

# Continuous Process Improvement: A Case of the Freshman Engineering Program at Binghamton University

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**Abstract** – A major focus of the first-year engineering program at Binghamton University is to aid freshmen with their transition from high school to college. First-year students are not admitted into an engineering department; instead, they are admitted into the engineering college. They experience a one-year general engineering program in their freshman year and they self-select their discipline near the end of that first year. Each semester, two highly linked courses, “Exploring Engineering” and “Engineering Communications”, guide the students as they make this transition. This is done through student-centered instruction paired with a strict program syllabus. The students are further helped to prepare for their choice of discipline through projects that provide hands-on experience and general overviews of engineering concepts and the disciplines offered at Binghamton University. This paper will provide a brief history of the undergraduate engineering freshman program at Binghamton University and subsequently describe the recent developments and improvements in the curriculum, including the use of technologies such as “clickers,” automated assessment, exploration of the use of Podcasting and other media-capturing technologies (e.g., Voice-over-PowerPoint, Camtasia and others), and improvements in the way we coordinate and link our two freshman engineering courses in each semester

**Index Terms** – Curriculum, First-Year Engineering Programs, Multimedia Tools, Virtual Learning Environment

## INTRODUCTION

An ongoing concern for engineering schools is the student retention rate [1]. In the past, a high drop-out rate was considered a sign of being a selective and difficult major and the low retention rate was often attributed as a “weed out” of students that did not meet the criteria [2]. A more recent feeling towards high attrition rates is that students are withdrawing from the schools due to other factors [1, 3]. These include ineffective curricula, poor performance, and a lack of interest. Every ABET accredited engineering college is trying to reduce the attrition rate of their students by increasing student interest in the programs

offered during the first year. This is primarily because the quality of education delivered during the first year is very important.

In the Thomas J. Watson School of Engineering and Applied Science at Binghamton University in New York State, the incoming freshman students are not directly admitted into an engineering department. During their first year, all students are admitted into the freshman engineering program known as the “Engineering Design Division (EDD)”. Then throughout the first year, students are exposed to the fundamentals of engineering through introduction to engineering courses (WTSN111/112: Exploring Engineering I/II) and engineering communications courses (WTSN103/104: Engineering Communications I/II). These courses comprise the core of the freshman engineering program, which is a two semester integrated curriculum, that combines the basic principles of engineering, including engineering problem solving and design, ethics, teamwork, communications, research and writing skills. In these courses, students are also introduced to the fundamentals and foci of each of the different engineering disciplines offered at Binghamton University. Along with this, the students are also enrolled in calculus and science courses as prerequisites to their sophomore year and beyond.

The challenge faced is to design a freshman engineering program that provides a strong foundation of the elementary and universal engineering concepts and to also provide curriculum in such a way that the students understand the concepts and are actively engaged. The aim of our ongoing efforts to improve the program is to find different, new, opportunities and strategies to further meet the aforementioned challenges and thus both improve the retention rate and to position the students to make a well-informed decision about selecting a discipline that is best suited to them. The primary focus of this paper will be on how to stimulate the interest of and engage the students in the large lecture component of (> 250 in recent years) WTSN 111/112, 103/104 with the help of multimedia devices like student response systems, voice over PowerPoint, and podcasts. This paper provides a brief history of the EDD program and discusses some of the challenges faced. Also, a discussion on how the recent

developments in the program were brought about is included.

### HISTORY OF EDD

Initially with smaller class sizes, there were several possibilities for semester long design projects that included an actual client. One such project was an Assistive Devices Project that included working with twenty-three outside agencies. Representatives from these agencies would work with the freshman program instructors to select problems that freshmen could solve, create designs for, and build. Direct contact with the agency and specifically the client resulted in the student's commitment to successfully complete the project and in many cases cemented their commitment to engineering. Another such project was called the Multi Media Project for Fourth Graders. For this project the engineering freshmen designed multimedia projects with the goal of introducing science and engineering concepts to 4<sup>th</sup> grade students. Since the freshman students needed to present the information to the 4<sup>th</sup> graders, they approached the project with a great sense of responsibility, meticulously cross checking each and every detail. Throughout the project the clients were the 4<sup>th</sup> grade teacher and the 4<sup>th</sup> grade students. At least two visits were held during the semester when the 4<sup>th</sup> graders visited the engineering classroom to give input about the curriculum on which they were working. The engineering students recorded the information and then designed the multimedia program, in a computer instructional format. During the second visit the freshmen presented their designs to the 4<sup>th</sup> grade teachers and students and received feedback about the effectiveness of their project. This process resulted in the formation of a relationship with the 4<sup>th</sup> graders and the 4<sup>th</sup> grade teachers that once again resulted in the freshmen striving to develop the best possible project. At the end of the semester, the project culminated in an engineering science fair that was attended by the 4<sup>th</sup> graders, their teachers, and their parents. The engineering students always went beyond all expectations to produce the multimedia projects, models, and posters. Again, this level of commitment was attributed to the relationship that was developed with an actual client and the real world engineering application.

