# Development and Delivery of a Project-Based Introductory Engineering Course for Online Delivery

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## Introduction

Engineering education is increasingly moving to nontraditional delivery modes, especially online delivery. Over 5.6 million students in the United States took at least one online course in the fall 2009 term.[1] This represents a 21 percent growth rate while there was only a 2 percent growth rate for higher education student population.[1] With this movement comes the challenge to meet the quality offered by traditional face-to-face instruction. In the online environment, it is often difficult to present complex engineering concepts. Also, the logistics of implementing team design projects into an online course is very complicated. An introductory engineering course typically addresses both complex engineering topics as well as team-based design projects. This paper reports on the development of an introductory engineering course for online delivery that includes team-based design projects.

Some previous work has been done with regards to moving engineering courses to the online environment. Enriquez developed an introductory circuits course for synchronous online delivery.[2] He found no statistical difference in the performance of the online students as compared to face-to-face students. Orabi showed no significant difference in the performance between online and traditional students in an entry-level engineering course, but the online students found it easier to fall behind in the content.[3] Kamp et al. evaluated e-learning in engineering education and concluded that online graphic visualizations were useful, distance-based student teamwork posed challenges, and instructors spent extra time in order to be successful in the virtual environment.[4] Brodie found that problem-based learning using online environments could be very successful and even enhance the flexibility in learning.[5]

This paper begins with some background as to why the course was developed for the online environment for the UW Colleges and the challenges that come with the online delivery mode. The process used to develop the course is then outlined. Then the course content and delivery methods used are detailed. The results from the assessment of the course are then given. Finally, some conclusions and future work are discussed.

## Background

The University of Wisconsin Colleges (~~UWC)~~UW Colleges) is part of the University of Wisconsin System. The UW Colleges are composed of two-year campuses geographically dispersed across the state of Wisconsin. The UW Colleges mission is to prepare students for success at the baccalaureate level of education. The UW Colleges is designed to offer the first two years of a liberal arts education as well as prepare students for transfer into their selected baccalaureate program. One of the explicit goals of UW Colleges is to participate in collaborative relationships with other University of Wisconsin institutions. This goal has come to fruition by the participation of the UW Colleges with the University of Wisconsin – Platteville

(UWP) and their Collaborative Engineering Degree program. The Collaborative Engineering Degree program is designed so that students can earn a bachelor's degree in engineering from UW Platteville without ever leaving their local UW Colleges campus or home.

The University of Wisconsin Colleges has been offering the first two years of general engineering courses for over 30 years. The curriculum is offered via face-to-face instruction at five of the campuses and via Distance Education at the other campuses. Prior to 2007, the courses that were offered via Distance Education were classified as Non-Online Distance Education (NODE). The NODE delivery method is a synchronous class meeting that was either offered via audiographics or via Compressed Video. Audiographics utilizes Microsoft Live Meeting where the participants are connected via a telephone conferencing system and share a computer screen. The faculty member controls the computer and the meeting. The second method of NODE instruction is Compressed Video. Compressed Video is a teleconferencing system where the faculty member can connect via video to five remote campuses. Both methods require students to attend class at a specified time and day. The students must be physically present at their campus to attend the course. The student could possibly attend the class meeting via a different location, but the cost is prohibitive for this method of delivery, so the students are required to be at one of the UW Colleges campuses.

In response to the UW Platteville Collaborative Engineering Program, the UW Colleges faculty determined that the students entering into this program would be better served by offering the UW Colleges engineering courses in an asynchronous format. The target audience of this program is working individuals who will be able to attend courses that are not offered during the typical working day. This was not the audience that was currently being served by the UW Colleges NODE course delivery. The NODE courses must be scheduled during a normal school day as the teleconferencing system has operators only during normal business hours. In response to this, the UW Colleges faculty determined that the current course offerings would need to be developed for an asynchronous delivery mode. The faculty determined that the courses would be developed and offered in an online environment. The faculty chose the online environment because:

- The UW Colleges has a robust instructional design staff that will help faculty design their courses for online delivery.
- The online delivery would allow working students to perform their course work in a time frame that is most compatible with their schedules.
- The online delivery would allow the UW Colleges to accept students from other universities and institutions across the country. Any person can take an online course from UW Colleges by enrolling as a special student.

Over the last four years the engineering faculty have migrated all of the courses offered to the online environment. The last two courses to move to this mode of delivery are Engineering Fundamentals and Strength of Materials. This paper discusses the online development and delivery of the Engineering Fundamentals course for online delivery.

In 2005, the UW Colleges faculty of met and decided that the students were not being well served by a 1 credit – Introduction to Engineering course. The faculty felt the students were not leaving the course with the skill set required of an engineering student, specifically the ability to work well in teams, the ability to efficiently and effectively solve engineering problems (including problem identification as well as proper problem solving techniques), an overall understanding of how a practicing engineer will use technology in their work, as well as a fundamental understanding and use of a spreadsheet program. This was further evidenced by the fact that the faculty felt that students were not performing to their expectations in subsequent classes to the level that the faculty felt a freshman/sophomore engineering student should. The faculty met for two days in 2007 and determined the new course would be titled Engineering Fundamentals (EGR 105). It would be a 3-credit course where 1/3 of the course would be devoted to an introduction to computer science and computer applications, specifically spreadsheets. The course description is as follows:

> This course is designed to equip engineering students with the necessary tools and background information to prepare them to be successful engineering students as well as a successful practicing engineer. Topics covered in this course include project management, team work, technical writing, working with data and using spreadsheets, creating presentations, engineering design, and a thorough understanding of the engineering profession.

The EGR 105 course was offered in the fall of 2007 via compressed video and has been offered every semester hence. The EGR 105 course was offered in the online format in the spring semester of 2011. This paper discusses the development and delivery of the course in the online and asynchronous environment. The engineering faculty felt that since the course was originally designed by a team, it would be a natural fit for the online development to occur using a team approach. Each faculty member in the team had different educational and working backgrounds. The team was comprised of three engineers and a computer scientist. The lead designer was the faculty member that would first deliver the course in the online environment. All team members were given access to the online course so that they could access the developed course lecture notes, homework, projects, and other developed material.

*Challenges*

Moving a course to the online/asynchronous environment is challenging for the faculty member regardless of the course. The time requirement for developing a well thought out and media rich online course is much higher than a traditional face to face lecture. The development team determined several challenges that exist from delivering EGR 105 in the online/asynchronous environment. These are mainly due to the students being geographically dispersed. As with many engineering courses, especially project-based introductory courses, team work is vital to the success of the students. With students located all over the state, and potentially all over the world, team work becomes very challenging.

Another integral part of the traditional introductory engineering course is the inclusion of the perspective of outside practicing engineers. This usually takes the form of either a field trip to the practicing engineer's company or bringing the engineer to class as a visiting lecturer. For reasons stated above, this becomes a challenge in the online environment.

Being able to give oral presentations is an important aspect of any engineer's career. For this reason, it is emphasized in the traditional introductory engineering course. Given that students are geographically dispersed and courses are generally delivered asynchronously in the online environment, including an oral presentation into the online delivery of the course is a major challenge.

There are several other difficulties that occur with any course being moved to an online environment. Some of these challenges include the students adequately grasping new concepts, the inability to ask questions in real-time, the assessment of student understanding that comes from being able to see their body language, the logistics of the technology working as intended, and many other issues. Above are some of the challenges unique to this course. These challenges were all addressed and met to the satisfaction of the faculty. Details of how the challenges were met are in the course content section below.

## Course Development for Online Delivery

The development of the course for online delivery took over eight months and can be broken into three stages: identifying the course components, designing the delivery method for each component, and developing the course content. These three stages are discussed below.

### *Stage 1: Course Component Identification*

Due to the mission of the UW Colleges and that over 50% of engineering students receive their education from NODE instruction it is imperative that faculty and instructional staff work together to ensure the content of the courses is the same regardless of the campus or the delivery mode. The students must come into thoses classes with the same basic understanding of concepts and theories.

In the spring of 2010, the engineering faculty and instructional staff met for over five hours to discuss the course components of EGR 105. The timing was deemed appropriate as the course had now been offered for three years and a curriculum revision may be warranted. There were six faculty and instructors in attendance at the meeting. The course description and curricular outline was provided to each person. A spreadsheet was then created where each attending member listed the lessons used to cover the course topics. The lessons used to address the course topics were varied as the backgrounds of each member are highly varied. At the conclusion of the listing there were over 60 lessons/methods listed for the course. The 60 lessons were then categorized into one of three areas: computers/applications; engineering principles; team/project design. Within each category the attending faculty ranked the lessons in order of importance. At the conclusion of this exercise, the topics were then scored and a rank order listing of lessons/methods was created. These lessons/methods were identified as the course components. These components should be covered in the course regardless of the mode of delivery. The components were discussed and at the conclusion approximately 1/3 of the course content was given to each category. The members discussed the various lessons and methodologies used in class to cover the components and developed a topical outline for every day of the course. This resulted in a course shell. The attending members agreed on the shell and all agreed to be a party to the development of the online course.

*Stage 2: Lecture Design and Delivery Strategies*

Approximately six weeks after the initial meeting, a meeting was held by the faculty who were still interested in the online development. The pool now dropped to four faculty members. The members met for a single eight hour meeting to further discuss the course.

The initial portion of the meeting was to create the course schedule, therefore identifying the order of the lectures. The course would be comprised of 45 lectures. A master schedule was created for the development. Each lesson was placed into the schedule, and the lesson was determined. The attending faculty then discussed the textbook chapter that would best support the lecture material. Each attending faculty member used a different book, therefore the pros and cons of each text were discussed. At the conclusion, a chapter from a book was identified. The faculty initially used texts from all publishers, but quickly determined that we would need to stay within the confines of a single publisher so a custom book could be easily created. The team decided to use Mc-Graw Hill. Along with the text identification, a team member was designated to be the developer of the content for the lecture. This team approach to development allowed each member to work in the area where they felt they had expertise. This approach worked well. The team tried to split the work evenly, but the lead instructor created approximately 40% of the lectures. The computer scientist created about 30% and the remaining lecture were split among the remaining team members.

*Stage 3: Developing Course Content*

The lead instructor supplied each team member with a lesson template so that the format of each lesson was the same to provide some continuity in the deliverables of the course regardless of the person developing the lecture. Each team member then began developing their lectures. Each member worked with the lead instructor and the online instructional designer to create the lecture material for the course. The lead instructor also worked with Mc-Graw Hill and created a custom textbook for the course based upon the chapters the team selected that best tied to the lectures. The team used some innovative approaches to lectures and project team work. These methods were discussed at the second team meeting. The approaches and methods used to deliver the course content are in the Course Content section of this paper.

**Course Content**

The EGR 105 course is comprised of 15 units which coincide with a 15-week semester schedule. The team felt it would be easier for the students to work in units that aligned with a calendar; therefore the 15 unit schedule was completed. As discussed previously there were three categories identified for the course: computers/applications; engineering principles; team/project design. The team determined that each unit would be comprised of 3 lessons equating to the three categories of the course. Two lessons each unit were devoted to engineering principles and team/project design and one lesson was devoted to computer science/applications.

The result of this development was the creation of 45 student lessons. Each lesson was comprised of lecture notes and videos, reading assignment, and homework. The lecture notes were developed by a team member, the reading assignment was from the custom Mc-Graw Hill textbook, and the homework was either from the textbook or created by the team member creating the lesson. The team felt that this information covered a majority of the material that would be delivered in a face-to-face class. The team did feel that the student taking this course in the online environment would be missing certain course components that face-to-face students would receive, specifically those topics addressed in the challenges portion of the paper. The following sections illustrate how the team addressed each of the challenges presented earlier.

*Team/Project Design Work*

The team felt that the students in the EGR 105 course regardless of mode of delivery would be required to complete two team project design projects. During the second team meeting the various projects employed by the team members were discussed and two projects were selected for development. The projects are somewhat scaled back as compared to projects typically done at a baccalaureate campus due to the lack of equipment and the geographical dispersion of our students.

The first project is the <u>Mouse Trap Car</u> project. This is a typical high school physics project, but the team has used this project before with great success in this course. The project is to design a mousetrap car where teams design a single car, create specifications, engineering sketches and assembly directions. From their technical documents, each student built a car and tested it. The results were compared and analyzed to identify missing information in the specifications and/or assembly instructions. The documents were then revised to ensure a more repeatable design. A final car was built and mailed along with the specifications to the instructor for final assessment and testing. Upon receipt of all cars, the cars were tested by the instructor and the winner declared. A portion of the final project score was based on how well each car did. The entire testing was videotaped. The instructor edited the tape and posted a condensed version of the test was posted on YouTube for the students to watch.

The second project was the <u>Wind Farm</u> project. The project was to design a wind farm to meet the electrical needs of a campus. Students were given hourly wind data for a year as well as electricity usage data for a campus. Students analyzed the data and researched specific windmills on the market in order to design a wind farm for campus. The deliverables for this project were a written progress report as well as a final written and oral proposal. For the completion of these projects the students were randomly placed into teams of four.

Once the projects were selected, the next hurdle was to determine how the students would communicate efficiently with each other so that they could complete their projects. The course used multiple methods of communication including email, virtual office hours, and discussion boards. The students could also use their own social networking systems as well as their mobile phones. The UW Colleges uses the Desire2Learn course management system to deliver online courses. The EGR 105 online course employed the use of discussion boards. There were discussion boards that were used by the entire class, and there were boards that were used for the team to hold private conversations. The threaded discussion was maintained throughout the semester.

Another method of communication was the use of a virtual classroom. The UW Colleges uses the synchronous meeting tool "Elluminate", by Blackboard. This meeting room allows for VOIP communication, the use of Whiteboards, application sharing and web tours as well as break out rooms for private discussion. The lead instructor felt that this was such a vital tool for the EGR 105 students that there were two mandatory virtual meetings during the first week of the semester. The student could attend either one of these meetings. The main purpose of the meeting was to introduce the students to Elluminate and explain how to use all of the conferencing tools. After the completion of the mandatory meeting, each team was given their own individual team meeting room where they would be the only participants in the room and they could meet with their team members. Due to the anticipated heavy use of the virtual classroom the purchase of headset/microphone was a requirement for this course.

To help further the students' understanding of an engineering design project, the lead instructor acted as the project manager for the first project. The students had weekly milestones for their project that were addressed in their weekly assignment. For the second project, the students would elect a project manager and they submitted a single progress report half way through the second project.

*Oral Presentations*

The final component of the wind farm project was to have a final presentation of their design proposal. The faculty determined that the teams would present their final project to the entire class. The faculty felt strongly that this presentation needed to be made to the entire class so a synchronous meeting was created as part of the course. The final project presentations were held in the virtual classroom the last day of classes for two hours. This was a mandatory meeting and the students were informed of this meeting prior to the beginning of the class.

*Engineering Professionals*

As stated earlier, one of the components of a face-to-face EGR 105 course is the interaction with a practicing engineer. Either the engineer would visit the class or the students may visit the engineer at his/her job. The faculty felt this was a vital experience for any EGR 105 student regardless of the mode of delivery of the course. In response to this the faculty determined that practicing engineers would be interviewed and recorded. These recordings would then be made available to the students. As stated previously, the course is comprised of 15 units and each unit has a theme. The lead instructor developed a set of questions that corresponded to the theme and the lessons that were created for the unit. Two engineers were identified (a civil and a mechanical engineer) each with over 20 years of working experience to be our interviewees. A camera crew was sent from the instructional designer and interviews were conducted. The recorded interviews were part of the course and attached to each unit.

The interviews were held at different locales, but were edited into one single recording for the students. This delivery of the interviews is more robust than anything that could be delivered in a face-to-face course as the engineers discuss how he addresses the topic in each unit. The faculty felt this was an excellent addition to the course and was well worth the time and expense of creating the videos.

*Connecting with Students*

The challenge with any online class is the ability of the professor to connect with his/her students to ensure the understanding of key concepts by the students. The students do not have the ability to drop by the faculty member's office and obtain help with homework, or just to sit and check in on how their semester is going. The lead instructor employed the use of virtual office hours and the use of the Elluminate classroom. The lead instructor has over 4 semesters of experience with the virtual classroom and has found great success in connecting with her students.

The use of the virtual classroom, online office hours and the practicing engineer interviews were all used to help meet the challenges of offering the EGR 105 course in an online environment. The faculty felt that these methodologies would help the students receive an educational experience similar to the experience they would receive in a face-to-face delivery mode.

**Assessment**

When EGR 105 was delivered for the first time, assessments were conducted to compare the online course to the traditional face-to-face delivery mode. The semester the online course was first offered, it was also offered in its traditional format by one of the team of developers. This provided a direct comparison between the two delivery modes for the course. The course content was nearly identical between the two modes. All the homework and projects were the same in each section. Each section also followed the same weekly schedule so the concepts would follow the same order. Of course, small changes were made in order for the content developed for online instruction to effectively fit into a delivery format of 75 minutes, twice a week.

The goal of the team was to ensure that the students in the online section had the same experience and success as the students in the traditional face to face section. Several assessments were used to determine if the online students attained the same experience and success as the students in the traditional face to face section. One assessment was a quantitative analysis comparing the grades of each section. Also, two surveys were created for the students to take and reflect on their work on the projects and the course. The first survey was given after the first design project and focused on how the course structure aided in teamwork on the project. The second survey was conducted at the end of the course focused on both the final project as well as the course as a whole. The fourth assessment was an analysis of the viewings of the engineering interviews for each section. Finally, the two instructors for each section met and discussed their perceptions of the course, the projects, the students and the overall experience of the course at the conclusion of the course.

*Student Grades*

The first assessment tool used to compare the two sections was student grades. Since identical assignments were given in each course section, a direct comparison of grades between the online and the face-to face section was made. While there was some subjectivity to grading, a rubric was created for each assignment and project which helped normalize the grades.

Table 1 shows the results of the grade comparisons for each section. The mean score for each assignment, project, and final exam are given. Table 1 also shows the resulting p-value from the t-test for each assignment. For this analysis, if the p-value is less than 0.01, there is a statistical significance between the sections. A noticeable result from this comparison was how much better the online students did as compared to the traditional students. The p-values for three assignments, the mousetrap car project, the take home Excel final, and the overall course grade were less than 0.01 indicating a statistically significant difference in these grades. In each case, the online section did significantly better than the traditional section.

| Assignment | Online Mean | Traditional Mean | P-value |
|---|---|---|---|
| Unit 1 | 95.7% | 100.0% | 0.13349 |
| **Unit 2** | **93.8%** | **80.5%** | **0.00933** |
| Unit 3 | 88.4% | 76.6% | 0.13740 |
| Unit 4 | 89.5% | 78.4% | 0.04184 |
| **Unit 5** | **89.6%** | **58.7%** | **0.00578** |
| Unit 6 | 93.4% | 75.7% | 0.01944 |
| Unit 7 | 81.4% | 59.6% | 0.10376 |
| Unit 8 | 84.6% | 64.9% | 0.12049 |
| Unit 9 | 92.8% | 76.2% | 0.02808 |
| Unit 10 | 82.1% | 68.5% | 0.08296 |
| **Unit 11** | **72.5%** | **34.7%** | **0.00342** |
| Unit 12 | 86.4% | 66.2% | 0.09971 |
| Unit 13 | 86.5% | 72.4% | 0.16086 |
| Unit 14 | 90.4% | 57.3% | 0.02722 |
| **Project 1** | **95.7%** | **88.9%** | **0.00067** |
| Project 2 Presentation | 90.6% | 66.5% | 0.01913 |
| Project 2 Proposal | 90.7% | 67.8% | 0.02644 |
| **Take Home Final** | **87.8%** | **50.8%** | **0.00718** |
| In Class Final | 84.3% | 66.8% | 0.03748 |
| **Total Grade** | **90.9%** | **70.2%** | **0.00076** |

Table 1: Grade comparison between traditional and online sections

These results are consistent with the results of a 2010 Sloan Consortium study surveying the perceptions of the quality of online instruction. In the survey over 75% of academic leaders at public institutions report that online is as good as or better than face-to face instruction.[1] The speculation for this difference may be due in part to the quality of the students in each section as opposed to the delivery. Both instructors have taught this course several times and the online instructor had one of the best groups of students she had ever had and the traditional instructor had the worst students he had had for this course. Nonetheless, with the better section being the online students, there is little concern that the content was not delivered adequately via online delivery. From Table 1 it can also be seen that the assignment from Unit 11 was relatively low as compared to the other assignments. The assignment was on unit conversions and consisted of an exceedingly large amount of conversions to be done by hand as well as using Excel. It was not that students were unable to execute unit conversions; it was that students were unable to complete all the conversions. The assignment was too long and will be shortened in the future. Overall, when comparing the grades of the two sections, the online students performed better than the traditional students demonstrating that the online delivery was more than adequate in achieving student comprehension of the topics.

