet the objective "Define Course Development Methodologies," the faculty must show evidence of real gain for the students who participate in complex, interdisciplinary projects and must detail strategies to build such projects successfully. The freshman design project, the cornerstone of tDEC must be validated to justify the effort expended by students and faculty from all the disciplines involved. Every year approximately 125 teams of 5 students each engage in a 15-week design project that results in grades in both Humanities and Engineering.

The cooperation needed to achieve a sense of design as process is atypical of the usual classroom experience for both faculty and students. There is no right or wrong answer and there is no single audience. The challenge for faculty from Humanities and Engineering is agree to on common goals and directives for the design project and ...and to teach students how to work successfully on teams. To assess the impact of our "learning community" we looked to formative evaluation.

Methodology

Throughout the academic year 1999-2000, student journal entries were collected to develop a formative evaluation of the design process they had been learning about in Engineering Design and Laboratory (ED&L) and in Humanities 106,107 and 108.

1. We have established a web depository for journal entries from several hundred students throughout the Freshman Design Project. This site will remain in use for further data collection in 2000-2001. Many of the journals were generated from the Humanities Manual for Hum 106 –108. They include prompts for reflection such as: (a)"How would you describe your strengths in your group? What weaknesses do you have that your group balances?" (b) "Having finished your first term in this program, what do you think is the job of an Engineer? Is it what you thought it would be when you decided to study engineering? Reflect on the similarities/differences between your expectations and the emerging reality." (c) "How do

you feel about the upcoming: (1) Final Report and, (2) Oral Presentation? What most concerns you? What steps can you take now to alleviate some of those concerns? What, in your eyes, is vital for you to get done ahead of time in order to feel more comfortable?" (d) "Now that you have completed the requirements of the Design Report, what have you learned about research and design? What would you have done differently if given the opportunity to redo the Design project?"

2. Since time for assessing the data was limited, the comments on one significant journal prompt are reported here. With ABET self study underway, the logical journal prompt to consider was "Reflect on ABET 2000 criteria and the E4 characteristics as defined by Dr. Quinn and the Boeing attributes. Do they agree with your experience here at Drexel thus far?" In week 9 the assigned reading had been "Comparison of Boeing Attributes for Engineers and the E4 Desired Characteristics" and "ABET 2000 Attributes" 108-9 *(Humanities for the Engineering Curriculum)* and "Drexel's E4 Program," by Dr. Robert Quinn found in *The Journal of Engineering Education* Vol. 82, No. 4, (October 1993): 196-202. (for the electronic version, refer to link on the TDEC web site)

3. Of the 250 journals submitted, comments were sorted into general categories. At a later time, it would be instructive to consider that 186 comments can be considered "positive," 12 "negative," 51 "mixed."

Drexel's curriculum apparently espouses the attributes described in the ABET 2000 criteria and the E4 characteristics as defined by Dr. Quinn and the Boeing attributes. Students overwhelmingly agreed that their experience at Drexel was consistent with what they had read. Overwhelmingly, students found that the design projects supported the goals of TDEC curriculum. Admittedly, they experienced troubles in getting groups to work well together, were surprised by the demand for good communication skills, and thought the workload heavier than anticipated. They also found the rewards well worth the effort. As one student said, "The freshman design project I believe is the single most important thing that we did to satisfy all the criteria of these three programs. It allowed us to experience what engineers do and that it is not just learning Math and Science but also to learn how to write professionally and to work with others."

Typical comments often note the amount of work but conclude the results are worth the effort. Sometimes comments are amusing in a disingenuous way: "I really enjoyed this experience. I believe that we learned how to manage our time and also how get together and work efficiently, being as though no one wants to be here half the night. The only bad part though was that the amount of work put in was not reflected in our reports, since we are engineers not English majors. Don't engineers pay people to do this?" Another student offered an interesting suggestion under the misconception that business students must be better writers: "I believe that the design projects should have different components. I believe that business majors and engineering majors should do the project together in a joint effort. I believe it would make the experience more realistic and we engineers would get better writing grades. Besides that we could watch what the business majors do in proposal writing and learn from them."

Of the many comments that agree that Drexel does indeed foster the attributes laid out in the ABET 2000 criteria, one is worth quoting at length:

> I feel that, yes, my experience and education has worked in conjunction with the E4 and ABET 2000 curriculum [sic]. In our intertwined classes, we have developed a shared learning style, and also have learned engineering as process through our freshman design projects, which were thankfully over as of Monday. We have also learned effective communication, since we had to do an oral presentation about all of the data we have collected over the past 4.5 months. Since Dr. Quinn's idea and vision was to better teach students engineering, starting from the very first day, I cannot think of another way to honor his memory and quest than by continuing an engineering project right at the start of the curriculum, whether it be the K'nex project or something else. I think the K'nex project and my freshman design projects have taught me more about engineering than anything else I learned this year. We learned how to function as a team, and also that there is always a set of guidelines that must be followed and met in order for a team to be successful with their design. It's been an experience, to say the least.

Faculty embarking on interdisciplinary and project-based education must be trained to work in concert and to understand the challenges that face them and the students new to the idea of satisfying multiple audiences (evaluators). Considering the issues involved in curricular change and the motivating factors, I have found that faculty want quantitative data to justify the expense of time and effort that any innovation demands. The advantage to gathering journals that reflect the students' learning experience is that we can generate numbers that show how many students are sharing certain experiences and still have the impact of the qualitative data. When faculty hear success stories they are motivated to try even small changes. And when they hear what students themselves say about the value of project-based learning they have a solid basis to continue a time consuming but worthwhile endeavor.

It is fitting that the students have the last word reflecting that the program needs to be seen in its entirety to be appreciated; students and faculty have to understand that the synthesis of an interdisciplinary curriculum takes dedication and time to achieve:

> What I also learned was that it gave me high ethical standards and flexibility when it came to communicating. And finally it gave me an understanding of how important teamwork is…. As my Humanities teacher has told me it wasn't about learning everything and retaining all that information. It was about teaching us how to think and how to use instruments in the real world. I had doubts at times that this program was going to be successful, but after almost a complete year, it has made me think twice.

Recommendations for Assessing Innovative Programs

For programs such as the Drexel Engineering Curriculum traditional assessment strategies are not enough. Traditional assessment strategies incorporate a variety of "objective measurements." Among the traditional assessment strategies are the course evaluation, standard testing, as well as

local comprehensive tests. Such strategies are important components in the assessment process as they measure such things as course content, instructor style, as well as the student's competencies.

In an innovative curriculum, which utilizes the concept of design and course integration to educate the engineer of the 21st century, assessment strategies must constantly be refined to incorporate the complete learning process. Such assessments - focus group discussions, journal analysis, as well as self and peer evaluations must be validated by the learning community. Such assessment strategies provide invaluable benchmarks for faculty and administrators. Assessment should be reflective of the curricular vision. Although focus groups and journal analysis are just the seeds of personal reflection, they lead to a holistic awareness of the learning process.

To conclude with an anecdote, many Drexel students being interviewed by prospective employers talked about how they were taught to think through problems in their freshman classes and how they did not understand why this was necessary until their first job. They were responding to an employer of national renown who asked:

- Tell me about something you've done that has given you a great sense of personal accomplishment.
- Tell me about a time when you were asked to learn something totally new and you were unprepared.
- Tell me about a situation where things went drastically wrong and how you responded.

Is this not qualitative assessment?

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