As the class size grew, these projects became less feasible. Then, in 2004, with a class size of 250 students, they could no longer be maintained due to a lack of available resources. The projects were at that time replaced with more conceptual projects. Throughout the next few years, the program continued to grow to just short of 400 students. As the program grew, the previous instructional methods became less effective. This soon led to a disparity between the laboratory sessions and lectures taught in the class which resulted in confusion among students [4]. Figure 1 below

elucidates the layout of the program offered by the EDD program.

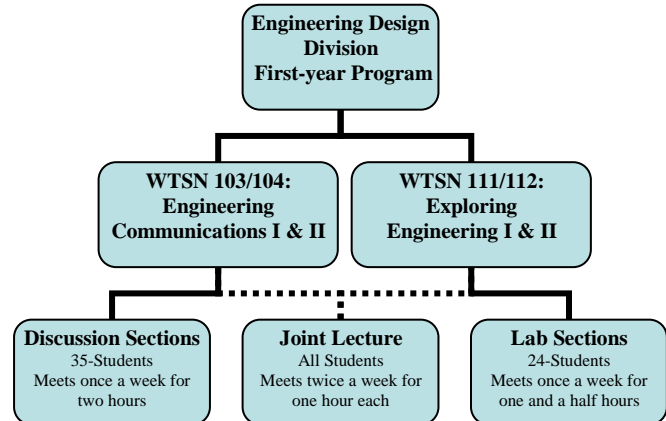


Figure 1: EDD Program Layout

It was now apparent that changes to the program were needed in order to meet the challenges that come with a larger class size. The first challenge for the educators was the delivery of the fundamental engineering concepts evident in all engineering disciplines along with applicable hands-on experiences to very large class sizes. The second of these challenges was to find ways and techniques to make the one-hour lectures more interactive in a class > 250 students in order to increase the level of student engagement. Finally, since some of the main objectives of the EDD program are to guide the freshmen in their transition to college and to assist them in selecting their majors, the third challenge was to stimulate their interest and further their understanding of the material. In the following section the different techniques used to meet these challenges and thus improve the EDD program are discussed.

### RECENT DEVELOPMENTS

The goal of the research was to improve the educational process in the EDD department systematically and self evaluate by benchmarking the program with other engineering schools. The quantification of the improvement can be done by analyzing the retention rate before and after the improvement. The following are the different tools and steps which were used in this process.

#### I. Benchmarked the EDD program

An exhaustive review of the freshman programs offered at different ABET accredited engineering schools was done in order to benchmark the freshman engineering program at Binghamton. Some of the programs included in this review were Virginia Tech, RPI, UMass (Amherst), U. of Pittsburgh, Penn State University, Ohio State University, and

the University of Arkansas. Since ABET accreditation does not involve a standard guideline for building engineering curricula, each college can and has interpreted the ABET criteria differently. Thus, there is no consistency or a standard curriculum throughout the engineering colleges. However, most of the colleges where the freshmen declare their majors later, offer a one-credit Introduction to Engineering course with associated laboratory activities. In this type of course, students are taught the basic fundamentals of engineering which include data analysis, graphic design, and problem solving techniques along with technical report writing and research techniques. With the help of the coursework, students are typically assigned project work where they get hands-on experience.