*Student Survey of the Mousetrap Car Design Project*

The first student survey was given after the mousetrap car project. The survey asked ten questions on a five-point Likert scale regarding the first project and how well the teams were able to work together as well as their overall impression of the project. The survey is included in the appendix. This survey was given to both the traditional face-to-face section as well as the online section and a Student's t-test was performed to compare the results between sections. Table 2 shows the results for each question on this survey including the averages and p-values from a t-test.

| Question | Online Mean | Traditional Mean | P-value |
|---|---|---|---|
| 1 | 4.56 | 4.38 | 0.5053 |
| 2 | 4.56 | 4.08 | 0.1226 |
| 3 | 4.67 | 4.15 | 0.1032 |
| 4 | 4.56 | 4.31 | 0.4109 |
| 5 | 4.56 | 4.62 | 0.7935 |
| 6 | 4.22 | 4.31 | 0.8087 |
| 7 | 4.56 | 4.31 | 0.2773 |
| 8 | 4.67 | 4.31 | 0.1109 |
| 9 | 4.11 | 4.23 | 0.6514 |
| 10 | 4.67 | 4.54 | 0.6104 |

Table 2: Results from student survey following Project 1(Mouse Trap Car Survey)

The mean score for each question is given for each section. The average score is above four for all questions in both sections. The students seemed to have a positive experience with the project including working with their teams. Table 2 shows the p-value for each question is above 0.01. Therefore, there is no statistical difference in the responses of the two sections. The online section perceived the project and working in teams similarly to the traditional section. The fact that both sections had an equally positive response to the project demonstrates the methods used in the online delivery lead to an experience equivalent to what is traditionally offered.

The qualitative data revealed similar comments in that both sections had an overall positive experience with the project. The qualitative data revealed dissimilar comments when discussing teamwork. The traditional section had comments that suggested it was difficult to find time to meet as a team, that more "in class time" should be given for the teams to work together and that the students would prefer to pick their own teams. The online section overwhelmingly had positive comments regarding the team work. The common theme in the comments were that it was easy to meet as a team, the use of Elluminate was indispensible in allowing them to work as a team, and that they felt they really got to know their teammates. The speculation of the instructors is that most of the online students had full-time jobs and had scheduled time in the evening to work on their coursework. Therefore, it is most likely that the students had an expectation of doing work at night. The project work was most likely considered to be part of their work expectations for the course. In contrast, the traditional section students also probably worked, but worked outside of normal school hours (most likely evening and weekends) and therefore, it became difficult to meet as a team outside of traditional school time.

*Student Survey of EGR 105*

The second student survey was given to each section at the end of the course and considered student's reactions to both the wind power project and the course as a whole. There were 11 questions on a five-point Likert scale for this survey as well as their overall impression of the wind farm design project and the course. The survey is included in the appendix. Table 3 shows the results for each question on this survey including the averages and p-values from a t-test.

| Question | Online Mean | Traditional Mean | P-value |
|---|---|---|---|
| 1 | 3.22 | 3.92 | 0.2017 |
| 2 | 3.78 | 4.25 | 0.3878 |
| 3 | 3.78 | 4.25 | 0.3627 |
| 4 | 4.33 | 4.50 | 0.5927 |
| 5 | 4.33 | 3.67 | 0.0758 |
| **6** | **4.00** | **2.67** | **0.0089** |
| 7 | 4.56 | 4.33 | 0.5147 |
| 8 | 3.89 | 3.67 | 0.5027 |
| 9 | 4.44 | 4.08 | 0.2927 |
| 10 | 3.56 | 4.08 | 0.3350 |
| 11 | 4.44 | 4.17 | 0.4537 |

Table 3: Results from student survey following the course (Student Survey of EGR 105)

The first three questions considered the wind project as compared to the mousetrap car project. These scores were relatively low. The instructors were not clear as to why the scores were low, because overall the student comments were mostly positive. The traditional section students all stated they worked better as a team on the second project. Overall, they stated they found it easier to work as a team and get their work done. The online section had two of seven teams state they did not work well on the second project. One student commented, "I think our team worked better together on the mouse trap project because what needed to be done for the project was more clear cut." Another noted, "The team did not function well at all. The initial meeting was only attended by 3 of 4 members and the scope of the project was beyond what anyone could comprehend." The other five teams in the online section all reported similarly to the traditional section, in that the teams worked much better in the second project as compared to the first.

In addition, questions 8 and 10 having to do with pace and workload had relatively low scores. When the surveys were examined for comments, most students felt the work was appropriate and did not have a strong opinion regarding the amount of work. No one complained that the work was excessive, yet the scores do not reflect this. Based on the comments, it is the belief of the instructors that the students felt it was appropriate. The instructors felt that the amount of grading was excessive for the course. Each week the instructors were required to grade three assignments; an engineering assignment (typically two sections), a computer assignment, and a project assignment (for the first half of the course). Finally, question 6 dealing with the textbook was not only low, but the traditional section was significantly lower than the online section with a p-value of 0.0089. There were some problems with the textbook including one section was out of order and that the chapter numbers in the text were not sequential, therefore at times making it confusing to determine where to look. These issues have been rectified in a new custom textbook. The difference between the two sections stems from a lack of buy-in from the traditional instructor who historically used no text in the course. However, aside from question 6 the p-values are all less than 0.01 indicating there is no statistical difference in the responses of the two sections. Both sections had statistically similar experiences regardless of the delivery method of the course.

*Engineering Interviews*

The team of developers felt that the engineering interviews were a vital component to the course. The interview topics were tied to each unit and demonstrated to the students how the week's material was applied in the "real world". It was also felt that it in some way reinforced that the topics that were being discussed and taught would be perceived as relevant to the student's future career. Much time and money was used to create the videos and both instructors felt it enhanced the course. The traditional section students were told to log onto a website outside of class to access the engineering videos prior to coming to the class each week. The online students had access to the videos along with their assigned readings and other course materials. The time spent by each class on the engineering interviews were analyzed. The analysis revealed that the videos did not work for the traditional section and were better received by the online version. Table 4 summarizes the findings.

| | **Percentage of Students Viewing** | |
|---|---|---|
| **Interview Number** | **Traditional** | **Online** |
| 1 | 20% | 100% |
| 2 | 27% | 87% |
| 3 | 27% | 74% |
| 4 | 13% | 74% |
| 5 | 7% | 70% |
| 6 | 0% | 65% |
| 7 | 7% | 61% |
| 8 | 20% | 70% |
| 9 | 7% | 65% |
| 10 | 13% | 65% |
| 11 | 20% | 70% |
| 12 | 0% | 65% |
| 13 | 7% | 57% |
| 14 | 0% | 65% |

| | | |
|---|---|---|
| 15 | 7% | 43% |

Table 4: Results from comparison of number of students viewing interviews

The results show that there is a significant difference (p-value = $1.86647 \times 10^{-13}$) between the traditional face to face section and the online section with regards to the viewing of the interviews. This data was disconcerting to the instructors as it was the feeling that this was a vital component to the course. It was the belief of the instructors that the interviews could be viewed as the glue that tied the course to the real world. The instructors believe this is a function of the interviews themselves. The traditional section was told to view the interviews prior to class each week; however, the students may have viewed this an "optional or supplementary" activity that should be done in addition to attending the class. The videos for the online section were embedded into the course material. Therefore, when the students were reviewing the material for the unit the interview was one more component of the course and was most likely not viewed as an "optional or supplemental" component, but part of the course material.

*Instructor Perceptions of the Course*

The final assessment was the instructors' perception of the course. The online instructor and the traditional section instructor had very different experiences with the course. During a meeting after the end of the semester, the traditional instructor noted that the cohort of students in the class were the worst group of students he has had in the three years teaching the course. The online instructor found that this was the most motivated and engaged cohort of students that she has had in her three years of teaching the course. It is the belief of the online instructor that this is a result of the type of students who took the online course. Most of the students in the online section were non-traditional students (over the age of 22), were working full time jobs and many had families. The students for the most part were highly motivated students working on attaining an engineering degree while working full-time and maintaining many other obligations. It is the belief of the traditional section instructor that many students were taking this course to "test the waters" and had little intention in attaining an engineering degree.

Both instructors tried to offer the course material in a similar manner, the traditional course was very structured and did not allow for "extra time" to be spent on a subject if the students struggled. If the students did not understand a concept they were required to come to office hours or spend extra time after class with the instructor. The traditional instructor found it nearly impossible to cover all of the course material in the allotted class time. The online instructor did not have similar experiences because the students were responsible for the material. The lecture notes, videos, and other information were presented in a concise and easy to follow format, but it was the student's responsibility to complete all of the course work. Therefore, the online instructor never felt pressure to meet a schedule for the delivery of the course material.

Both instructors reviewed the amount of time spent on this course as compared to previous semesters. Both instructors felt that this course was more time consuming than previous offerings of the course. The traditional section instructor noted that he spent more time one on one with students and after class reviewing material as it was difficult to get through all of the course material during class time. The traditional section instructor felt constrained by the structured format of the course. Overall, the traditional section instructor felt he spent 10 hours on the course each week. The online section instructor noted that she spent more time on the online course as compared to previous semesters. The instructor believes the online environment is an excellent mode of teaching some courses, but requires an excessive amount of time to teach it well. Much time is spent communicating with students in and out of virtual office hours, attending students meetings if requested and grading homework. The online instructor had 3 virtual office hours a week which were almost always attended by students, had over 1700 posts to the discussion boards throughout the semester, and as many emails in which to read and respond. On average the online section instructor felt she spent in excess of 20 hours per week on this single course.

The online instructor believed that the use of Elluminate for the virtual office hours and synchronous meetings was vital to the success of the students in the online section and to their working as a team and producing quality projects. The use of Elluminate aligns with Moore's theory of transactional distance. The theory states that distance is a pedagogical phenomenon and the learner is not considered with location, but with student interaction and engagement.[6] The use of Elluminate allowed the students to be connected with the professor and with their teammates.

Both projects were reviewed by both instructors at the meeting after the end of the term. The instructors felt that the quality and level of detail presented by the online student teams far exceeded the projects of the traditional section teams. The quality of the presentations was superior for the online students, and the data analysis for the wind project was at a greater level of detail for the online students. Both instructors feel this may be attributed to the ability of the online students to work more effectively in teams than the face to face students.

Both instructors believe that the interviews are a vital component to the course and allow the students to not only understand what a practicing engineer does in his or her career, but the interviews add relevancy to the course material. Both instructors were disappointed in the number of students who viewed the videos and had expected that all students would watch all of the videos.

## Conclusion and Next Steps

A team of engineering faculty and instructors met to analyze an existing Engineering Fundamentals course developed, and delivered the course in an online environment. A list of learning outcomes and topics were developed and the delivery of each topic was chosen to achieve the desired learning outcomes given the constraints and possibilities of the online environment. The course was broken into 15 units, each unit was composed of 3 lessons corresponding to the three major categories of the course (computers/applications; engineering principles; team/project design). Most topics were delivered using online text and/or videos created by the team of faculty and the instructional designer. In addition to the online components, a custom textbook was built with help from a publisher for students to reference during the course. Interviews of two engineers were recorded to give students an engineer's perspective of most topics during the discussion of each topic in the course. Students were able to meet synchronously with each other or with the instructor using a virtual classroom. Two team design projects were developed for the course. An oral presentation was required for the second project and was conducted in a virtual classroom. Two synchronous meetings were required of the students.

When the course was initially taught the online section performed better the traditional face-to-face section showing the online environment was successful at delivering the course content. In addition, the perceptions of the course by students were similar for both sections. Two surveys given to students in both section had similar responses. The engineer interviews were much more utilized by the online students versus the face-to-face students. This may have been due to a perception that the videos were optional for the face-to-face students. Finally, both instructors felt the course was successful, but a little too much work for both the students and the instructor.

Moving forward, the course will be offered again after some minor revisions. These revisions include making the course ADA compliant and changing the homework. The homework will be shorter and will include questions regarding the interviews for the unit. It is the belief that this will encourage students to view the videos. The online course was successful in that the online section students had better grades as evidenced by the data analysis and had similar experiences as the traditional section students as evidenced by the results of the two surveys. The results show that project based introductory engineering course may be successfully taught in the online environment.

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# Development of Freshman Seminar Design Project

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## Abstract

This paper discusses the challenges associated with the development of a design project for a freshman seminar course in engineering. Two different projects that the author has used in class will be described and compared. The effectiveness of the projects at achieving both the course and overall departmental objectives will be discussed.

## Introduction

There are many challenges when planning an Introduction to Engineering course at the freshman level. These challenges revolve around achieving the objectives of the course in a limited time and taking into account the limited experiences of many of the students. The objectives of such a course are typically to increase the students understanding of what engineering is, provide some background knowledge and experiences that will serve as a foundation for the material they will learn over the next 4 years, and to encourage the student's interested in the field of engineering. Typically the culmination of these classes takes the form of a design project. The format of the design projects can vary, and this paper will discuss two very different formats that the author has used thus far in the Introduction to Civil Engineering course at the University of Minnesota Duluth (UMD). A brief description of each project will be provided, as well as a discussion of the response of the students, the effectiveness of the project at achieving the course objectives, and the lessons learned.

## Background

The University of Minnesota Duluth (UMD) is a comprehensive regional university located in Duluth, MN. There is an active student population of 11,729 as of fall 2010 enrolment[3].There are currently 74 different majors available with one of the newest being Civil Engineering. The program started in the fall of 2008 with the first graduating class in 2012. The program was formed because of a need for a civil engineering program in northern Minnesota and was heavily driven by local industry. The early influence of industry had an impact on the mission statement of the program included below:

> *"The mission of the Department of Civil Engineering at the University of Minnesota Duluth is to prepare graduates for professional practice and graduate study through a program firmly based in strong technical skills, fundamentals, hands-on learning, sustainability, and professionalism. To meet this goal, the Civil Engineering curriculum vertically integrates oral and written communication, contemporary issues, successful teamwork, significant design experience, and the skills needed to engage in life-long learning into general education and engineering courses."* [2]

The projects that will be discussed within this paper both incorporate many of the principles described in this mission statement, with the effectiveness of the project at achieving those objectives being one of the primary criteria for evaluating the effectiveness of the project.

**Course Description and Objectives**

Introduction to Civil Engineering is a one credit freshman seminar course that is offered every semester at UMD. Every freshman and transfer student who hasn't had a similar course at another university is required to take the course. The objectives of the course are to:

- Provide student with a better understanding of the field of civil engineering including a description of each of the four areas of civil engineering offered at UMD
- Introduce the topics of ethics, professionalism, globalization, teamwork, and sustainability within the context of civil engineering
- Provide an introduction to the design process

Another objective of the course that is not formally stated, but is still an important part of the course is to have the students engaged in the class and material to get them excited about engineering in general, and civil engineering specifically. Engaging the students early in the curriculum, such as in a freshman seminar course, is one way to improve retention of students throughout the program[1].

The course meets once a week for the 15 weeks in each semester. Included in the 15 weeks are approximately 5 guest speakers from the engineering industry around Duluth, MN. These speakers represent practicing engineers from the various focus areas of civil engineering including structural engineering, water resources engineering, environmental engineering, traffic engineering, geotechnical engineering and project management. These speakers talk about the work done in their field, highlight projects that they are currently or have previously worked on, and talk about what it is like to work in an engineering firm. They also provide time for the students to ask questions. This section of the course is very well received by students and provides a wealth of valuable information.

Approximately seven of the lectures are used to introduce topics that will be used throughout the civil engineering curriculum, as well as for the design project integrated into the course. These topics include: an introduction to civil engineering, the design process, sustainability and LEED, professionalism (licensure etc.), ethics, globalization and effective teamwork.

The remaining three lectures in the course are dedicated to the design project. One lecture is used to introduce and explain the project, and the final two lectures are used for the students to make their presentations.

**Project 1 Description**

The first time the author taught the course a more typical design project was used. This semester a new chancellor was installed at UMD, and the design project was to complete a preliminary design of a private residence for the new chancellor. The project was composed of multiple phases, with a deadline for each phase as well as a final report and presentation summarizing the work completed. The components of the preliminary design that the students needed to complete included:

1) Select site for construction
2) Provide drawing of site showing location, orientation and size of building
3) Provide preliminary floor plan of building
4) Provide LEED credits expected and level of certification
5) Initial cost estimate (optional)

The project was conducted in groups of four or five, with the groups assigned by the instructor. The first submittal the students had to complete was a group charter which outlined the rules of the group, listed a "kick out" clause (what a student had to do to get removed from the group), and designated a leader of the group. The second submittal was to choose 3 or more potential sites for the building and then use a weighted decision matrix to evaluate the sites and determine the site where the building should be constructed. The third submittal was to provide drawings (hand sketches were allowed because the majority of the students have not had and CAD course yet) documenting the building location on site, and a preliminary floor plan. The final submittal was to evaluate what LEED credits were optimal for their structure in order to obtain a minimum rating of LEED Silver. The final report included all of this information, revised based on comments received, and an optional preliminary cost estimate. When the project was introduced a brief tutorial was provided on how to use an online tool to complete cost estimates so some basic guidance was provided. In addition to a final report, the students were asked to develop a five to ten minute presentation summarizing their work that was presented in front of the class. Their peers were then allowed to ask questions.

**Project 1 Results**

Some samples of student work are shown in Table 1 and Figure 1. Table 1 shows how a typical decision matrix for the project was created. The three different sites were evaluated over a range of categories, with each category assigned a weight to allow for varying importance. Figure 1 shows a typical schematic drawing of the floor plan. These drawings are used for other parts of the project as well, including determining the LEED credits the structure might be able to achieve, as well as for determining quantities for the preliminary cost estimate.

| | | Conceptual Solutions | | | | | |
|---|---|---|---|---|---|---|---|
| | | Site 1 | | Site 2 | | Site 3 | |
| Criteria | Weight | Rating | Rt x Wt | Rating | Rt x Wt | Rating | Rt x Wt |
| Distance from campus | 7 | 9 | 63 | 9 | 63 | 9 | 63 |
| Land Development | 8 | 3 | 24 | 9 | 72 | 2 | 16 |
| Natural Surroundings | 6 | 8 | 48 | 5 | 30 | 9 | 54 |
| Noise | 4 | 9 | 36 | 7 | 28 | 8 | 32 |
| Preservation of Nature | 9 | 3 | 27 | 8 | 72 | 2 | 18 |
| View | 5 | 8 | 40 | 4 | 20 | 7 | 35 |
| Total | | 238 | | 285 | | 218 | |

Table 1: Decision Matrix

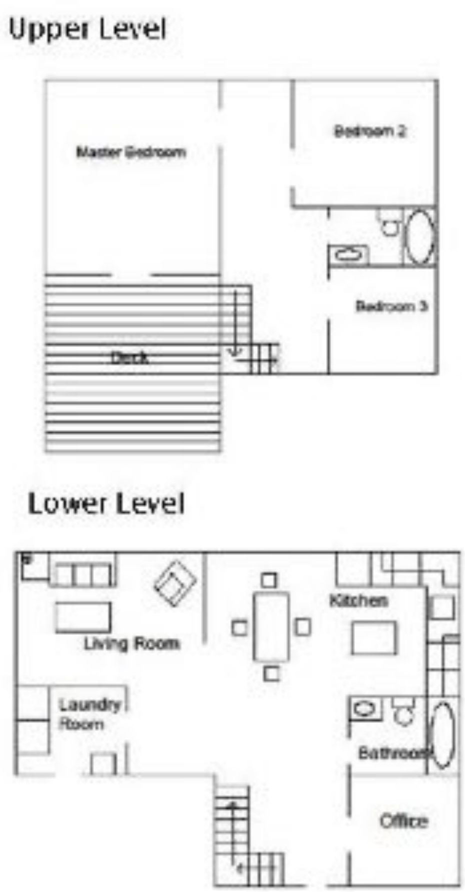


Figure 1: Schematic Building Layout

Each of the groups completed the project as assigned, including all of the components of the project. The majority of the groups also completed the optional preliminary cost estimate. All of the work was completed at a level that was appropriate.

**Project 2 Description**

A very different project was assigned the second time the author taught the course. Instead of completing the design of a structure, the students were to design an experiment or demonstration that they would have to conduct in class. When the project was introduced, the instructor took the class on a tour of the building to highlight the equipment and facilities that were available for the students to use to conduct their demonstrations.

As with the first project, this project was conducted in groups of four or five, with the groups assigned by the instructor. Also, the project was broken into submittals with some of the submittals structured in a similar way. The first submittal was the same as Project 1, with the students writing a group charter. The second submittal was also similar; the students were to pick at least 3 possible demonstrations, and then use a weighted decision matrix to determine which demonstration they would conduct. The third submittal was to find three technical articles (preferably peer reviewed journal articles) that are related to the demonstration, and provide a summary of each, indicating how it relates to their topic. The final report included all of these components as well as a description of the procedure they followed and a summary of the results. The final component was to conduct the demonstration in front of the rest of the class. Each group had approximately 10 minutes to present and conduct their demonstration.

**Project 2 Results**

There were a variety of topics chosen for this project, all of which were appropriate for the project statement. The topics chosen were:

- Concrete compressive strength for various aggregate types
- Compressive strength of wood with and against the grain
- Concrete compressive strength with different percentages of sand
- Compressive strength of "store bought" versus concrete made at UMD
- Water flow over a broad crested weir
- Tensile strength of different metals
- Solar ovens
- Strength of different cross-sections of wood in flexure

The groups all completed each of the components of the project at an appropriate level. The final presentations were not as polished as the instructor had wished, and in the future more guidance will be provided about the structure of the presentation, including conducting a demonstration of what is expected.

**Discussion**

Both projects succeeded in achieving some of the objectives of the course. Both projects served to introduce the design process by forcing the students to break down the project into steps, consider multiple solutions, chose the best solution, and then develop the solution to fit within the given parameters. Both projects also required the students to develop their teamwork skills. Project 1 was able to incorporate a more direct sustainability aspect into the project through the inclusion of the LEED credit rating system. However, Project 2 did allow for sustainability to be included depending on the topic chosen, which allows interested students to pursue this area if desired. Project 2 provided a better overview of the entire field of civil engineering. By having eight different topics the students were exposed to project in almost all of the areas of civil engineering. They also were required to look through the literature of the field, which served to further broaden their experience.

When examining the mission statement for the department, as with the course objectives, both projects achieved some of the goals stated. As stated above, both projects required teamwork and provided design experience. Both projects also required effective oral and written communication through the final written report and presentation. Project 1 included sustainability explicit in the project statement. Project 2 provided the hands on learning that is stressed in the mission statement. Through an introduction to discipline specific literature, project 2 also lays the foundation for the skills needed to engage in lifelong learning.

In general, the students found Project 2 much more engaging. The students asked more questions both throughout the completion of the project and at the final presentations. Because the students chose the projects they were more enthusiastic in the completion of the project, and the resulting reports and presentations demonstrated that enthusiasm.

## Conclusion

From the results discussed above, the author found Project 2, where the students had to design and conduct an in class demonstration to be the more successful and beneficial project. The objectives of the course, and the goals laid out in the mission statement of the department were better met by this project. In addition, the students found the project more interested, became more engaged in the class and project, and in general were excited by the entire process. The author intends to use the same structure in the future with minor adjustments.

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# Case-Based Learning: A Creative Experience in Comparison to Traditional Teaching Methods

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## Abstract

This paper describes the steps taken in planning, developing, and executing a *case study/ case history* course in geotechnical/ foundation engineering at an international university. The paper sheds light on: how a "workable" format for the course was arrived at; the organization of the course; and the results of evaluating the effectiveness of this approach versus traditional lecturing. Problems and challenges that could arise when offering the course for the first time are also addressed. Embedded in this experience and its related protocols are the emphases on engineering design and the practice, teamwork and leadership development, organizational management, and oral and written communication skills. The paper concludes by confirming that discussions, through an open forum, are judged to be superior to traditional lectures in improving critical thinking, cultivating desirable personal attributes, and acquiring problem-solving skills.

## Introduction

Lecturing or "teaching by telling" is the traditional and the most widely used form of instruction in most engineering institutions. The major drawback of the lecture approach is that it usually results in long periods of uninterrupted instructor-centered, expository discourse, relegating students to the role of passive spectators.[1] This method, however, continues to be the most dominant teaching method in engineering institutions and widely used in most classes.

To improve the relevancy of engineering education, we believe that teaching, or more fundamentally, student learning needs to be emphasized. *Learning,* as defined today, is more than the acquisition of knowledge. Bloom [2] has defined five increasing levels of learning or comprehension. Starting with *fact-based knowledge*, and followed by: *comprehension* (using factual information and explaining facts), *application* (applying facts to solve problems, analyzing concept structures), *synthesis* (creating something new by using different components), and *evaluation* (exercising judgments and comparing new facts with existing knowledge). It is said that traditional teaching engages only the first level of learning as students down load information from a traditional lecture and upload it back on an examination and or a report. Not only does traditional teaching fail to take students through all five levels of learning, it also fails to engage students in the teaching-learning process. [3, 4, 5].

In civil engineering education today, there is a growing need to replace traditional approaches of teaching by utilizing pedagogies of engagement [5], and simultaneously bringing practical problems and issues that practitioners usually face, into the classroom.[6] Pedagogical studies have demonstrated that the *case study/ case history* approach to engineering education provides a greater understanding of the multifaceted nature of civil engineering.[7,8] They can be used to simulate a variety of learning protocols such as: design and analysis experiences, interdisciplinary issues and concerns, costs, hazards, owner preferences, and compliance with standards and guidelines. *Cases*, by and large, describe situations, projects, problems, decisions, etc., and are primarily derived from actual experience, and do reflect thoughts, outlook, and concerns of: managers, professionals, regulatory agencies, communities, and owners. *Cases* are also widely used in other disciplines such as: education, medicine, and law. Cases expose students to open ended, ill defined problems whose solution often depends on making assessments, judgments, and decisions by technical and management people of the organization involved

## What is A Case Study?

A *case study* typically is a record or a narrative account of a technical and a business issue (problem) that actually has been faced by an individual and/or a group, together with relevant facts, opinions, and prejudices upon which decisions have to depend. Several case formats appear in the literature. Most cases are intended to engage students in a learning process through: analysis, open discussion, and ending with evaluations and recommendations. A *case history* describes how a problem was approached and solved, and often examines the consequences of the decisions made. A *case problem* remains open ended - leaving the analysis and choice of a solution up to the students. A *case study* often includes an "ideal" or "benchmark" solution; also identifies or illustrates best practice. The main purpose of a *case study* is to illustrate a principle and/or the value of a specific approach or method. The *case method* refers to a specific strategy for using cases in the classroom to structure an active learning process of self-discovery [9].

Shapiro [10] presents several approaches to developing knowledge and skills. *Lectures and readings* are appropriate for "acquiring knowledge and becoming informed about techniques", *exercises and problem sets* are "the initial tools for exploring the applications and limitations of techniques," but the development of philosophies, methodologies, and skills is best served by the *case method*. *Cases* are used to extend the learning experience beyond the classroom exercises and laboratory experiments. Shapiro states that "the case method is built around the concepts of metaphors and simulation." Each case is a metaphor for a selected set of problems or issues. In their analysis and discussions, students are expected to simulate the information processing and decision-making skills of managers or engineers involved in the case. *Cases* require students to consider multiple factors and to integrate information from various sources. Thus, *cases*, in various forms, are one solution to the widening discrepancy between traditional classroom teaching and what really takes place in the real world [9]. They give students experience with situations and challenges they do not usually come across during traditional classroom activities. In any of their form, thoughtfully planned and well prepared cases provide:

- ***Relevance***. *Cases* depict real situations at a particular location and point in time. As such, they provide an insight into the decision-making process. Students see the relevance of the case to their future careers.

- ***Motivation***. *Cases* can provide incentives for students to immerse themselves in real engineering tasks. Also, assuming the role of a practicing engineer can be challenging and stimulating.
- ***Interaction***. Students learn more when they participate and become involved in the case–its history, background, discussion, and resolution.
- ***Integration***. *Cases* require students to draw upon knowledge from different sources and to integrate concepts, techniques, and tools they have learned in previous courses.
- ***Communication***. Review of a reported case, along with relevant documents, memorandums, literature, etc., plus the need to relate information to other participants (instructor, students, practitioners, etc), necessitate use of appropriate language and presentation methods. This aspect of case handling would invariably improve students' communication skills and help in building self-confidence.

Finally, one of the fundamental principles underlying the *case study* approach is: the nontraditional role of the instructor, whose role is not so much to teach students as to encourage learning. His/her role is more of a facilitator, and he/she has to be both a teacher and a practitioner.

**The Specifics of the Experience**

At an international university, the author introduced a *case study/ case history* course in the area of geotechnical/foundation engineering to Civil Engineering seniors, to achieve better learning outcomes through class participation, foster a deeper approach to learning, broaden students' perspectives, and emphasize foundation design issues and problems visa a vie the Region in general and the locale in particular. At the same time, bring the practice into the classroom, and stress on the imperative of superior communication skills and life-long learning in professional practice. The author has always been of the opinion that students, as emerging professionals, should have a venue on the local practice, preferably in a nontraditional setting, with emphasis on interdisciplinary problems. Also, adopting instructional practices that engage students in the learning process is one of the defining features of the course. The importance of student engagement is widely accepted and there is considerable evidence to support the effectiveness of student engagement on a broad range of learning outcomes [5, 11]. Specifically, students should learn, as early as possible, to work with others, to coordinate multifaceted problems, and search for information on their own.

After decades of increased emphasis on engineering science, engineering undergraduate education has become largely dissociated from the practice of engineering. The emphasis on analysis had outpaced the incorporation of synthesis and design as well as a number of broader educational and intellectual imperatives that were becoming increasingly evident. Concurrent with the building of the analysis emphasis over the decades, the undergraduate educational experience has become increasingly fragmented into what appeared to students as independent parts. There have also been strong pressures to add new technical subject matter as well as pressures and national agendas which have increasingly been calling for more rounded engineering graduates with the ability to function in a socially interactive, communicative, and business climate of modern industry. Satisfying such a broad set of demands within the traditional program structure seems extremely difficult. Indeed, a significant culture change should take place in engineering education. The challenge is clear, but the path forward is not well defined.

Lately, the author came to the realization that a *case study course*-if properly planned and executed- would raise students' awareness of the practice, exposes students to decision-making, trains students to think "holistically," and provides an opportunity for teamwork and leadership development. After getting the approval, efforts were directed towards: sketching out the general framework, searching for the proper materials, and outlining the process of execution. The decision was made, early on, that the intended course should focus primarily on geotechnical issues and problems of the Region. Therefore the selected cases and relevant presentations' materials would have to be from the Region, reflecting Region's issues and concerns. Initial search for relevant publications, that would fit the description of documented case histories from the Region, were very scanty. Therefore, other sources would have to be resorted to in order to compile the desired number and type of documentation for the intended exercise.

***1) Documentation:*** A formal call was sent out to almost all geotechnical/foundation consulting offices that have operated in the Region, requesting documented cases in the form of engineering reports. Within three to four weeks from the date of request, nearly one hundred geotechnical reports were received. A thorough selection process, based on: scope, relevance, technical content, and lessons learned, brought the number of "usable" reports down to twenty. Further sorting and evaluation, reduced the number down to fourteen *case histories*, believed to reflect accurately the design and construction issues and concerns that beset geotechnical engineers in the Region. Each case was subjected to analysis and scrutiny, and supplemented with background information to reduce ambiguities and uncertainties, and help guide students through the learning process. Selected cases addressed a wide range of multifaceted real-world projects, categorized totally or principally as: geotechnical/ foundation engineering. Major headings and /or titles of majority of the selected cases have included*: i) analysis and design of foundations for a housing complex; ii) slope stabilization of a major highway; iii) geotechnical investigation and foundation design for a high rise building ; iv) analysis and design of an offshore loading facility; v) site investigation, analysis and foundation design of large storage tanks; vi) investigation, design, and performance of a stone column foundation; vii) design and construction of shallow foundations over salt-laden cemented sands; viii)instrumentation, monitoring ,and analysis of an embankment slide; ix)load tests on drilled shafts for highway bridges; x)ground modification by dynamic compaction for a shopping mall; and, xi)shallow foundation on a diagenetic limestone formation.*

Each case was reformatted and subsequently arranged according to a pre-set outline to ensure that each *emphasis* area is properly covered. The emphasized areas included: 1) site-specific soil and rock data; 2) analysis and design of the foundation; 3) recommendations, safeguards and alternatives; 4) post construction monitoring; and 5) non technical factors that have influenced decision making and final recommendations. The final document comprised of: the fourteen "reformatted" cases plus instructor's perspective of the nontraditional approach of the planned delivery of the course were made available to interested students, well ahead of the start of the semester. Therefore, interested students had ample time to review content, ask questions, suggest changes if needed, and develop their own impression of what the course would entail, should they decide to register. In general, developing the documentation was hard work, time consuming, and required a great deal of diligence and care. In most institutions the development of instructional materials is typically not rewarded through promotion, tenure or pay. However, the author has the conviction that the big reward is in seeding the process of vibrancy and innovation in undergraduate engineering, for which the faculty should take a leadership responsibility.

***2) Relevant thoughts and processes:*** Faculty members who decide to use *cases* effectively in teaching must *rethink* their role in the classroom and change their behavior in significant ways. In this case, the instructor has to think of himself/herself as a manager, a facilitator, a planner, a care taker, or possibly a leader of the group. In his/ her capacity as a planner and a facilitator, the instructor has to articulate the key components and associated instructional strategies. Invariably, this would require expertise in the subject matter, as well as conviction, knowledge, and experience in nontraditional ways of teaching and learning. There are general steps considered by the author as helpful in achieving success. These steps include: i) articulation of key topics of the course and arrival at optimum methods of delivery; ii) attempt to uncover- as much as possible and prior to the start of the course- the different learning styles, dominant thinking processes, and other learning characteristics of incoming students, through suitable questionnaires complimented with interviews; iii) designing and/ or selecting learning experiences/ activities and instructional tools that are compatible with students' thinking processes and learning styles; and finally, iv) insuring that the selected tools and the designed learning environment, foster autonomous learning.

Assessing "what works" requires looking at a broad range of learning outcomes, interpreting results carefully, quantifying the magnitude of any reported improvement, and having some idea of what constitutes a "significant" improvement. This last will always be a matter of interpretation, although it is helpful to look at both statistical measures such as: effect sizes and absolute values for reported learning gains [(11)]. No matter how results are presented in the literature, faculty adopting instructional practices with the expectation of experiencing results similar to those reported should be aware of the practical limitations of educational studies. In general, educational studies tell us what worked, on average, for the populations examined and learning theories suggest why this might be so. However, claiming that faculty who adopt a specific method will experience similar results in their own classrooms is simply not possible. Even if faculty members master the new instructional method, they can not control all other variables that affect learning. There are conditions where a teacher may have to "go with the odds." The more extensive the results supporting a new method, and the more the instructor's students resemble the reported test population, the better the odds are that the method will work for a given instructor. Notwithstanding the problems that could arise, engineering faculty should be encouraged to examine the literature on novel methods of teaching. Some of the evidence for *active learning* is compelling and should stimulate faculty who use traditional methods to think about adopting teaching and learning in nontraditional ways [(11)].

The instructor, based on his own experience, has come to the conclusion that *collaborative learning* is a viable alternative and would be a good choice to promote a broad range of learning outcomes. In particular, collaboration enhances academic achievement, student attitudes, and student retention. *Collaborative learning* can be defined as any instructional method in which students work together in small groups towards a common goal [(12)]. As such, *collaborative learning* is viewed by many as encompassing all group-based instructional methods [(5)]. The core element of *collaborative learning* is the emphasis on students' interactions rather than on learning as a solitary activity. A related question of practical interest is whether the benefits of group work improve with frequency. Springer et al [13] looked at the effect of incorporating small, medium and large amounts of group work on achievement and student attitudes. They found that medium time in groups is the best for achievement, and high amount of time in groups produced the highest effect on students' attitudes. A separate problem determining what works is deciding when an improvement is significant. Proponents of *active learning* in general, cite improvements without making reference to the magnitude of the improvement, i.e., whether small or relatively significant [11].

***3) General plan:*** Despite some hesitation at the beginning, the instructor took the first step and made the decision to let *collaborative learning* be the prime instructional method for the *case study/ case history* course he was in charge of. The course attracted twenty one seniors, who successfully had passed two prerequisites: geotechnical engineering I, and foundation engineering. A total of seven groups - three members per group- were formed. At the outset, it was understood that group mates have to work together, help each other, trust one another, and arrive at a general consensus within the group on subject matter analyzed and/ or discussed in class. A group recorder- agreed upon by group members- was assigned the responsibility for providing the views of the group and feedback during discussions. He/ she also reported to the instructor on all matters that the group wished to relate. The following points helped to improve the quality of group work: instructions passed onto groups were explicit; guidelines regarding responsibilities of a member within a group, as well as relations between groups, were sketched out and agreed upon; and, an appropriate time frame for all activities was arrived at and communicated. Each group was assigned two case histories out of a total of fourteen pre-selected cases as explained earlier. This meant that each of the seven groups would take charge of two cases in terms of: presentation, provision of additional supplementary information when needed, and documenting generated discussion that proceeded presentation. The three 50 minute sessions per week were apportioned as follows: The *first session* was primarily devoted to the presentation of the selected case by the assigned group, followed by a short question and answer period. During the *second session*, an open discussion, guided by the instructor, would be geared towards relevant technical and nontechnical issues that had a bearing on the case. In this *second session*, all seven groups that made up the class contributed to the discussion. In the *third session*, an invited speaker, a practitioner, would address the class, focusing on real issues and concerns that only practitioners could address. During the final fifteen minutes of the *third session,* the instructor would summarize the case pointing in the direction of: lesson(s) learned, discrepancies, if any, and how the presented case would relate to and/ or supplement the knowledge students have been exposed to in previous courses.

Getting off to a good start is vital, so the first class session was an ideal opportunity to be clear about expectations and to impress on the students that the success of the course depends on the contribution of every student in the class! It was an appropriate time for the instructor to share his expectations for the course, describe the overall goals, and explain the relevancy of the course to students' program in general. Also, the instructor stressed on how case histories can enrich the practice, and how to judge data derived from case histories. During the first session, the instructor briefed the students about his teaching philosophy in general and discussed the benefits of using *collaborative learning*. Students were also invited, during the first week, to an icebreaker: to break barriers, foster a sense of community, and create a climate where students begin to feel that the instructor is some one they could approach. The *rapport* that was initiated early on in the semester was sustained through out the semester. To facilitate this *rapport*, the instructor was available to students during office hours, or by appointment. He also stressed on the need, for each group, to get to know each other, open up to one another, and seek each others help and advice in all matters relevant to the course. The instructor found out, soon after the course had started, that some students needed help beyond the scheduled classroom activities. Specifically, students, who had limited exposure to ways and means of putting on a presentation, needed advice on how to prepare for their assigned case history presentation. Assistance was also provided in the following areas: clarifying some principles and in bridging the gap between prior knowledge and new course material; shedding light on tools, tests, and devices used in the field; and, in interpreting field data and arrival at final design recommendations.