The course structure at Binghamton University is more or less similar to the other schools. However, unlike the other schools, the EDD program links the WTSN111/112 course and WTSN 103/104 course. The WTSN 111/112 course is devoted to the engineering concepts and their applications while WTSN 103/104 focuses on leading a semester long engineering design project that includes team work, technical research and writing, presentation skills and professional behavior. Further, in each semester, the students are taking 4 hours of engineering-related credits (e.g., in the fall, WTSN 103 is 2 credits and WTSN 111 is 2 credits). Compared to the other programs in our search, the EDD program at Binghamton University appears to be unique. Three projects are assigned to the freshmen during the academic year (two in the Fall and one in the Spring). In the Fall, they are assigned “MAKE” projects wherein they build and/or repurpose older products to make new devices. For examples of these activities, see [5]. These projects provide hands-on experience and require the students to work with different engineering tools and techniques. Upon the completion of the projects, all the students assemble at a competition event during which they present their devices. A panel of judges, comprised of engineering faculty, engineers from the University’s physical plant and facilities, and engineers from local companies with varied engineering backgrounds act as judges for this competition. This is the highlight of the Fall EDD program.

The second set of projects offered during the Fall is the Reverse Engineering project wherein the students use their creative skills to improve a product with realistic goals and within a fixed, small budget and schedule. During this project, students are assigned a small common kitchen appliance, and are then asked to perform a functional decomposition of the product. They are then required to make modifications to the parts, and present their modifications in an engineering report that includes 3D technical drawings of any modified parts.

In the Spring semester, the students complete the third major activity which is an approximate semester-long Conceptual Design project. In this project, the students have

to research a particular global issues problem (irrigation issues, decreasing environmental impacts of dams, etc.) and develop a conceptual design solution. These projects are designed to expose students to the disciplines of engineering and practical engineering design applications while exposing them to existing global projects in existence throughout the world. Since the engineering course and the communications course are linked, these projects allow for the demonstration that both are vital parts of an engineering career. As the students learn the engineering processes, they also learn how to communicate their ideas in a variety of ways, including formal documents and presentations of their solutions. These projects have strived to conceptually build in a client which accounts for the success of these yearlong projects.

## II. *Increased Student-centered learning*

As the number of students increased throughout the last few years, the number of graduate Teaching Assistants (TA) needed to run the activity lab sections also increased (with some restrictions). As budget constraints reduced the TA allocations, yet to still provide the students as much in-class guidance as possible, Undergraduate Course Assistants (UCAs) were introduced in order to help the TAs in the labs. Since these TAs and UCAs come from different engineering backgrounds, they are required to attend a training session each week. During this training, the TAs and UCAs are introduced to all the lab materials, and are also instructed on pedagogy. One added benefit of the UCAs is that they recently completed the first year program and allow for a thorough review of the lab materials [1]. Undoubtedly, it is easier to gauge student learning in smaller classes. Each laboratory session is for 1 hour, 30 minutes and consists of around 20-25 students, this allows for a student centered learning environment. In these sessions, the students are introduced to different software and hardware packages along with their applications in diverse engineering disciplines. Also to maintain consistency among the labs taught by different TAs, voice over PowerPoint lectures and Camtasia software can be used which can record and capture audio and video from the PC.

Another recent initiative in these laboratory sessions is that all freshman students participate in at least two laboratory related activities tied to each engineering discipline offered at Binghamton University prior to the date at which they self-select their engineering major.

## III. *Engaging students*

The lab activities and assignments give students good hands-on experience but it is difficult to judge the students on their understanding of the basic concepts. Also, it is necessary to engage students and make engineering studies exciting to them. Since the EDD program is 4 credits for

two classes, the in-class work load is less and since it is very time consuming to correct > 250 handwritten assignments and grade them (e.g., on fundamental engineering analysis types of problems), the EDD program has now started using an Automated Assessment System of Blackboard (Version 9). This system can handle up to 30 questions from a variety of different types (e.g., Multiple Choice Questions (MCQs), fill-in-the-blank, and other). These questions are uploaded on the system with correct solutions and feedback. The students are given sufficient time and sufficient number of attempts to complete the assignments.