Typically, students within the group, would meet after class, exchange views, iron out differences, and arrive at a consensus regarding the salient points of the case and lesson(s) learned. Their understanding/ views / opinions are documented and made available to other groups within days from the date of the presentation. The instructor, in a follow up session, discusses openly differing views, and through an open debate, arrives at the major points that are worth noting- and how such information and/or results may be used in the future. The compilation of these points, referred to as "the crux", for each of the fourteen cases, was a source book that students referred to in preparing for the final examination which accounted for 30% of the course grade. The bulk of the grade (70%) was assigned to in-class and out of class *participation*, including: presentation, participation in open discussion, attendance, and his/her collaboration with team mates. Every group member was rated by his/her team mates. The students' *participation* grade was based 60% on professor's rating and 40% on the ratings of team mates. During the first iteration, almost all students expressed their satisfaction with the grade they got in the course. A straight grading scale was used: 85 to 100= A, 75 to 84.99 = B, 65 to 74.99 = C, and 55 to 64.99 = D. The use of a straight scale reduced competitiveness and helped convince many that there is no penalty for helping each other.

***4) Difficulties that have arisen:*** Some of the challenges that have characterized the experience, and worthy of mentioning, were: i) *English language-related issues:* English was a second language to all students in the course. Therefore, instructor' understanding, patience, and support in overcoming students' deficiencies in oral and written English, was required and appreciated by all. ii) *Lack of courage to express one's self**:*** Despite the fact that students wanted to be active learners, and to express their view in the open; many could not say what they wanted. They simply did not have the courage and self confidence to stand up and make a statement in the presence of their classmates. This is attributed, in large measure, to the traditional education system that has prevailed for years, relegating students to the role of passive spectators.iii) *Lack the drive and desire to learn on their own:* Most students were not used to do their own search or attempt to learn on their own. They are accustomed to being told what to do. And if they do what they were told to do, they will get the grade they deserve. Students are thoroughly deficient when it comes to thinking critically about problems other than those they have been tutored to respond to. iv) *Difficulties in seeing the big picture:* Many have difficulties seeing the "big picture". They have poor perception of the "holistic view". The engineering educational experience today has become increasingly fragmented into what appeared to the students as independent parts. v) *Shallow approaches to learning:* Most students have become used to shallow approaches to learning, apparently fueled by a high workload and fear of failure. In the shallow approaches to learning, the student focuses on learning isolated tasks often through memorization. The student's goal is to be able to reproduce the information; therefore, the student does not focus on understanding or determining meaning but instead: on superficial form.

The above noted challenges were frustrating to the instructor and difficult to overcome. The instructor, through the well-planned course activities and by using *collaborative learning*, tried to help the students in overcoming some of these "deeply rooted" undesirable personal traits; and the instructor believes that he has partially succeeded. Also, mounting pressures, to add new technical subjects coupled with ineffective teaching methods, exacerbated further against student time for independent thought, development of desirable personal traits, and the personal satisfaction and joy of learning.

***5) Improvements and challenges in learning outcomes***: Despite the noted deficiencies, brought about by the prevailing traditional approaches in the transmission of knowledge, the author believes that improvements in learning outcomes were achieved. The moderate success of this experience is largely attributed to the assertion of the instructor that a positive classroom environment should prevail despite some setbacks and resistance on the part of some students. There is considerable evidence to support the effectiveness of student engagement on a broad range of learning outcome. Included here is the effectiveness of engagement in increasing student attention span during lecture. The specifics of this positive environment were manifested by:

- *Higher level of student participation*: student-student dialogue and interaction, and building a sense of community with one another.
- *Nontraditional classroom environment*: where questions and answers, open discussion, and general consensus, replaced- to a large extent- the traditional lecture format.
- *The perspectives of geotechnical professionals*: the presentations, comments, and evaluations made by invited practitioners from the locale, helped enrich and enliven the experience, by focusing on real issues and concerns that only practitioners could address!
- *Insistence on a holistic approach*: the multiple factors involved in all or some of the cases, including: financial, climatic, available resources, and managerial issues, helped students develop an understanding of the case(s) from a holistic point of view and not from an engineering perspective only.

Also, the positive interpersonal relationships, promoted by cooperation amongst individuals within a group, as well as inter-group cooperation, has helped boost self-esteem and made some students more socially skilled than before. Many students did come forward and acknowledged that they gained in terms of: improving their technical know how of Region's soils and geology, linking theory to practice, exercising engineering judgment, decision making, and becoming more acquainted with presentation and communication skills. Table 1 shows the technical areas that were focused on during the course, and around which in-class discussion was generated. The author believes that the components described in Table 1, brought out during presentations and follow up discussions, helped in shedding light and in answering questions that did arise during course proceedings. The subject area that was most controversial and led to discussions after each presentation was the arrival at the final recommendations and how data was interpreted and why was the decision and/or recommendation made the way it appears in the report? Needless to say that the presence of practitioners in the class has helped greatly in facilitating the documented decision making process and helped shed light on variations and alternatives. Also, practitioners' use of technical terms and making reference to field devices and equipment, students are not familiar with, has helped raise many questions and led to various types of side discussions that had not been anticipated by the instructor

| ***Componen t*** | ***Subject Area*** | ***Specifics*** |
|---|---|---|
| **I** | **Properties and characteristics of local soils** | • An overview of Region's dominant soils and its surface geology.<br>• Developing better understanding of controlling processes in: collapsing soils, expansive soils, cemented soils, and saline soils.<br>• Exposure to soil investigation techniques including in situ testing.<br>• Exposure to post construction monitoring with particular reference to compressibility of clay layers. |
| **II** | **Data reduction and analysis** | • Review of data reduction methods.<br>• How probability theory could be applied to raw data.<br>• Gaining an understanding of how field and lab data could be analyzed to generate design parameters. |
| **III** | **Design considerations , appropriate formulae, and methods** | • Dwelling on allowable bearing capacity and tolerable settlements, with particular reference to locally deployed methods and formulae.<br>• Address stress increases in soil mass due to foundation loads.<br>• Review elements of foundation design in soils susceptible to wetting.<br>• Review of load transfer mechanisms in piles and drilled shafts visa vie local experience.<br>• Calculation methods and determinants of sheet pile wall design and braced cuts. |
| **IV** | **Ground modification** | • A review of: vibroflotation, dynamic compaction, stone columns, and sand drains. |

*Table 1. Major components of relevant technical subjects that were focused on.*

The instructor, during the entire semester, was trying to stress that the information should not only pass from the instructor to the students, but also from the students to the instructor and among the students. He was always emphasizing that interdependence is essential to learning, and it is at the heart of a student-engaged instructional approach. The instructor, in his desire to bring about a change in students' attitudes towards learning in general, and, at the same time, maximize their benefits and enhance their involvement with  the *case history course*, in particular; exercised extreme care in teaching. He taught about connectedness, objectivity, competence in decision making, and the need to consider non-technical issues such as: the environment, community development, and socio-economic factors. Care in teaching requires *attentiveness* to the students, and hence to the diversity in: background preparation, learning styles, and in interests related to the course. Therefore, ideally one should know the students before planning the course. However, the course and its planning came first chronologically. Care, as understood by the instructor, means that one should plan the course with all the competence in the subject area, with the most appropriate pedagogical method, and with built-in

flexibility. Unfortunately, there were elements that were beyond the control of the instructor, such as: students' background, classroom physical setting, and program's rigidity.
An extremely useful way to consider student learning is to look at deep versus shallow approaches to learning [14]. Our current understanding of the difference between the two approaches stems from a research done in Sweden that relates deep approaches to learning to biochemical changes in the brain and may lead to long term changes in cognition, attitude and character structure [15]. In shallow approaches to learning, students learn by memorizing; they do not focus on understanding, or dig deep into meaning but instead on superficial form. In a deep approach to learning, students focus on determining the meaning of what they are learning and on learning the connections and patterns which make learning holistic. Students, by and large, have the capability to develop and use either approach to learning. Deep approach requires more effort, more time, and more concentration than shallow approach. Students who are used to shallow approach to learning may find a deep approach difficult. The instructor was convinced that the majority of students in the class were users of shallow approaches to learning. He felt the urge to make them consider using the deep approach instead. He continuously reminded the students "to think" before making a statement or writing down an answer. Some of the slogans and general statements the instructor repeated, time and time again, during the semester are listed in Table 2.

- **Have an open mind! And try to think outside "the box"!**
- **Be inquisitive, do not be shy to ask, and think before asking!**
- **Scrutinize documented material, and do your own search!**
- **Searching, at times, is demanding and can be exhaustive!**
- **Air out your views and thoughts before reaching a conclusion.**
- **Open up to your group mates and do not isolate yourself!**
- **Be positive in your attitude towards your group mates. Help, encourage, and support each others' efforts to learn.**
- **Abandon the precept of "competition" and replace with the spirit of "cooperation."**
- **Learning is not memorizing. Learning is understanding and retaining knowledge.**
- **You are not in this course (*case history in geotechnical eng.)* solely to fulfill a requirement to graduate. You are in the course to acquire knowledge that has enduring value beyond the classroom.**

*Table 2. Slogans used to remind students of commitment they needed to make to maintain good standing and maximize their benefits from the course.*

To the surprise and dismay of some students, this course was not the "plug-and-chug" type where students insert numbers into the "right" equation, and get results; and accordingly get enough credit to pass even if they do not understand the problem. Instead, the course relied on developing the thought process and was aimed at developing students' ability in processing and digesting new information, synthesizing and integrating said information, modeling and/ or depicting field conditions, and arriving at appropriate conclusions and/ or recommendations.

## Summary and Concluding Remarks

The goal of the *case study/ case history* course described herein was to improve the relevancy of civil engineering education in the arena of geotechnology. Cases are normally used to extend the learning experience beyond the traditional classroom activities. Cases are optimum when they relate real-world issues and expose students to analysis and decisions encountered by practicing engineers. A *case study/ case history* course is one solution to the existing discrepancy between what is taught at the university and what actually takes place in the field. The case approach to learning requires more of the student than merely assimilating information. Passive listening is not sufficient. The student must be an active participant, and assumes roles that he/ she may have not experienced before such as: presenting information, participating in open discussions, and most importantly: Being an active member of a group.

The paper describes the steps taken in planning, developing, and executing a *case study/ case history* course in geotechnical/ foundation engineering at an international university. The paper sheds light on how a "workable" format for the course was arrived at; discusses the organization of the course; reveals some of the problems that have arisen; and focuses on improvements and challenges in learning outcomes. Embedded in this experience and its related protocols are the emphases on: (i) how geotechnical engineering is practiced in the Region; (ii) pedagogies of engagement and *collaborative learning* in particular; and (iii) development of more effective communication skills including: oral, written and other delivery methods.

Perhaps the greatest challenge in this exercise was the attempt to create an *active class environment* and break away from the traditional method of "teaching by telling" that has gripped the education system for a long time, with little opportunity, if any, for questions and answers and/ or a feedback loop. Despite some inherent deficiencies, attributed principally to the rigidity of the education system in place, most students have expressed their approval and satisfaction of being in a *collaborative learning* environment. The most frustrating part of teaching this course was the extreme difficulty in getting some students to participate and become team players, and/ or to have the courage to ask questions. The most rewarding part was the opportunity to work with many students who clearly grew during the course, broadened their perspective about the geotechnics of the Region, and acquired desirable traits, including the ability to ask intelligent questions and participate in a useful technical discussion.

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# The Role of Adjunct Faculty in Undergraduate Engineering Education: A Cohort Needed to Enhance the Practice

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**Abstract:**

This paper examines the status quo of adjunct faculty in engineering institutions and argues that adjuncts could enrich an academic engineering program by bringing in their practical experience and by introducing relevant applications and design venues to the classroom. Adjunct faculty do also help in setting up linkages with the industrial sector, which often leads to: employment opportunities for graduates, co-op activities, and potential development of collaborative research programs. Nevertheless, the present status of most adjunct faculty is tenuous, subject to shifting enrollment, and considered as a temporary arrangement, or until a "full-time" faculty is appointed. Unfortunately adjuncts, often with proven records of excellent teaching, are marginalized by the academic systems in place today; and their efforts and contributions to the academic process are undervalued. If fair treatment, and proper recognition are accorded to adjuncts; then, their morale, loyalty to the institution, and their teaching effectiveness would improve markedly.
Next, the paper reports on a success story of an adjunct, a practitioner with excellent credentials, who "teamed-up" with a "full-time" faculty, in an attempt to bring-in the "practice" to 4$^{th}$ year students in a *geotechnical/ foundation engineering* class. The success achieved in meeting stated objectives, i.e., including students' exposure to the "practice", was attributed, in large measure, to the proper coordination that preceded course delivery. The paper sheds light on this experience, and focuses on the contributions and effectiveness of the adjunct in: course planning, delivery of "practice-related" material, organizing instructional activities, as well as adjunct's ability and effort in engaging students, in and outside the classroom. The positive outcome of this experience has lead other faculty members to follow the same path, i.e., by searching for practitioners-as adjunct faculty- to assist in bringing the practice into the classroom, in partnership with "full-time" faculty.

**Introduction:**

If given the opportunity, adjunct faculty who have practiced engineering, could enrich an academic program by bringing in their practical experience and by introducing relevant applications and design venues to the classroom. The practical experience of adjunct faculty manifests itself in various ways. In particular, their familiarity with the "nuts & bolts" of the practice, including: appropriate design and construction methods, customer needs, alternative solutions, environmental and social impact aspects of the design, as well as their experience in decision-making, are ample reasons why their expertise would enrich students' learning and brings them (the students) closer to the realities of the workplace.

Employers, by and large, are generally satisfied with the basic technical preparation of today's graduates, but find them largely unaware of the vital roles that engineers play in bringing products and services from "a concept stage" to the marketplace. An important reason for this "drawback" is that faculty members, today, often lack industrial experience and/or any other type of practical experience. This is particularly troubling when faculty members, straight out of graduate school and have absolutely no experience "under their belt," are assigned to teach practice-related courses. Often, teaching design-oriented and/or field-related subjects do require "first-hand" knowledge that instructors could only get by having taken part, or been involved in real engineering problems. Relying mainly on textbooks and/or published reference material, as the only source to teach from or make reference to, is regarded by many, as an oversimplification or a deviation from reality.

This paper sheds light on the pros and cons of opening-up to off-campus practitioners, and argues for engaging properly selected adjunct faculty in the teaching-learning process, in partnership with full-time, regular faculty members. The impetus here is three fold. <u>First</u>, the general belief that well-seasoned and experienced practitioners can be a tremendous resource to tap; in combination with regular "full-time" faculty- who are, in most instances, the "research-type" who have not had the opportunity to practice engineering. <u>Second,</u> industry's prevailing perception that engineering education does not prepare graduates adequately for the practice. Therefore, from industry's perspective, the quality of education for engineering practice is seen as deficient. <u>Third,</u> The importance of blending practical experience in teaching design and design-related courses is repeatedly emphasized by ABET during accreditation visits and by other engineering organizations, such as ASEE, in conferences and through relevant publications. Thus, directions for proper merging of professional experience with engineering science in design courses are a concern that comes up often in educational forums. How best could such "a merging scenario" be planned and implemented, depends on: faculty foresight, available resources, and the commitment-on the part of the faculty and the administration-to the mission.

The paper reports on a success story of such a merger in a geotechnical/foundation class. The success achieved was attributed, in large measure, to the proper coordination that preceded course delivery. In this exercise, an experienced and willing practitioner was sought out to supplement the regular lectures offered in an elective course to $4^{th}$ year civil engineering students. Students' evaluations, their views, comments and overall impressions (during-and at the end of the course) have been very encouraging to say the least! The positive outcome of this experience has lead other faculty members to follow the same path, by searching for practitioners-as adjunct faculty- to assist in "bringing-in" the practice into the classroom.

**The Pros and Cons of Adjuncts:**

There are many reasons for employing adjunct faculty. Unanticipated increase in enrollment, the start up of new programs, the need for specific expertise, and the replacement of sabbatical or on-leave faculty, are some of the reasons that may necessitate making temporary arrangements to ensure coverage of instruction. Unfortunately, department heads, administrators, and most faculty members, look upon hiring an adjunct faculty as a "stop-gap" measure. Not only that, but there are those skeptics, that are vehemently against employing adjunct faculty on the grounds that: i) they do not have the teaching skills, ii) are not familiar with rules and regulations that control the day to day academic operations, iii) they lack organization skills, iv) do not possess the self-confidence, v) do not have the enthusiasm in comparison to their full-time colleagues, and vi) often lack familiarity and depth of insight with course material. Simultaneously, however, there is a growing recognition of the potential contributions that adjunct and other part-time faculty could make in the teaching arena, provided a thorough search for "the right type" of adjunct faculty is carried out through proper channels.

Although no firm rules or guidelines on how to search and identify candidates for an adjunct position are available at present; the most common starting point is the unsolicited applications from individuals in industry and consulting firms, seeking part-time work as adjunct faculty. The motivation often is to supplement their income. There are those that like to do it for other reasons such as: exposure to the academic environment and an interest in working with students, to gain experience in presentation and delivery of information, to take time-out from their daily schedule, or as a stepping stone into a full-time teaching position. In addition, full-time faculty may recommend colleagues, from outside campus, they have known through professional societies or through other domains, who may have expressed an interest in working with students. Another approach, though not widely practiced, is to advertise in local papers, and in specialized newsletters and magazines; spelling out in some details relevant information about: the position, desired qualifications, and the conditions of employment.

A thorough review of candidates' qualifications and experience is necessary, but may not be sufficient in insuring quality of instruction. Candidate's ability to deliver a lecture properly should be put to the test through his/her presentation of a seminar attended and evaluated by faculty members and students. Presentation of a technical seminar, though stressful for some candidates, is an invaluable means for assessing candidate's teaching skills. A scheduled presentation is also an opportunity for regular faculty to meet adjunct candidates, before and after the seminar, to get to know the candidate and discuss matters of mutual interest, including potential future collaboration. [1]

Some of the adjunct faculty-particularly those who are seniors in specific industries-could offer important linkages for the development of industrial affiliate programs, co-op activities, summer training opportunities, and employment opportunities for new graduates. They may also provide new ideas for senior design projects, topics for graduate theses, or render help in the establishment of collaborative research programs.

When a choice has been made and the candidate has accepted, it is important that he/she feels welcome and be assisted in becoming familiar with his/her new surroundings. To expedite the process, new adjuncts should sit together with their new colleagues and go over all relevant matters related to their assigned tasks, ranging from course objectives, to teaching logistics, and including prevailing classroom culture and department vision. For the new adjuncts to feel at home and become effective members of the university community, they need to understand the mission, prevailing practices, goals; and particular characteristics of student population such as: scores, interests, capabilities, and a wide range of relevant facts and statistics. For adjuncts that have not taught before, their first semester on the job is always very crucial. It is the time where they may need assistance from full-time faculty members who have taught the course before or are familiar with the course material.

To improve the teaching effectiveness of novice adjuncts, they need to be exposed to pedagogical training in the form of specialized seminars, workshops, or short courses. Many adjuncts, particularly part-timers, may resist getting any formal training on the ground that their time is limited and their primary job is off-campus and not teaching. The administration may not be able to convince all, but the fact remains that exposure to teaching-learning principles, would have positive impact on faculty teaching skills. Pedagogical knowledge could also be given as part of the New Faculty Orientation, or during special meetings intended mainly for adjuncts.

The academic systems in place today have not been fair to adjuncts in general. The author has known of many "full-time" adjuncts that have been mistreated despite their proven records of being very good teachers. They are often marginalized by the tenure system, in the sense that their efforts and contributions to the academic process are undervalued.[(1)] As pointed out by Gosink and Streveler,[(1)] there are ways for recognizing the contributions of adjuncts. Their suggestions have included the following:

- Look into the feasibility and/or the legal aspects of offering 3-5 year contracts to those who have demonstrated their abilities as good teachers.
- Accord appropriate titles, awards and citations, to distinguish proven teaching skills of qualified individuals, on par with regular faculty members.
- Encourage new recruits to take graduate courses towards a degree or to develop new skills and knowledge, including teaching skills. This is usually done on campus at no cost to the department.
- Encourage experienced instructors to teach new courses to widen their scope and increase their versatility; thus help them get out of "a rut" by developing new potentials and be of more value to the department.
- Allow those with experience to serve on various academic committees and assign them to undergraduate advising, as is the case with regular faculty.
- List those that have been in the teaching arena for over a year in catalogues and brochures, as well as in the telephone directory.

In summary, if care, recognition, and fair treatment are accorded to adjuncts, their morale, loyalty to the department and the college, as well as their teaching effectiveness would improve markedly.

**Reporting on the Experience:**

At one of the International Universities, a course, *Foundation Engineering*, introduces students to the fundamental concepts and applications of foundation analysis and design with emphasis on relevant methods and applications in the arid and semi-arid soils of the Country in contention and the Region in general. The prerequisite, *Geotechnical Engineering I*, exposes students to the basics of soil mechanics; from classifications of soils to consistency and the limits, on to soil water/permeability/seepage and effective stress principle, leading to compressibility and consolidation, and ending with shear strength. The author who happens to be the instructor for both courses, has always been of the opinion that certain subjects, including *Foundation Engineering*, should be instructed by practitioners; but, if not feasible, then practitioners should be involved in the instructional process, possibly as guest speakers. To proceed with the idea of bringing the practitioner to the classroom, a preliminary plan was drawn, and a search for an expert in the subject matter, preferably with some teaching experience, commenced as soon as formal approval was secured. The search had begun nearly a year ahead of the semester in which the course is to be offered. A formal announcement was dispatched to various companies in the Region describing the position, desired qualifications, financial compensation, and other employment-related conditions. It was also stipulated, that the appointment is initially for one year, renewable for longer periods, depending on outcome & feedback from students and faculty.

The search led to a candidate that had the desired qualifications, and was willing to accept the position, but had no prior teaching experience. However, his skills in lecturing and delivery of teaching materials were put to the test by having him present a seminar on a subject of his choice. Attendees' overall impression was very positive; and on that basis, he joined the department as a part-time adjunct faculty. The candidate, a registered professional engineer with a master's degree in geotechnical engineering, and geotechnical experience that stretches over a ten-year period. He was particularly suited for the position because of: i) his knowledge and familiarity with the soils and geology of the Region; ii) his direct involvement with the practice in the locale; and iii) being in charge of the geotechnical section in his consulting firm, facilitated getting the right kind of information and records, such as: soil data, case studies, exposure to equipment in-use, and relevant testing procedures. Most important, he was excited, eager and looking forward to bringing-in his experience to the classroom. Initially, three different alternatives, on how to proceed with the instruction of *Foundation Engineering*, and in particular, the role/contribution of the adjunct to the process, emerged. *Alternative One* was for the adjunct faculty to take complete charge, teach the course in its entirety, and consult with the full-time faculty when necessary. *Alternative Two,* called for apportioning teaching (the instructional activities) into two separate parts. The major part (embodying most of what is normally covered in prior semesters) would be handled by the full-time faculty. While the adjunct's contribution to the course, estimated at 20 to 30 % of total class time, would focus on the practice-side, i.e., addressing design and construction of foundations in the locale. *Alternative Three* specified a joint effort in terms of: planning course material, delivery of subject matter, organizing in-class and out of class activities, and in testing and evaluation. It was understood that the adoption of *Alternative Three* meant that both instructors would be present in the class room, at the same time, and actively involved in the instructional process: delivering the material in a coordinated manner, engaging students through questions and answers, or allowing time for an open discussion. After an exhaustive and thorough search, *Alternative Three* appeared to be the preferred choice for both instructors, who were willing to "give it a try" and pledged to put in the extra effort that would be required to guarantee success.

In the sections that follow, we examine relevant aspects that pertain to *planning the course*, *conducting the course*, and focus, particularly, on *the role of the adjunct faculty* in this endeavor.

**<u>Course planning</u>:** To begin with, a course plan agreed upon by both instructors was drawn up embodying instructors' vision of what needs to be covered in the time allotted. The plan had four elements: a set of *instructional objectives*, a *course syllabus*, a fair and equitable *testing and grading guidelines*, and a *"back up"* scenario for students that need more attention.

*1) Instructional Objectives*: This aspect was a construct of: (i) the knowledge and skills that will be conveyed ;( ii) what students must be able to do when finishing the course successfully; and, (iii) what constitute an acceptable performance. Thus, preparing the objectives helped clarify purposes and goals, allowing the instructors to identify important material, delete extraneous content, and plan course activities in an efficient way.

*2) Course Syllabus*: The syllabus, made up of ten interconnected parts, described course content, communicated goals, and included instructional objectives that guided course delivery. It also contained grading policy, provided information about selected textbook and reference material, and addressed other course logistics. Table 1 presents an "abridged" course outline with pertinent details. Time-wise, the course outline was apportioned and streamlined in order to insure that actual delivery was held within the allotted time: i.e., three contact hours per week, for a total of sixteen weeks, plus an additional hour for questions and answers and/or to supplement the regular lecture, for those that need it. To enrich the "practice-side" of the course, plans and provisions were made for: presentation of three selected *case histories* based on work done in the locale, and believed to be of relevance to course material; plus three pre-arranged *field trips* to sites nearby, to expose students to:(i) exploration and field testing equipment and methods in use, as well as (ii) the field data acquisition systems deployed in the area. Table 2 is a tally of the *cases* presented. Table 3 describes *trips* made during the course cycle referred to in this article.

*3) Testing and Grading*: Unlike prevailing norms of testing and grading, the guidelines from which instructors could measure students' accomplishments allowed for group collaboration in addition to individual performance. It was made clear at the outset that a course grade would be arrived at based on a combination of the following:

- Homework and joint projects submitted by the group,
- One mid-term exam and a final,
- A minimum of two-page commentary on each of the *case histories* presented in class,
- A brief group report for each of the *field trips*.

Instructors would also look at class participation through questions and answers, attendance, and collaboration within the group. To encourage teamwork, the instructors would do their at most to foster student cooperation, diminish the level of competition, and insist that students ought to compete with a "set standard" and not compete with each other. An additional bonus that helps those that may not do well on the mid-term is to be given the opportunity to "resurrect" those points on the final. The idea is as follows: points a student misses on the mid-term are logged on the record as "unearned points" in such a way that the corresponding section of the final is increased in value by the same number of points. [(2, 3)] For the students, this plan translates into the possibility that, however poorly they perform on the mid-term, they do have the opportunity to raise their grade in the course.

| *Part* | *Title* | *Details* | *Time Allocated* |
|---|---|---|---|
| **I** | **Review** | Index Properties<br>Stresses and Strains | One Week |
| **II** | **Regional Geology & Soils** | Desert Soils, Saline Soils<br>Cemented Soils | One Week |
| **III** | **Compressibility, Consolidation, and Settlement** | Theory, Relevant Tests and Techniques | One Week |
| **IV** | **Bearing Capacity Theory and Calculations** | Appropriate Formulae, Charts and Procedures | Two Weeks |
| **V** | **Shallow Foundations (Footings and Mats)** | Bearing Capacity Considerations | Two Weeks |
| **VI** | **Shallow Foundations (Footings and Mats)** | Settlement Considerations | Two Weeks |
| **VII** | **Deep Foundations (Piles, Shafts, and Piers)** | Bearing Capacity Considerations | Two Weeks |
| **VIII** | **Deep Foundations (Piles, Shafts, and Piers)** | Settlement Considerations | Two Weeks |
| **IX** | **Case Histories** | Three Cases Depicting Regional Behavior | One Week |
| **X** | **Field Trips** | Three Pre-Selected Sites | One Week |

*Table 1. An abridged course outline of Foundation Engineering.*

| *Case Histories* | *Designation* | *Details* |
|---|---|---|
| **1** | **The Settlement of the Two Hundred Bed Hospital** | Exposing students to probable cause of excessive settlement of footings over *saline soils* and the remedial measures that were implemented |
| **2** | **Driven Pile Foundations in Calcareous Sand** | Exposing students to design and installation of piled foundation for a 20 story building in *calcareous sand* |
| **3** | **Building Foundation Over Expansive Soil** | Exposing students to the use of foundation piers with a suspended floor slab over an *expansive soil* |

*Table 2. Three case histories typical of geotechnical/foundation problems and conditions in the Region (selected and presented by the adjunct faculty).*

| *Site No.* | *Trip Reference* | *Details* |
|---|---|---|
| **1** | **Subsurface Exploration** | • Observing borehole drilling operations<br>• Soil sampling, Split-Spoon Sampling<br>• Use of: Thin Wall tubes, Piston Sampler, Rock Coring<br>• Observations of water table fluctuations<br>• Observing Cone Penetration Testing<br>• Preparation of boring logs |
| **2** | **Plate Load Test & Settlement Monitoring** | • Observing a Plate Load Test in progress<br>• Monitoring foundation settlement on sand |
| **3** | **Pile Driving in Sand** | • Observing pipe piles driven in sand |

*Table 3. The three field trips intended to expose students to relevant geotechnical/foundation operations (selected and conducted by the adjunct faculty).*

*4) A "Back up" Plan to Assist Slow Learners*: There are always students that tend to fall behind, or do not get it the first time; and therefore, require more attention and/or assistance to try to catch up! The instructors did find out, soon after the course had started, who amongst the group required additional help to cope with the material and raise his/her standard to the desired level. The devised plan (*Back up Plan*) was a combination of the following: (i) allocation of additional time to help reinforce information given during regular class time; (ii) simplification of the harder concepts using different techniques and/or applications, and; (iii) attempting to instill a sense of community amongst the students- so that students themselves would help each other in coping with the material and overcome some of the more demanding parts of the course. By the end of the course, almost 15% of the students had benefited from the *"Back up"* plan, and were appreciative of the additional effort and care shown by the instructors and members of the group.

**Course Delivery**: Getting off to a good start proved to be vital to instructors and students alike. The first two sessions were ideal opportunity to be clear about expectations and to impress on the students that the course is well-planned and organized in such a way that having two instructors is positive and very beneficial to the students long-range. It was the time for the two instructors: to share their views and expectations for the course, to describe the overall goals of the course, to explain the role of each of the two instructors in the course; and in particular, how the two instructors plan to "intertwine" the course material, letting the practice and its ramifications supplement the theory, the principles, and the descriptive portions.

Typically in the 50 minute lecture period, one of the two instructors would start the session by: presenting the topic on hand, disseminating the prepared material (aided by the overhead projector), followed by a pause for a few minutes. During the pause, the students would raise questions that are normally answered by either one of the two instructors; then the lecture is resumed and brought to a terminal point for the day followed by either: an open discussion, a demonstration, an elaboration and/or comments made by the instructor who is not the lead instructor for that day or that week. Each class period was designed with the goals of (i) improving students understanding of the new concepts in a systematic manner, and resurrecting some of the knowledge they had in *Geotechnical Engineering I*, such as: stresses and strains, shear strength and failure in soils, compressibility and settlements, etc.(ii) having students apply the new learned concepts, and develop in them the ability to "globalize" by looking at the problem on-hand from different perspectives, and (iii) help stimulate interaction by encouraging students to ask questions during the pause periods, and help them develop the self-confidence needed to overcome language difficulties resulting from the fact that the language of instruction is English while students' native language is an entirely different language!

Another way to establish a positive classroom demeanor was: to adhere to the scheduled start and stop time of the class; to deliver the material at a reasonable pace; to assign "help" sessions when needed; to avoid reading "verbatim" from the textbook or other references; to provide copies of relevant materials to help students reduce having to take extensive notes during the class period; and to make use of a website to deliver appropriate course-related material as needed. Also, the two instructors were generous with their time during office hours; and were responsive to students' requests, and open to suggestions and new ideas. To further promote a successful classroom environment, the instructors, utilized positive, optimistic, and success-oriented teaching. They were trying to harness a spirit of cooperation and understanding; and to foster a desire amongst students to do their "level best!", and that effort and time spent by the students is going to pay off at the end. Despite the positive spirit that prevailed, the instructors were apprehensive and concerned: as to whether they would be able to meet stated objectives and bring the course to a successful conclusion? A list of their concerns included the following:

- Are the students being *overloaded*? And is the material being delivered at the *right pace*?
- In terms of time and effort: the course should probably be worth *four* credit hours rather than t*hree*? And a recitation and /or a lab session need to be added.
- From students' perspective, having *two instructors* in the classroom, at the *same time*, is not common and may be *confusing* to some students.
- Are instructors' *expectations realistic*? Will the students *respond positively* to this novel approach of course delivery?
- Having two instructors in the class, how should *students' performance* be measured? Do students need to have *rapport* with both instructors?
- Are *instructional activities* properly designed to meet the challenge?

Towards the latter part of the course, and because of class time limitations, the instructors had to eliminate some of the topics that had been scheduled initially. It was later realized that there was more material in the initial syllabus than could be effectively handled. Another aspect that had been discussed, but not fully implemented, was the need to cater to different learning styles. (4) Learning style practices should conform to accepted standards, and be carried out by competent instructors, who could devise suitable activities that appeal to each learning style. Also, to promote effective learning, within the context of varied learning styles, it is advisable to form groups within the class and to monitor the performance of the groups to insure that each and every group is a "working unit," and members of the group do get along well, help each other and learn from one another! In *Foundation Engineering*, the instructors grouped the students, devised activities and tasks that brought the students closer together, and made sure that joint tasks were consistent with course objectives. Therefore, an attempt to create an *active learning* environment was pursued in this experiment, despite the fact that traditional teaching methods were dominant and practiced on a wide scale. *Active learning* implies class participation, i.e., the students, the instructors, and the teaching material are intertwined through preconceived and organized learning/teaching activities.[3] Research has shown that what students tend to remember is highly correlated with their level of involvement.[5,6] Edgar Dale's cone of learning[7] shows that students remember about 20% of what they hear, 30% of what they see; but tend to remember up to 90% of what they actively participate in, such as: discussions, questions and answers, problem-solving, and hands-on activities. This is to say: the higher the level of student involvement, the greater is his/her comprehension and the higher is his/her retention. Indicators have shown that an *active learning* environment has a positive impact on student's personality. It tends to boast self-confidence, improves communication skills, and makes the student a better team member. For *cooperative learning* experience to be successful, it is imperative that the following be integrated into the class activity :[5, 8]

- *Interdependence*- Students should perceive that they need each other to complete the planned activity;
- *Interaction*- Students should work together in planning, executing, and arriving at conclusions. They should share the work load equitably and share the credit;
- *Accountability*- Students should be accountable individually as well as a group. Keeping track of knowledge gained by the individual (through the group) should not be overlooked;
- *Sharing known skills*- Students who possess certain knowledge or skills (computer skills, laboratory skills, data analysis and reduction skills, writing skills, presentation skills, etc.) should be willing to pass it on, and/or share it with their group members;
- *Collaborative skills*- Groups cannot function effectively if members do not have (be willing to learn) or use some needed social skills. Such as: leadership, decision-making, trust building, and conflict management;
- *Monitoring progress*- Groups need to discuss amongst themselves whether they are achieving their set goals; they need also to prioritize the scheduled activities, introduce changes when needed, solicit advice and assistance with the consent of the instructor, and maintain cordial and working relations amongst the members. Instructors also should monitor groups' progress, give feedback on how each group is performing, and insure adherence to accepted standards of: ethics, social responsibility, and safety.

Success in implementing *active learning* is attributable, in large measure, to: proper planning, dedication and care shown by the instructors, as well as their abilities and foresights. Experience is definitely a major factor. A proper start for instructors wanting to try *active learning* versus traditional methods of delivery is to step into it gradually, seek continuous feedback from students who are directly involved, and consult with experienced colleagues who can offer constructive comments and advice. [3, 9]

**The Role of the Adjunct Faculty**: From the previous sections, it is reasonable to infer that *Foundation Engineering*, in general, went rather well and was almost on target! In retrospect, proper planning that preceded course delivery had a lot to do with the success achieved. In all fairness, adjunct's eagerness, desire, commitments, and efforts were instrumental in meeting set goals, and declared objectives, i.e., “bring the practice into the classroom”.

On the ***planning*** side, and after a careful review of the syllabus, the adjunct was able to generate the material (design procedures in use, relevant construction and constructability issues, prevalent soil conditions, lessons learned, typical foundation behavior and potential problems in the locale, and a great deal of relevant case studies, statistics, presumptive bearing capacity values, etc.). He was also able to sort it out, stream line it, and diffuse it within the general course outline so that it supplements the various topics as specified in the course chronology. His selections of *case histories* were: relevant, concise, derived from the locale, and addressed timely issues and concerns. He and his teammates (his colleagues at work) were the proponents of the selected *cases.* They were responsible for data acquisition, engineering analysis, the write-up, and the final recommendations. The three selected *field trips* were also based on the adjunct’s recommendation, who prepared a write-up for each, explaining what would be observed, and the significance of the observations, and how do field observations relate to the specifics in the syllabus.

On the ***Delivery*** side, the adjunct was always on time, physically present in class with the full-time faculty the entire semester, ready to contribute and/or express his views at the appropriate moment. He made good use of his “lap top”, and often resorted to “xeroxed” handouts to reduce students’ note-taking during the lecture. When his turn came to deliver his part, he was courteous, considerate, and spoke slowly and clearly. His main contribution in every session was to supplement the subject matter, with relevant examples derived from the Region, focusing primarily on the “practice” or the practical side of the topic on hand. For example, when *settlements of shallow foundations* was the theme under consideration; he showed: *settlement plates* being installed and fully operational; an example of the discrepancy between *measured* and *calculated* settlements; guidelines for *tolerable* settlement based on local *building code*; and presented *allowable bearing pressures* in sandy soil based on settlement consideration. He often, presented valid points and commented on the specifics of the day during the *pause* periods; led the discussion at the end of the session, and answered questions even when improperly phrased! The three case studies he chose to present, during the latter part of the course, were extremely valuable, relevant, and well received. He was extremely helpful during office hours, and the rapport he initiated with students during the first week, he was able to sustain throughout the semester. His contributions to the experience during the aforementioned semester can be highlighted as follows:

- His foresight, effort, an abilities as a practicing engineer did enrich the course, made it more relevant, and brought “real” problems into the class room;
- Drawing on his own experience as a geotechnical engineer in the locale, provided students with first-hand information about local soils and their potential behavior in supporting foundations;
- His ways of responding to questions, engaging students, and encouraging them to come forward with their questions and comments, promoted confidence and community amongst the students;
- The presence of the adjunct faculty in class, side by side with the full-time faculty member, broke the monotony often experienced in traditional lecture room setting, and was instrumental in creating a class room environment, that resembled a

professional engineering forum.

The full-time faculty member (at that time), was lucky to have had the adjunct by his side. He (the full-time faculty) gained a lot from the experience. Once the precedence has been set, other faculty members in the Department wanted to follow suit, and began their search for the right type of practitioners, to enrich the academic process by bringing the practice into the class room. After *Foundation Engineering* was over, and the final course grade was out, a "questionnaire" was sent to those who enrolled in the class seeking their opinions, evaluations, and any comment(s) they may wish to offer. Twenty six out of a total of 30 students returned the "questionnaire" on time! The opinions expressed and comments made were, by and large, positive to say the least. After regrouping, and rephrasing to correct the English language; some of the comments offered by the ex- students, could be summarized as follows:

- The adjunct was easy to approach every time and every where, and was always helpful,
- His input into the course has dramatically improved students' understanding of the material, enlivened the experience, and made the course more meaningful,
- Many students felt that the adjunct faculty was eminently qualified to teach *Foundation Engineering by* himself, should the need arise. On the other hand, a considerable number of the ex-students approved of the arrangement of having the two instructors in the classroom; and many argued that *Foundation Engineering* could not have been delivered as effectively, had it not been for the two instructors working harmoniously together in planning and delivering the course material,
- Some students expressed their desire to see similar arrangement be implemented in other Civil Engineering courses; with particular reference to design and construction type courses,
- The field trips, planned and conducted by the adjunct, were described as: very useful, particularly in developing an awareness of how soil exploration work is performed in the locale. Also their comments on the value and benefits derived from the Plate Load test and settlement monitoring site were equally positive.