The automated assessment systems have their own advantages and disadvantages. After a small pilot study with the automated system it was observed that some students did like the idea of getting their results immediately after submitting the assignments along with correct answers and feedback since they could understand where they were going wrong. However, there were some students who did not like the idea of automated assessment due to technical failures in the system while writing the assignments. Since the technical failure was a common cause variation it could be fixed; hence, we adopted this idea to engage students outside the class and lab. The TAs along with regular responsibilities of teaching in the laboratories and grading the assignments, are also now responsible for helping to develop Engineering Analysis problems with respect to different engineering departments. The TAs representative of each engineering department work with faculty in their home departments to develop problem sets from their discipline. The problems are intended to capture basic types of problems that engineers from different disciplines encounter, but are intentionally not exceedingly difficult problems. Students in the freshman program are required to complete no fewer than two of these problem sets. The idea is that they will likely complete the problem set for the discipline towards which they are leaning (and see basic examples of the types of problems they may encounter in that discipline) and the other problem set may be another discipline they are considering. Along with assignments, tutorials are also uploaded where they can test their concepts and question the TAs if they do not understand. Since the pattern of the examination questions is similar to the tutorials, this will help the students to prepare for the midterms and final exams.

As a result of this technique a virtual learning environment was created for the students. The self tests and tutorials did help students understand the concepts and their applications to a greater depth. It was noticed that after the self tests were introduced, students took more interest in comprehending the problems which improved their problem solving skills.

To enhance student commitment and ensure efficient delivery of the content, lectures are beginning to be recorded using Echo 360 software. The recorded videos are available in different formats. One of the available formats

is a podcast format which is then uploaded on the Blackboard as a URL which students can download and play it on their MP3 players or iPods. They can then listen to the lectures on the go and once again, if required, take notes if they missed anything. This will also be helpful for students who missed their lectures due to ill health. As per the Chronicle of Higher Education, the techniques of podcasting the lectures or information have been widely adopted by different universities [6] and we are entering into that arena. Findings show that this technique was widely accepted by students, especially the non-native English speakers, who found it difficult to follow the lectures. This method has helped to mitigate student stress and has facilitated in the understanding of the material.

The next challenge was to make the large lecture class more interactive with the instructor. It is not easy for an instructor to assess if the students are gaining an understanding of the material during the lectures. It is also quite difficult to engage and let all of the more than 250 students participate in the class. To meet this challenge, we have recently adopted the Student Response Systems also referred to as Audience Response Systems or, simply, the Clickers. There is a misconception that clickers can be used only for multiple choice questions which is not true. Additionally, many universities use this system and the several reasons why they use them include the following [7]:

- Class participation/attendance/quizzes
- Evaluation of students' understanding/misconceptions/confusions
- Motivate shy students to participate
- Comparisons between the peers' views
- Stimulation of discussion

The merit with clickers is that they can be used by any department from engineering to medical science to literature classes. Thus, a comparison was conducted between different clickers used by other universities which included Quizdom, PRS, i-Clickers and others. However, it was learned that the Chemistry and Physics Departments at Binghamton University had adopted the same type of response system: the i-Clickers. This made the decision in EDD easy. Since all first year engineering students (aside from the few students that transfer in credit) take Chemistry and Physics and are required to purchase an i-Clicker, this system was adopted in the EDD program as well. In an experiment in a recent semester, we conducted a pilot study using i-Clickers in a large lecture class of >250 engineering students and in a separate class of 15 literature students. It was observed that the students, in both classes, paid more attention in the class than they did without them. From the instructors' point of view, they found the device convenient enough to use and engage the class in active discussion.

## CONCLUSIONS

Along with the revision of Curriculum Content, the study was extended to improve the Instructor–Student relationship and delivery of the content with the help of technologies like clickers, Podcasts, Camtasia, and automated assessment through Blackboard. The student response systems (using i-Clickers) were adopted to take attendance, to engage students during the lecture via quizzes, and to take polls for concept grasping. The Automated Assessment System with feedback, embedded in Blackboard (Version 9), allowed us to assign self tests to the students which helped them to understand the concepts and encouraged them to solve problems and get instant feedback.

In addition to these changes, the Engineering Design Division has also embraced the technology of ‘on the go lectures’ through Podcasting and the video edit/capture software called Camtasia. By means of this software, the consistency of laboratory sessions is maintained throughout the different sections (e.g., this becomes a de-facto standardized repository for the general concepts and techniques for each laboratory activity). As a consequence of adopting the multimedia technology, the education processes in the EDD program have shown a significant improvement and we hope more proof of this will be forthcoming via continued reductions in attrition.



Figure 2: Overview of the recent developments

The Figure 2 illustrates a brief pictorial representation of the recent developments observed at the EDD which facilitated the instructors to engage the students with the help of clickers and test themselves through self tests with the help of automated assessment system along with podcasts of the lectures which enables them to review their concepts.

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