The experience reported on here was repeated several times; and a number of minor changes, mostly in sequencing teaching material, were since introduced. The experience has gained momentum, and has since been applied to other engineering courses in the same institution.

**Summary and Concluding Remarks**:

Properly selected adjunct faculty can enrich an engineering program by bringing their practical experience and by introducing relevant field applications and problems to the classroom. Adjunct faculty members can also provide important linkages for developing joint programs between industry and academic departments, and employment opportunities for graduates. Nevertheless, the position today of adjunct faculty, in most engineering colleges, is tenuous, subject to change in enrollments, negative administration and faculty perception, limited connectivity with mainstream issues, often marginalized by the tenure system, and their presence on campus is considered as temporary; until replaced by a "full-time" faculty member. The current practices of hiring adjunct faculty, their "diminished role" as academics, and the difficulties that most of them encounter in engineering colleges, today, must change! A change towards: improving the image, recognizing the rights, and acknowledging the contributions of the adjunct, need to permeate in the academic circles, in an attempt to correct misconceptions that have persisted for a very long period. The adjuncts, by and large, are extremely capable. If treated fairly and given the opportunity, they would indeed enhance the teaching/learning process; and in all likelihood, do what we, the “full-time” faculty, could never do, i.e., bring the practical experience into the classroom!

Another arena for the adjunct, who possesses a proven record of practical experience in a specific area, is to “team-up” with the “full-time” faculty, in an attempt to bring in the practical side of the subject into the classroom. This means that two faculty members (the “full-time” faculty and the adjunct) would share in teaching the class. There are various possibilities on how to “intertwine” the teaching material, and merge the teaching activities. In all likely hood, the main “run of the mill” instructional activities, are usually “put across” by the full-timer, while those intended to shed light on the practical side, are normally handled by the adjunct, who is most likely, a practitioner.

This paper reports on a success story of such a merger in a geotechnical/foundation class. The success achieved was attributed, in large measure, to the proper coordination that preceded course delivery. In this exercise, an experienced and willing practitioner was sought out to supplement the regular lectures offered in an elective course to 4th year civil engineering students. In addition to the practice-related activities brought into the lecture hall; case histories were also introduced by the practitioner, as well as pre-selected field trips, focusing on soil exploration and other relevant monitoring and testing procedures.

Students’ evaluations, their views, comments and overall impressions (during-and at the end of the course) have been very encouraging to say the least! The positive outcome of this experience has lead other faculty members to follow the same path by searching for practitioners-as adjunct faculty- to assist in bringing-in the practice into the classroom.

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# INTEGRATING STUDY ABROAD EXPERIENCE WITH TEACHING SUSTAINABILITY COURSE IN AFRICA

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**Abstract**
The environment has some capacity to cope with the impact from all human activities so that a certain level of impact can be absorbed without lasting damage. However, studies show that current human activities exceed this threshold with increasing frequency, diminishing the quality of the world in which we now live and threatening the well-being of future generations. Part of this impact derives from the manufacture, use, and disposal of products which are made from materials.

This paper presents a method of teaching and exploring sustainability within the materials, manufacturing, and design context by highlighting a study abroad course that was taught during the 2011 May term. The program was led by Professors from University of Minnesota Duluth (UMD), USA and Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana. It exposed students to global concepts of sustainability with emphasis on alternative materials and manufacturing methods in Ghana. Learning was reinforced by visits to local manufacturing facilities, art centers, museums, and historical villages. Also, students were engaged in cultural activities including: learning Akan language, dancing, keyboarding, textile dying, and basketeering as part of their study abroad experience in Ghana. During the program, students were given projects to analyze, evaluate, and make recommendations on how to improve on the sustainability aspects of a product. The major sustainability measures considered are embodied energy and carbon dioxide ($CO_2$) footprints and the projects conducted were on bamboo bicycle frame; non-chemical water filter; and production of kente cloth. Students' learning was assessed with written report, project presentation, and diary of tours/cultural activities linked to sustainability.

Keywords: Sustainability, Embodied Energy, Eco-audit, Environmental Impact, and Study Abroad

## I. Background

UMD and KNUST have agreed to establish collaboration in teaching, study abroad experience, and research between the two universities. A three-credit sustainability course is designed for junior and senior level Mechanical, Industrial and other Engineering major students in the College. This course is taught as a short term study abroad program consisting of two and half hours of lecture and several hours of field trips at KNUST, Kumasi, Ghana, West Africa. The UMD College of Science and Engineering is a predominantly four-year ABET accredited engineering school offering engineering degrees in Mechanical & Industrial, Chemical, Computer Science, Civil and Electrical & Computer Engineering. The College of Engineering at KNUST comprises of four Faculties and two Research Centers. The Faculties include the Faculty of Chemical and Materials; Civil and Geometric Engineering; Electrical and Computer; and Mechanical and Agricultural Engineering. Their Technology Consultancy Center (TCC) and Energy Center are the main research wings of college. KNUST has several programs that focus on use of local materials and processes for making eco-informed products including non-chemical clay water filter developed by TCC; and bamboo frame project by Materials Engineering.

## II. Objectives of the Course

It is hopeful that upon completing this program, the students will be able to perform the following tasks: (1) Analyze and describe any materials' life cycle; (2) Conduct eco-audits using CES EduPack eco-audit tool; (3) Analyze eco-data: values, sources, precision; (4) Design an eco-informed product; (5) Relate legislation with sustainability; (6) Write report on a sustainability project; and (7) Make oral presentation on sustainability project and Ghana trip experience.

Objective one is achieved through lectures and case studies on life cycle of products and International Standard Organization (ISO) 14000. Objectives two through four are achieved through lectures and completing group projects on sustainability. During the program, students will use EduPack Software, Granta Design[2] to facilitate learning and implementation of projects. Objectives five through seven are achieved through report and oral presentation. Students are required to prepare their reports in an engineering technical paper format and the presentations are made in two parts: first part on results of project and the second part on Ghana trip experience.

## III. Description of Course

The course has three major components: lecture; projects/cultural activities/tours; and report/presentation as illustrated in Figure 1. Each of the components is described in the following paragraphs.

**Lecture.** The lectures are used to educate students on topics related to sustainability including: material resources; consumption; depletion; environment emissions; life cycle assessment (LCA); and recycle. An approach that the lecture emphasizes is the principles guiding a simple and rapid strategy for implementing eco-informed decisions at the design stage of product development. Developed by Ashby[1], the approach has three major components: Adoption of simple metrics of environmental stress; Distinction of the four phases of life; and Formulation of design objectives based on the energy or carbon breakdown of the phases of life. However, before this strategy is introduced and implemented in the lecture, the students learn the details and difficulties of full Life Cycle Assessment (LCA). The standards for conducting an LCA, issued by the International Standards Organization (ISO 14040 and its subsections 14041, 14042, and 14043) are studied in full, stressing the difficulties of interpreting the aggregate measures (eco-indicators) by an engineer at the design stage of product development. Further, the students learn streamlined LCA as an alternative strategy to simplify the complexity of a full LCA study; this method of assessment focuses on the most significant inputs, neglecting those perceived to be secondary. Figure 2 illustrates a typical material life cycle that was studied, where an ore is mined and processed to produce a usable material, which is then transformed into a more useful product via manufacturing processes. At the end of useful life of the product, it is disposed, recycled, or refurbished and reused. An important outcome from learning LCA is that students understand that at each stage of life of a product, energy and materials are consumed and emissions are generated that include:

waste heat and solid, liquid, and gaseous emissions. Students are able to evaluate energy or $CO_2$ footprint as the logical choices for measuring environmental impact because they are related and are understood by the public at large.

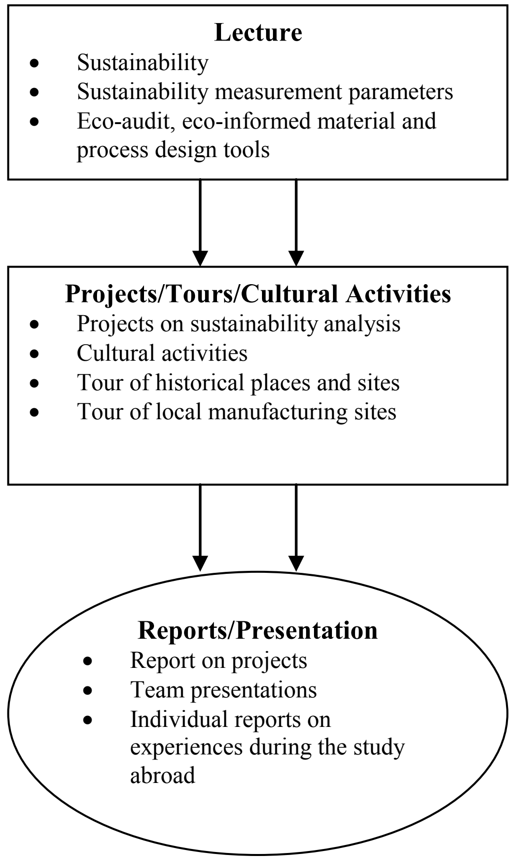


Figure 1 Components of the study abroad program

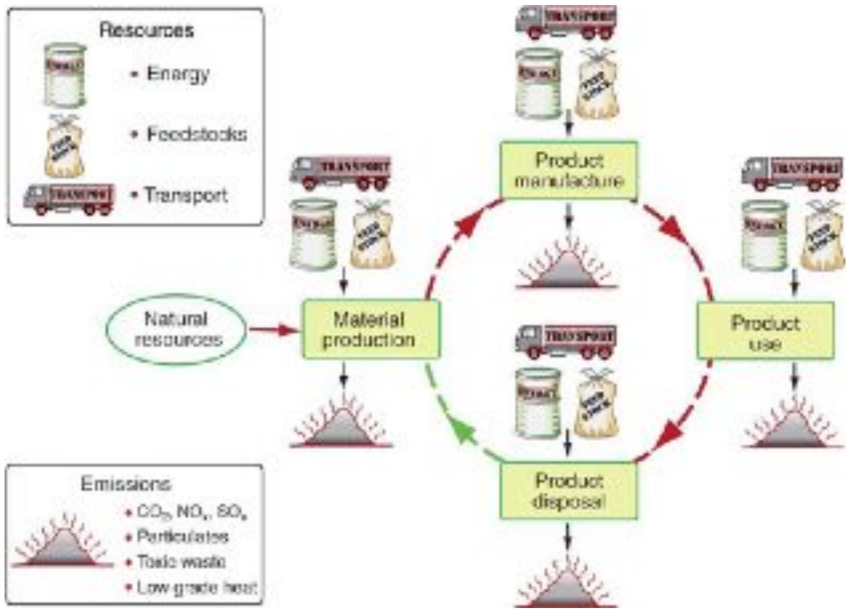


Figure 2 The material life cycle showing consumption of energy and materials and emission of waste heat, solid, liquid, and gaseous emissions. (Ashby, 2009)

**Projects, Tours and Cultural Activities.** Three groups consisting of three students in each are formed and assigned to work on three different sustainability projects. The projects are defined with opportunities to analyze the sustainability of locally made products and conduct comparative analysis with non-locally made similar products. The results from the sustainability analysis are then used to make eco-informed decisions about actions that should be implemented to reduce environmental stress of the products studied. Figures 3 illustrate the three projects which are titled as follows: sustainability evaluation of kente cloth production process; sustainability analysis and evaluation of a bamboo bicycle frame; and sustainability evaluation of locally manufactured non-chemical clay water filter. These projects are briefly described in the following paragraphs.

3.1 Kente textile production

3.2 Bamboo bicycle frame

3.3 Non-chemical Clay water filter

Figure 3 Three projects on sustainability

*Sustainability Evaluation of Locally Manufactured Non-chemical Clay Water Filter.* The Applied Industrial Ceramics Center of KNUST has developed and manufactured a non-chemical water filter from clay material to be distributed to the rural villages for filtering drinking water. This will have great impact on the lives of people living in areas where water filtering is normally avoided due to unavailability of an affordable and functional water filter. The materials used in the design and manufacture of the water filter are classified as renewable because they are natural and can be recycled. Amongst the five major components of the water filter, two are imported from China; two are transported from Accra, Ghana; and the filter unit is made locally with clay at KNUST. Figure 4 is a picture to illustrate the components of the water filter unit. The manufacturing processes involved in making the filter include: clay molding; slip casting; firing; and sintering. The objectives of this project include: to analyze and evaluate the sustainability and economics of this product; compare the results to similar type of filter but made with nonrenewable materials; and make recommendations that will focus at making the non-chemical clay water filter more eco friendly.

Clay filter

Figure 4 Assembly of the clay water filter

*Sustainability Evaluation of Kente Textile Production Process*. Kente weaving was developed in the 17$^{th}$ Century A.D. by the Ashanti people from the town of Bonwire; now the leading Kente weaving center in Ashanti, Ghana. Kente was adopted as a royal cloth and is produced as a cloth of prestige reserved for special occasions. The weaving apparatus are hand made by weavers themselves or by others who are specialized in equipment making. The loom is one such apparatus that is constructed with wood; a set of two, four or six heddles attached to treadles with pulleys and spools inserted in them; shuttels with bobbins inserted in them, and sword stick. Yarns are from factory made cotton, silk or spun rayon from factories in Ghana and outside Ghana. It takes an average of four weeks to weave 10 yards of kente with triple layer design; triple layer is more complicated than single layer weaving. Loom process is considered renewable as it is made with wood and does not use fossil fuel as illustrated in Figure 5. The objectives of this project include: to analyze and evaluate the sustainability and economics of kente production process; to compare the results to similar kente cloth made by printing; and to recommend solutions to improving the sustainability of the product.

Figure 5 Manufacturing of kente cloth with loom apparatus

*Sustainability Analysis and Evaluation of Bamboo Bicycle Frame*. Youngso project, Apaah, Ghana is manufacturing bicycle frames with bamboo materials. The rest of the bicycle systems are built and assembled similar to our conventional bicycle design. The bamboo material is harvested, treated and inspected before using it as a building material. Once the frame is completed, it is shipped to final destinations of use in the rural areas and sometimes to North America and Asia. Currently, there is a 10 year warranty on a bamboo bicycle frame. Figure 3.2 is a picture to illustrate a finished bamboo bicycle frame. Similar to the other two projects, the objectives of this project include: assessment and evaluation of the sustainability of a bicycle frame built with bamboo material; comparison of bamboo bicycle frame to aluminum and fiber glass reinforced composite frames; and recommendation of solutions to reduce the environmental stress of bamboo bicycle frame. In addition, comparative engineering analyses of the three frame materials are conducted using SolidWorks software.

*Cultural Activities and Tours*. Cultural activities including: learning of Akan language; dancing; drumming; textile dying; and weaving are integrated with the program to give students cultural education about Ghana. In addition, several historical places; manufacturing centers; African art museums; historical villages; and centers of attraction are visited to give students study abroad experience. During these tours and cultural activities, students are expected to keep a diary about their experience including how they impact global sustainability.

**Writing and Presentation.** In the writing component of the program, each group is expected to prepare a detailed report with an engineering journal format describing the project objectives, procedures, results, analysis, and conclusions. Literature survey is conducted by the students to support their background knowledge on the materials, physical properties and current research that have been done on the respective project. On the data analysis and results sections of the report, students are expected to compute and demonstrate the following analysis: (1) Computation and description of embodied energy of the products' components; (2) Computation and description of $CO_2$ footprint of the products; (3) Identification and description of opportunity to improve sustainability of the product; and (4) Evaluation of economics and recommendation of solutions to improve the sustainability of the product.

## IV. Discussion

This approach of teaching sustainability bridges the gap between theory and practical experience that many students encounter in many engineering programs. The study abroad program in Ghana is a whole life experience for the students about Africa and understanding of sustainability from a global perspective. The scopes of the projects are designed to be completed in two weeks and give students the practical skill of designing eco-informed products. The project teams are formed to have both multicultural and multidisciplinary characteristics; as a result, providing opportunities for the students to learn engineering from varying perspectives. There are advantages and disadvantages associated with this approach of delivering education to students as follows: (1) Teaching sustainability course in Africa provides the students an opportunity to learn and understand sustainability from global perspective; (2) Integration with cultural activities and tours provides the students with better education about how Africans live with specific emphasis on Ghana; (3) The projects conducted facilitate students' understanding and retention of course material on sustainability; (4) Students develop critical thinking skills as they are challenged to provide and describe solutions to improve sustainability of a product at a design stage; (5) Students become familiar with writing conventions of engineering journals; and (6) Students learn to work and write in multicultural and multidisciplinary teams.

Few of the disadvantages that may be associated with this approach of learning are: (1) The cost of completing the three credits course is higher than a normal three credit course taken at home; and (2) Increased faculty and student time is required daily to accommodate the cultural activities; tours; projects; evaluation of reports; and presentations.

## V. Assessment of Course

*Students' Assessment*. Students are assessed on the three areas of the course: lecture/project; report/presentation; and cultural activities/tours. Students' participation on the project is evaluated by faculty observation, as well as students' team evaluation. Their reports and presentations are assessed as a team and as an individual respectively. Their experience from the cultural activities and tours are evaluated from the journal they have kept about the sustainability aspects of these activities.

*Course Evaluation*. One of the primary reasons of the course evaluation is to find out how the students feel about some of the activities that were included in the program; what should be removed or retained if the course is to be taught again. An evaluation was conducted by KNUST and another was conducted after the students have returned home by UMD. The students have provided positive feedback to this learning approach and have shown to have deeper retention of the subject. All the students expressed that they hold different opinion about Africans and how they live. They expressed that the cultural activities and tours were the best part of the program and should be continued. They liked the multicultural and multidisciplinary nature of the teams because it provided opportunity for them to exchange both cultural and political knowledge about USA and Ghana. However, they expressed that the time was not enough for them to prepare detailed report that was expected from them. Finally, they expressed that integration of an eco-audit and material selection software in the program was very valuable and should be continued with a level three version of the software.

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# Curriculum Assessment Using Professional Certification Criteria

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## Introduction

This paper describes a curriculum assessment approach developed for a graduate-level program in environmental health and safety (EHS). The program was created in the mid-1970s to serve a growing need for trained safety professionals and its graduates are considered by many EHS professionals to be qualified and prepared for practice, as evidenced in part by informal employer surveys and placement rates annually approaching 100% within six months of graduation. But employer surveys and placement rates do not provide much information useful for curriculum assessment. Recognizing that the curriculum itself had not undergone any recent assessments, program faculty decided in 2008 to address the following question: does the current curriculum provide sufficient opportunity for students to obtain the knowledge and skills required for professional practice in EHS? Further, how could faculty answer this question internally without bias?

To answer these questions, the program faculty quickly realized they needed an objective, externally-based curriculum assessment scheme. The point cannot be emphasized strongly enough: this was not an outcome assessment effort. Although an important piece of the overall assessment puzzle, the faculty was not interested at this time in assessing how well its students were learning the subject matter being presented in the curriculum. Rather, the faculty was more interested in the fundamental questions of curriculum assessment mentioned above. After all, outcomes assessment inherently assumes that a good outcome measure indicates effective learning which, in turn, positively correlates with the professional quality and competence of a program's graduates. However, what if a student learns a topic well, but the topic is irrelevant to practice? Or, what if a topic relevant to practice is only mentioned in the curriculum – or worse, not presented at all? Without proper curriculum assessment, outcomes assessment may reliably measure a graduate's learning, but runs the risk of being an invalid tool for assessing their professional quality and competency.

### *Current practice*

In this context, learning outcomes are most commonly described as the foundation for driving programmatic changes, but at least for STEM-based programs, most outcomes are adapted directly from ABET criteria for accreditation and are accordingly vague (e.g., "an ability to communicate effectively"). Worth noting as well, ABET clearly defines program outcomes:

> "Program **outcomes** are narrower statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program." [1]

However, the "skills, knowledge, and behaviors" are not defined in any way. In fact, most accreditation and certification boards leave it to program faculty to decide what skills, knowledge and behaviors should be included in their program in order to meet their stated outcomes. For example, the Educational Standards Committee of the American Society of Safety Engineers (ASSE) had worked with ABET in the mid-2000s to specify specific program criteria required to be in place if a program wanted ABET accreditation. Subsequently, this committee published guidelines for the broad topics to be included in a safety curriculum, but with a caveat:

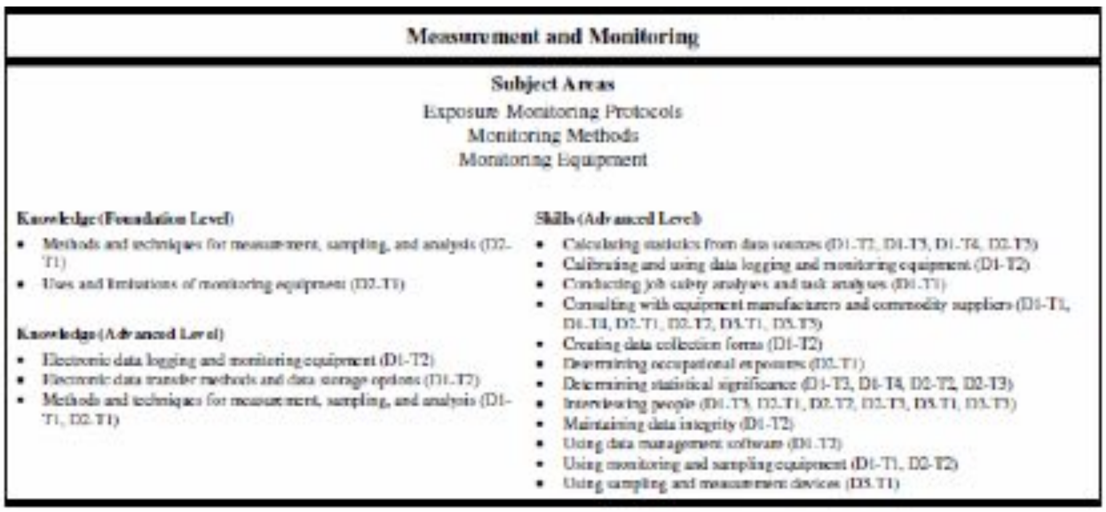
> "The committee did not want to provide a long list of required courses or topics areas that were common in previous safety curriculum criteria by the [Board of Certified Safety Professionals] and ABET. The committee believes strongly that programs should be provided flexibility…"[2]

Yet, anecdotally, most programs typically exercise the flexibility to *not* assess their curriculum at this level. Of the academic programs that do, *curriculum mapping* appears to be the most common tool used to make this decision.[3,4,5] This method requires identifying what students do in their courses and what the faculty expects them to learn (the skills, knowledge and behaviors) and then clarifying the relationship between the two, or "mapping the curriculum." This process reveals if a student's learning opportunities are linked or consistent with faculty expectations. Inconsistencies suggest places for curriculum improvement that bridge the gap between the two and, in turn, increase the likelihood of meeting program objectives. In order to identify the skills, knowledge and behaviors needed by a student, common practice is to glean information from a program's stakeholders (e.g., faculty, administration, alumni, employers, funding agencies, peer programs, and professional societies). However, each stakeholder has its own agenda and another problem arises: each party has a different and biased opinion about what students need to know when they graduate.

***External job analysis***

Notably, accredited certification and licensure agencies utilize recognized methodologies based on a voluntary consensus standard for Conformity Assessment (ISO/IEC 17024) in order to ensure that their examinations test people on the activities, knowledge and skills required in their profession. The key step in this process involves a job analysis of current practitioners. Within the EHS profession, the Board of Certified Safety Professionals (BCSP) has a primary mission to assess the professional competency of safety professionals via the Associate Safety Professional (ASP) and Certified Safety Professional (CSP) exams. Surprisingly, the BCSP was very transparent in its exam development process, publishing highly-detailed "blueprints" describing the skills and knowledge expected of a safety professional and from which the ASP and CSP exams were developed.

The exam blueprints were derived from a three-stage job analysis study of current safety professionals, including 1500 survey responses with respect to the skills and knowledge needed to perform the safety job in a professional, competent manner.[6,7] BCSP then categorized the resulting 249 knowledge items as either "foundation" (relevant to the ASP exam) or "advanced" (relevant to the CSP exam) and listed the knowledge items along with an additional 298 skill items under a hierarchy of domains (e.g., risk management) and tasks (e.g., "design effective methods to reduce or eliminate risk"). Relevant to this initiative, the BCSP also undertook a generalized curriculum mapping effort, linking the skills and knowledge items with 15 "subject matter" domains typically taught in a safety program[8] (see example for Measurement and Monitoring in Figure 1) – but provided no guidance on how to adapt this generalized curriculum map to a specific program. However, in a separate publication, one of the individuals involved in the original job analysis study did provide some guidance by not only describing the job analysis survey but also suggesting several ideas for using its results to assess a safety curriculum.[9] With these two sources of information in hand, the program faculty now had an objectively derived set of skills, knowledge, and behaviors and also some ideas as to how to assess the curriculum.



**Measurement and Monitoring**

**Subject Areas**

Exposure Monitoring Protocols
Monitoring Methods
Monitoring Equipment

**Knowledge (Foundation Level)**

- Methods and techniques for measurement, sampling, and analysis (D2-T1)
- Uses and limitations of monitoring equipment (D2-T1)

**Knowledge (Advanced Level)**

- Electronic data logging and monitoring equipment (D1-T2)
- Electronic data transfer methods and data storage options (D1-T2)
- Methods and techniques for measurement, sampling, and analysis (D1-T1, D2-T1)

**Skills (Advanced Level)**

- Calculating statistics from data sources (D1-T2, D1-T3, D1-T4, D2-T3)
- Calibrating and using data logging and monitoring equipment (D1-T2)
- Conducting job safety analyses and task analyses (D1-T1)
- Consulting with equipment manufacturers and commodity suppliers (D1-T1, D1-T4, D2-T1, D2-T2, D3-T1, D3-T3)
- Creating data collection forms (D1-T2)
- Determining occupational exposures (D2-T1)
- Determining statistical significance (D1-T3, D1-T4, D2-T2, D2-T3)
- Interviewing people (D1-T3, D2-T1, D2-T2, D2-T3, D3-T1, D3-T3)
- Maintaining data integrity (D1-T2)
- Using data management software (D1-T2)
- Using monitoring and sampling equipment (D1-T1, D2-T2)
- Using sampling and measurement devices (D3-T1)

Figure 1: Example of BCSP's mapping of knowledge and skill items to subject matter areas. The D (domain) and T (task) numbers cross-reference the underlying exam blueprints.[8]

## Methodology

Because of the sheer number of skill items and the difficulties in teaching skills in a traditional academic setting (most skill development occurs during actual practice, such as in an internship or after graduation, although lab experiences mitigate this to some degree), the faculty decided to exclude the 298 skill items identified by the BCSP from the assessment and focus exclusively on the 249 knowledge items. Although the paper describing the job survey suggests several ideas for how the blueprints might be used to assess curriculum, it provided only cursory details with respect to implementing any of the approaches. Nor had any academic EHS programs published any work utilizing these suggestions. So, without any precedents on which to rely, the program faculty decided to proceed with developing its own methodology for assessing its curriculum.

To accomplish the review, the program instructors and three recent graduates from each course were recruited by the faculty to provide feedback voluntarily. The first task for the participants was to review the curriculum course-by-course. For each of the fourteen courses in the program, the instructor and students were asked individually to go through the complete knowledge item list and mark all items they believed to have been covered included in the course. This step helped narrow the focus of each subsequent course review as any items left unmarked by all four individuals in this phase were not included in later phases of the project. In addition, a primary, secondary or tertiary priority ranking was assigned to each remaining item based on the number of respondents marking the item (e.g., 3 or 4 marks indicated a "primary" topic for the course).

Next, for each course, the individuals rated the extent of coverage for the remaining knowledge items using the criteria in Table 1. To improve consistency between respondents, one person conducted personal interviews with each respondent to allow discussion and clarification of the knowledge items and assist respondents in determining the appropriate coverage rating. This person also gathered anecdotal evidence on each criterion to support the ratings given and explain any discrepancies with the priority assignments. The resulting ratings and rankings for each of the knowledge items across the 14 courses were then entered into a Microsoft Excel spreadsheet. Analysis of this master dataset consisted of exploring coverage at three levels: individual knowledge items, knowledge items within subject matter areas (as defined by the BCSP) across the program and knowledge items within a course.

Table 1: Rating scale for knowledge item coverage

| **Evidence of Item Coverage Within a Course**<br>**Rating Scale: (0-5)** | |
|---|---|
| 5 | Thoroughly covered in lecture. Projects, presentations, quizzes, tests or other tangible products were utilized to assess mastery of the knowledge item. |
| 4 | Discussed extensively in lecture. Material related to the item was included in homework assignments or quizzes to assess the level of knowledge acquired. |
| 3 | Item was covered in the course and included in notes, slides, handouts, activities, etc. However, students were neither tested nor asked to demonstrate their understanding of the item. |
| 2 | The knowledge item may not have been covered or discussed in lecture, but was included in assigned reading material. |
| 1 | Although possibly relevant, the item was not covered in any way in the course. |
| 0 | The knowledge item is not relevant to this course. |

**Results**

Of the 249 knowledge items, only three items (business management software, Poisson distributions, and agricultural/food supply safety) were left unmarked across all 14 courses. On the other hand, 11 items were marked in at least 10 of the 14 classes (including education and training methods, several types of administrative hazard controls, facility safety principles and hazard identification); there were no items that appeared in all 14 courses.

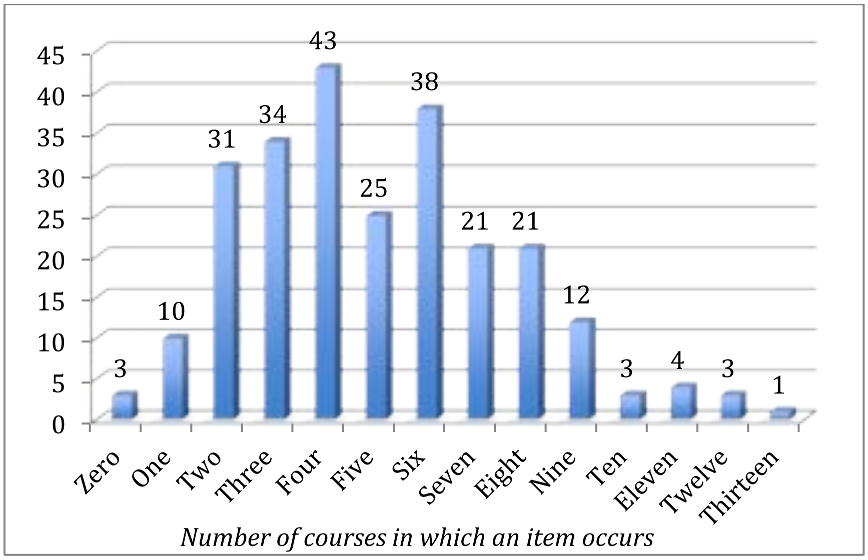



Figure 2. Frequency of knowledge item occurrences within the curriculum (14 courses total)

Coupling this with the coverage ratings, further analysis (Table 2) revealed that the program delivered 88% of the BCSP knowledge items with a quality of coverage rating of 3 or better (76% of the items received coverage ratings of 4 or better while almost 65% were rated as a 5). In addition, aggregating the items into the respective subject matter areas showed that anywhere from 58% to 100% of the knowledge items covered within each of the 15 subject matter area had a quality of coverage rating equal to 3 or better (Table 2). For example, the curriculum covered all the knowledge items in four subject areas with a coverage rating of 3 or better (ergonomics, measurement/monitoring, organizational/behavioral sciences, and risk assessment/management) while failing to adequately cover between 20 and 42% of the items in another four subject areas (business management principles, general sciences, EHS management and auditing systems, and security sciences).

Finally, each of subject areas was investigated further by identifying which courses had adequate coverage ratings for each knowledge item within a subject area (3 or higher) and which courses had inadequate coverage ratings (0-2). At this point, the analysis could have explored knowledge items with excessive coverage (in order to identify items within a course that could be de-emphasized in favor of spending more time on other items), but the faculty chose to focus on exploring which knowledge items were not being covered adequately.

As an example, consider the EHS management and auditing systems area (Figure 3), which had the lowest percentage of items rated as adequately covered (58%). The course level analysis revealed that course 6011 presents all the knowledge items pertinent to this area, covering half of the topics adequately and the other half inadequately. Courses 6002, 6012, 6111, and 6211 each present some of the knowledge items pertinent to this subject area and each does so adequately for at least 20% of the items. Other courses (e.g., 6051, 6101, 6401 and 6821) touch on these items, but only a few and, in many cases, inadequately. A subsequent review revealed that a set of EHS standards comprised the majority of items inadequately covered in the curriculum: the ANSI/AIHA Z10, ISO 19011, the ISO 14000 series and the OHSAS 18000 series.

Table 2. Knowledge item coverage by subject matter area

| Subject Matter Area | Number of knowledge items | % of items rated 3 or higher for coverage | % of items rated 5 for coverage |
|---|---|---|---|
| Business Mgmt Principles | 28 | 71.4% | 39.3% |
| Ergonomics, Human Factors Sciences | 11 | 100% | 81.8% |
| Emergency Mgmt | 8 | 87.5% | 75.0% |
| Environmental Sciences | 18 | 94.4% | 66.7% |
| Education, Training, Communication | 23 | 95.7% | 78.3% |
| Fire Sciences | 11 | 90.9% | 90.9% |
| General Sciences | 8 | 62.5% | 62.5% |
| Hazard Recognition and Control | 44 | 100% | 93.2% |
| Health Sciences | 18 | 94.4% | 61.1% |
| Industry-specific Safety Principles | 12 | 91.7% | 66.7% |
| Measurement/Monitoring | 5 | 100% | 100% |
| Organizational/Behavioral Sciences | 10 | 100% | 50.0% |
| Risk Assessment and Risk Mgmt | 18 | 100% | 55.6% |
| EHS Mgmt and Auditing Systems | 12 | 58.3% | 25.0% |
| Security Sciences | 23 | 78.3% | 26.1% |
| Average | | 88.3% | 64.8% |

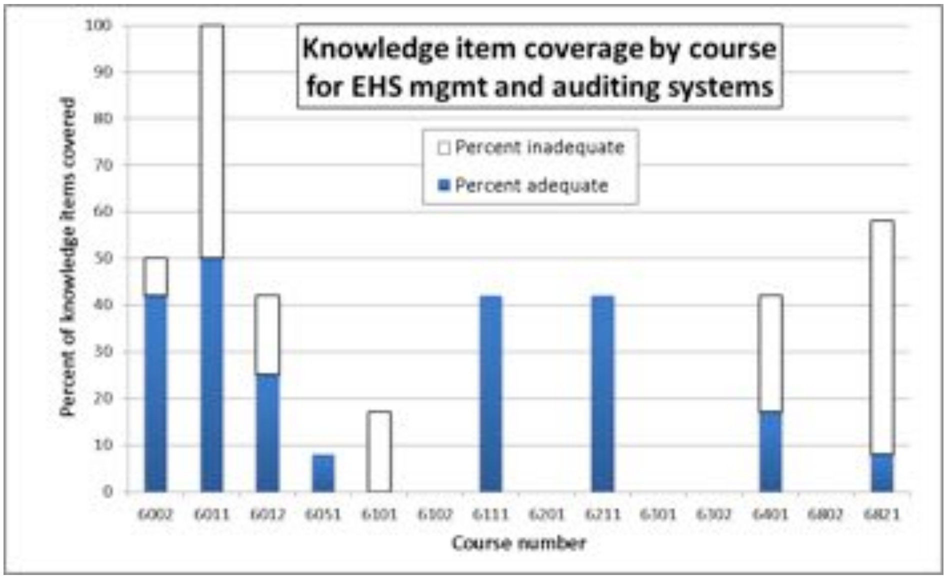



Figure 3: Knowledge item coverage across courses in the *EHS management and auditing systems* subject area. "Adequate" is defined as items covered with a rating of 3 or better.

**Discussion**

As the results suggest, the curriculum was covering the requisite knowledge items, but had room for improvement. The analysis clearly revealed missing knowledge items and inadequately covered material, but more importantly, the results could be easily shared with and utilized by program instructors. For example, by adding a lecture and an in-depth assignment on EHS standards in the 6011 course, a reasonable expectation is that subsequent evaluation would yield higher coverage ratings for many of the individual knowledge items and improvement in percentage of adequately covered items within the EHS management and auditing systems subject matter area. Any additional coverage of EHS standards in other courses likely would further boost these ratings.

The biggest disadvantage in using this approach was the time and effort required. On average, the surveys and interviews took about two hours per course, and each participant had to take their task seriously to provide accurate information. For each course, the instructor had to commit to the time required and provide data not only on the subject matter covered but also information on how material was presented and tested. In turn, a subset of students needed to commit time and effort to do the same, and recruitment was challenging given that some class sizes were quite small. The graduate student on the project spent an average of four additional hours per course: setting up the assessment spreadsheets, coordinating and conducting the surveys and interviews and then entering and interpreting the data.

Although program faculty felt the approach needed some additional fine-tuning in terms of the time commitment, they all agreed that the approach is promising. One main reason is that the BCSP foundation provides a significant degree of objectivity to curriculum assessment. Rather than rely on feedback from numerous stakeholders in the program, each with different agendas and conflicting opinions, recall that the knowledge items used in this approach are derived from a profession-wide job analysis study conducted in compliance with an accepted international standard (ISO/IEC 17024) and utilizing data collected in three stages, including 1500 survey responses from practicing EHS professionals.[6,7] Regardless of academic institution, the vast majority of faculty would not be unable to perform a study of this depth for their program.

More importantly, the results from this approach answered the questions raised earlier in terms of whether or not program graduates are exposed to the material they should know in order to practice as EHS professionals. This curriculum assessment methodology provided answers at several levels by providing baseline measurements of knowledge item coverage both within individual courses and in the overall program. Even more encouraging is that the BSCP made recent changes to its blueprints that should simplify this assessment methodology: the exam blueprints now have fewer domains while more clearly detailing the knowledge and skills areas within those domains.[10] Because BCSP has been open with publishing the skills and knowledge items sets derived from their job analysis studies, this approach can be readily adapted to any EHS program. Degree programs in other disciplines may be able to apply this method, but only if the certification or licensing body for that discipline is willing to share its job analysis results.

## Conclusion

Reflection on this curriculum assessment process identified opportunities for beneficial improvements within both the program curriculum and the methodology itself. But ultimately, by using the certification agency's job analysis data to indicate the knowledge needed by graduates of a safety program and developing a combined rankings and ratings methodology to assess coverage of this knowledge, the faculty was able to satisfactorily and objectively answer the initial question posed: indeed, the program's students were graduating with the "requisite skills and knowledge to practice effectively…in a competent, professional, and ethical manner."

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# Examples of Rubrics Used to Assess ABET Student Outcomes in a Capstone Course

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## Introduction

In our Electronics Engineering Technology (EET) program, we are continually re-evaluating the student outcomes and how they are measured by the assessment process. We have defined, with the approval of alumni and our industrial advisory board, sixteen Student Outcomes labeled (a) - (p). These begin with the ABET Criterion 3 Student Outcomes (a) - (k)[1] , and then add the Program Criteria for Electrical/Electronics Engineering Technology, and some university required student learning outcomes, which are labeled (l) - (p). ABET requires at least one evaluation of each student outcome at some point in the program, preferably toward the end of the curriculum. We have chosen to do most this evaluation in the Project Management/Capstone two-semester course sequence. In the first semester, students learn the theory and basic practices of project management, and also define, plan and begin their capstone project. In the second semester they complete their group project. Most of the program's learning outcomes are assessed using direct measures from evidence of student's project work, with a few assessments coming from the student's opinions of their own progress, an indirect measure. What we are concerned with is how to evaluate the direct evidence of student work, that is, "grading" the student's progress on meeting the assigned learning outcomes.

Almost all evaluation at the level of a program's Capstone course is subjective, as the course deals with how well the student project groups can define and solve a technical problem, not an objective measure such as whether the students know a fact or not. We have found that keeping track of all the evidence of student learning, and doing as objective as possible evaluation of the student's work, requires the use of standardized rubrics.

## Rubric Rationale

Rubrics can be defined as descriptive scoring schemes that are developed by teachers or other evaluators to guide the analysis of the products or processes of students' efforts[2]. The use of a rubric is more likely to provide meaningful and stable appraisals than are traditional scoring methods. Assessing student's knowledge and skills on the basis of a scale offers several advantages. First, it presents a continuum of performance levels, defined in terms of selected criteria, towards full attainment or development of the targeted skills. Second, it provides qualitative information regarding the observed performance in relation to a desired one. Third, its application, at regular intervals, tracks the student's progress of his or her skill mastery[3].

The scoring scale used on a rubric does not have to follow only one pattern. For our program, we mostly use a scale of 10 (high) to 1 (low) on many of our overall scoring rubrics, where we are following a 90% = A, 80% = B, etc., grading scale. Simon describes their process of developing a scale. In the first version, the scale is developed around the expected student performance at the level of excellence. As the course progressed, examples of performance at each level are identified and used to refine the scale. Scoring occurs when the faulty identifies, within the scale, and for each criterion, a description that most closely matches the observed performance. When the faculty use the rubric to assess student work, they can compare the identified or observed performance level to a predetermined standard level[3]. Many other rubrics will have just three or four different levels of measure, as will be demonstrated below.

Another definition of a rubric is that it is a scoring tool that is generally used for subjective and authentic assessments. In subjective assessments, rubrics help create a certain level of objectivity. As a result, learners are clearer about the expectations prior to assessment and are clear about their areas of weakness and strength after the assessment. In authentic assessments (which are usually subjective), rubrics help educators communicate and assess levels of performance[4].

Rogers writes that data collection activities must be examined in light of good program assessment practice, efficiency, and reasonableness[5]. The National Academy of Engineering in 2009 issued a report called "Developing Metrics for Assessing Engineering Instruction: What Gets Measured is What Gets Improved". In that report they reinforce the concept that a sustainable evaluation system must not require implementation that is burdensome to faculty or administrators. Using rubrics for assessment standardizes the evaluation of the assessments, and reduces the burden on faculty time[6].

Rubrics can be used at three different phases of an assignment: pre-assessment, assessment, and post-assessment. In the pre-assessment phase, rubrics can be used to communicate expectations with students; hence, giving them clear directions and helping them avoid confusions which usually hinder their learning. During the assessment phase, rubrics are used to allow for more easily scoring the assignment. After a rubric is scored, the scored-rubric is given back to students to communicate, summatively, their grade and formatively, their weaknesses and strengths[4].

## Rubric Categories and Examples

Traditional education research breaks rubrics into two main categories, analytical or holistic. The rubric in Figure 1 is an analytical, also considered a quantitative, rubric. Analytic rubrics are usually preferred when a fairly focused type of response is required[7]. This example is used as an objective measure, from a test, of how well students learned project management definitions and basic skills such as developing a CPM Chart. In the figure, as we will do for most the rubric examples below, we define which specific ABET student outcome that this rubric helps measure.

| ABET Outcome | Tool | Superior 10 | Excellent 9 | Good 8 | Fair 6-7 | Poor 0-5 |
|---|---|---|---|---|---|---|
| (n) the ability to apply project management techniques | Midterm Test | 100% on exam | 90-99% on exam | 80-89% on exam | etc. | |

Figure 1 Analytical Rubric

Holistic, also considered qualitative, rubrics are used to evaluate or assess the whole process, performance, or product. Although holistic rubrics contain a scale and criteria, their use is such that the element under investigation is given one score for the entirety of the performance. This type of rubric is predicated on the idea that instructors "know quality when they see it"[8]. Further, the use of holistic rubrics is probably more appropriate when performance tasks require students to create some sort of response and where there is no definitive correct answer[7].

Mertler suggests that for holistic rubrics, the faculty should write thorough narrative descriptions for excellent work, down to poor work, incorporating each attribute into the description[7]. Figure 2 shows a holistic rubric used for measuring teamwork, which is a highly subjective thing to measure. The rubric attempts to use descriptive labels to help the course instructor be able to rate student teamwork more objectively.

| ABET Outcome | Tool | Superior | Excellent | Good | Fair | Poor |
|---|---|---|---|---|---|---|
| | | 10 | 9 | 8 | 7-6 | 5-0 |
| (e) an ability to function effectively as a member or leader of a team | Rubric at middle and end of project | Completes all assigned tasks by deadline without prompting<br><br>Work accomplished is thorough, comprehensive, and advances the project<br><br>Proactively helps other team members complete their assigned tasks to a similar level of excellence | Completes all assigned tasks by deadline<br><br>Work accomplished is thorough and advances the project<br><br>Works with other team members as required. | most tasks<br><br>mostly through<br><br>only with prompting | some tasks<br><br>does not advance<br><br>only on some tasks | few tasks<br><br>little work accomplished<br><br>works poorly with team members |

Figure 2 Holistic Rubric Example

Figure 3 is another holistic rubric. This particular assessment is done after the course is complete and grades are given, and the course instructor can be more objective about scoring, and does not have to worry about student reaction to a grade.

| ABET Outcome | Tool | Superior | Excellent | Good | Fair | Poor |
|---|---|---|---|---|---|---|
| | | 10 | 9 | 8 | 7-6 | 5-0 |
| (p) the ability to analyze, design, and implement industrial control systems or computer network systems | Final Report | Design process completely detailed<br><br>All appropriate supporting documents present in written report<br><br>Clear understanding of design process demonstrated | Mostly detailed<br><br>Most<br><br>Mostly clear | Basically detailed<br><br>Some<br><br>Some-what clear | Sketchily detailed<br><br>Few<br><br>Little | Not detailed<br><br>No<br><br>Poor |

Figure 3 Portion of Final Report Rubric

The next example, Figure 4, can also be called a holistic rubric. The rubric is used for the several status reports generated during the course of the project, and also for the final report.

| ABET Outcome | Tool | Superior 10 | Excellent 9 | Good 8 | Fair 6-7 | Poor 0-5 |
|---|---|---|---|---|---|---|
| (k) a commitment to quality, timeliness, and continuous improvement | Status Reports and Final Report | Reasons with all good/correct results and/or interprets data very well.<br><br>Develops exemplary conclusions based on results. | Reasons with mostly good/correct results and/or interprets data well.<br><br>Develops good conclusions based on results. | Reasons with some good/correct results and/or interprets data somewhat well<br><br>Develops some good conclusions based on results. | Reasons with minimal good/correct results and/or interprets a small amount of data well<br><br>Develops minimal conclusions based on results. | Reasons with poor results and/or interprets data poorly<br><br>Develops poor conclusions based on results. |

Figure 4 Holistic Rubric

Holistic rubrics can include examples of work that meet each level of the rubric[8]. In the capstone project the groups must be able to summarize why an organization would pay them to do this project, which we call the Project Justification Statement. Figure 5, in which the actual text of the examples is removed for space reasons in this paper, gives a qualitative description and quantitative number to each example. The students see this rubric before they begin their work.

| | |
|---|---|
| 0 pts. Way too short | Example – 1 sentence |
| 1 pt. Too short | Example – 2 sentence |
| 2 pts. Better – includes numbers & graph | Example – paragraph & graph |
| 3 pts. Nice numbers, but no explanation | Example – table of numbers only |
| 4 pts. Almost good enough | Example – several paragraphs |
| 5 pts. (Few groups achieve this in the first pass) | No example given, so groups don't just copy the good example |

Figure 5 Project Justification Statement Rubric

Rubrics can also be categorized as either formative or summative in nature. Formative assessments are usually administered in the classroom, and are used as feedback to improve teaching and learning. Examples include teacher's feedback on work in progress, such as drafts of papers or preparations for presentations. Summative assessments measure what students have learned at the end of some set of learning activities, such as teacher-made tests at the end of the year[9].

An example of where we use a formative rubric in our program is close to the beginning of the capstone project. In class, in the project groups, the students are asked to do the following exercise of three steps. There is no grade given, but the feedback from the course instructor, using the rubric, helps the groups to begin to plan their capstone project. The results of this rubric, Figure 6, are used as a part of the overall assessment of ABET (f) an ability to identify, analyze, and solve broadly-defined engineering technology problems.

1. Brainstorm and come up with tasks that must be done for your project. Don't limit yourself to putting them in order to start. Just think of tasks that must be done to complete your project. There is a time limit of 5 minutes.
2. Add some detail to the tasks, as needed. 15 minutes.
3. Put the tasks in order, using yellow Post-Its to indicate a time order. 5 minutes

| Brainstorming Rubric | 4 pts Exceeds Expectations | 3 pts Meets Expectations. | 2 pts Nearly Meets Expectations. | 1 pts Below Expectations. |
|---|---|---|---|---|
| Quantity of tasks How many tasks have you considered? | > 20 | 10 – 20 | 5 – 10 | < 5 |
| Variety of ideas Is there are a wide variety of tasks indicated? | There is a very wide variety of tasks indicated | There is a variety of tasks indicated | There is a little variety of tasks indicated | There almost no variety of tasks indicated |
| Depth of Detail Are tasks supported with detail? | All tasks are well supported with many details. | Most tasks are well supported with many details. | Some tasks are well supported with some details. | Few tasks are supported with few details |

Figure 6 Formative Brainstorming Assignment & Rubric

The rubric following, Figure 7, is used on the final report. It is classified as a summative rubric, because it is only assessed at the end of the course.

| ABET Outcome | Tool | Superior 10 | Excellent 9 | Good 8 | Fair 6-7 | Poor 0-5 |
|---|---|---|---|---|---|---|
| (m) the ability to locate, organize, critically evaluate, and effectively use information from a variety of sources | Final Report | Very well researched, excellent sources | Well researched, excellent sources | Well researched, good sources | Fair research, fair sources | Poorly researched, poor sources |

Figure 7 Summative Rubric

The following summative rubrics, Figure 8, are used to assess student essays on what can be termed the ABET "Professional Skills"[10] outcomes. These are qualitative in nature and highly subjective. The assessments of, and rubrics for, these student outcomes are most in need of improvement in our program.

| ABET Outcome | Tool | Superior | Excellent | Good | Fair | Poor |
|---|---|---|---|---|---|---|
| (i) an understanding of and a commitment to address professional and ethical responsibilities, including a respect for diversity<br><br>(j) a knowledge of the impact of engineering technology solutions in a societal and global context | Essay assignment | Complete demonstration and understanding | Thorough demonstration and understanding | Basic | Little | Poor |

Figure 8 ABET Professional Skills Rubrics

The Design Review is an important professional fact of life in the field of engineering and engineering technology practice. In our program we use it when there is a little less than two months to finish the project. The students are given this rubric to see, Figure 9, to help them prepare the appropriate material for the review. The review is done by a panel of faculty, including the Capstone course instructor, the faculty technical advisor, and other Engineering Technology faculty who are not associated with the project. This type of rubric is summative in nature, in that they are given a grade that is a significant part of the semester grade, essentially on the quality of the project work done to that point. But the assessment is also formative, as students use the feedback that they receive, most often from the independent faculty representatives, to improve their project work.

| Design Review Rubric | **4 pts** Exceeds Expectations | **3 pts** Meets Expectations. | **2 pts** Nearly Meets Expectations. | **1 pts** Below Expectations. |
|---|---|---|---|---|
| Up-to-date Status Report, Customer Reviews, Tracking Gantt | X | Present | X | Not present |
| Deliverables Table - show what has been finished | X | Present | X | Not present |
| All documentation that you have to date on what you have done technically on the project. | Documentation is all clear, complete, and organized | Documentation is mostly clear, complete, and somewhat organized | Documentation is clear, but not complete or organized | Documentation is not clear, incomplete, and is disorganized |
| Hardware and/or software of project to date | Project works as plan describes, is almost ready for final version | Project works to some extent, it is clear what works needs to be done in next few weeks | Projects works somewhat, but it is unclear what work still needs to be done | Project does not work, work needed to complete is unknown |
| If you need to change your plan / scope of the project / deliverables, etc., in order to complete the project by Apr. 15, write that out and make it as clear as possible | Plan is Very Clear | Mostly clear | Somewhat unclear | Unclear |

Figure 9 Design Review Rubric

Oral presentations are done at a Senior Design Conference sponsored by the College of Engineering late in the first semester, and again to the entire Capstone course student population, and sometimes underclassmen in EET, at the end of the project. This is used to help assess ABET (g) an ability to communicate effectively regarding broadly-defined engineering technology activities. Figure 10 shows the rubric used, which evaluates both the individual's speaking skills, and the group's PowerPoint and organizational qualities. In the first semester, this provides a formative feedback; whereas at the end of the project it is a summative evaluation.

| **Individual Presentation Skills** | Superior | Excellent | Good | Fair | Poor |
|---|---|---|---|---|---|
| 1. Speaker had appropriate volume of speaking voice. | 5 | 4 | 3 | 2 | 1 |
| 2. Speaker did NOT exhibit nervous habits. | 5 | 4 | 3 | 2 | 1 |
| 3. Speaker made eye contact with audience | 5 | 4 | 3 | 2 | 1 |
| 4. Speaker used visual aids well. | 5 | 4 | 3 | 2 | 1 |
| 6. Speaker had a thorough understanding of the material | 5 | 4 | 3 | 2 | 1 |
| **Presentation Content and Quality – Group – all in group have same score for this** | | | | | |
| 1. Group followed prescribed guidelines. | 5 | 4 | 3 | 2 | 1 |
| 2. Group had appropriate amount of information. | 5 | 4 | 3 | 2 | 1 |
| 3. Group had easy to follow visual aids. | 5 | 4 | 3 | 2 | 1 |
| 4. Group had organized, concise, and relevant information. | 5 | 4 | 3 | 2 | 1 |

Figure 10 Oral Presentation Rubric

As we have developed rubrics over the years, we find some do not fit in the categories mentioned above. We define the following rubric, Figure 11, as a record-keeping or checklist rubric. Moskal defines checklists as an appropriate choice for evaluation when the information that is sought is limited to the determination of whether specific criteria have been met[11]. The course instructor is determining if the project group is updating their project status on a webpage as the project is on-going, and not necessarily assessed the quality of the information posted. Not all items are present from the beginning of the project, so the rubric sections are added as needed. The figure is condensed to show all the items that are present at the end.

| | | | | |
|---|---|---|---|---|
| Project Name | Date Assessed | | | |
| These items are evaluated in the Formal Project Proposal – just need to be present | | | | |
| Title Block, Abstract, Charter, Formal Project Proposal, PowerPoint from Conference | Present - 1 | | Not Present - 0 | |
| Need to be updated during project. If an item is not needed for this project, or is not required to be done yet, do not score it | | | | |
| Reports: Gantt Chart, Customer Reviews, Status Reports, Deliverables Table, Justification Statement | Excellent – 3 Updated on schedule | Good – 2 Missed 1 update | Fair – 1 Missed 2 or more updates | Not Present - 0 |
| Technical Information: System Diagram, Links to similar projects, Pictures/drawings, Circuit schematic, Links to spec sheets, Enclosure drawings, Parts list w/ Costs, Software listings, User's Manual | Excellent - 3 Up to date – matches project status | Good - 2 Behind by 1 date/ revision | Fair - 1 Behind by 2 or more | Not Present - 0 |
| Total - % of possible points | | | | |

Figure 11 Project Webpage Status Rubric, condensed

The project webpage rubric is one that the author has modified and changed the most of any rubric used in the Project Management / Capstone course sequence over the years. Mertler says that you should be prepared to reflect on the effectiveness of the rubric and revise it prior to its next implementation[7]. It does not help retain consistency of scores from year-to-year, which your program may want as you document your continuous improvement efforts, but it is often necessary.

In our EET program we have found that groups write better final reports when the group has been keeping their webpage information updated well[12]. We use this rubric as a part of our assessment for ABET (o) the ability to use appropriate engineering tools in the building, testing, operation, and maintenance of electronic systems.

Another checklist type rubric is shown in Figure 12. There are many different sections to evaluate on the Formal Project Proposal and the Final Report, which take place near the beginning and the end of the project. Both students, as they writing their report, and the course instructor, when grading, can check to see if that part of the report is present. Within each checkbox, without listing levels of excellent, good, etc., the course instructor will give a point value less than max if that section is less than acceptable. Then, the comment section is needed to further elaborate on why this score was given, and can record the quality of that section. This is used mostly as a summative evaluation, but students are given a chance to re-write the formal proposal, correcting shortcomings that are pointed out, in order to improve their score. This rubric makes it fairly easy to assign points and give a grade. The results of this rubric are used as a part of the overall assessment of ABET (p) the ability to analyze, design, and implement industrial control systems or computer network systems.

| **Section** | **Points** | **Sections** | | | **Comments** |
|---|---|---|---|---|---|
| On time? | -10/wk. | | | | |
| Title Page | 2 | | | | |
| Sec. I Exec. Summary | 3 | One page? | Completely describe? | | |
| Sec II. Charter | | Objective? | Customer & needs? | Resources? | |
| | | Priorities & Constraints? | Deliverables? | System Diagram? | |
| | 10 | Budget? | Matches WBS? | Report dates? | |
| Sec III. Description | 30 | Objective? | Long description? | Deliverables as a table? | |
| | | System diagram? | Technical reqmts? | Limits & Exclusions? | |
| | | Justification? | Cust Review? | Status Rpts? | |
| Sec IV. Matrix | 5 | Graph? | Descriptions? | | |
| Sec V. WBS | | Numbered? | Descriptions? | Person responsible? | |
| | 30 | Time Estimate? | Actual costs? | "As done" labor costs? | |
| Sec VI. Gantt | 20 | Same as WBS? | Separate Reports and Project tasks? | Baseline? | |
| | | Neat, readable? | Times identified? | | |
| Total | 100 | Additional Comments | | | |

Figure 12. Formal Proposal/Final Report Rubric

One point of concern that comes up in a group project is how to measure, within the team, the individual student's contribution. The following two rubrics, done by the faculty technical advisor of the project team at the end of the project, attempts to do so. First, the group is given a rating for each of these seven ABET assessment points. Figure 13 shows the first half of this holistic, summative rubric. Wording to help define what is Superior, Excellent, etc., for each of these ABET points is hard to define. In our program, we have gone back and forth between just using a 1 – 10 scale, and using specific descriptions for each level, as we do in other rubrics. At this time we are just using the numerical scale, but that may change in the future.

| Technical Advisor Rating of Project Team Members | |
|---|---|
| **Group** | |
| Using a 1 – 10 scale, with 10 being the highest score, please rate the project group for these EET ABET Assessment points. If you cannot score an area, because you did not observe this, please use N/A | |
| ABET n) Demonstrate the ability to apply project management techniques (Overall – how did the project turn out?) | |
| ABET d) Demonstrate ability to design systems, components, or processes for broadly-defined engineering technology problems appropriate to program educational objectives | |
| ABET e) Demonstrate an ability to function effectively as a member or leader on a technical team | |
| ABET f) Demonstrate an ability to identify, analyze, and solve broadly-defined engineering technology problems | |
| ABET k) Demonstrate a commitment to quality, timeliness, and continuous improvement | |
| ABET o) Demonstrate the ability to use appropriate engineering tools in the building and testing of electronic systems | |
| ABET p) Demonstrate the ability to analyze, design, and implement industrial control systems or computer network systems | |

Figure 13 First part of Technical Advisor Rubric

The faculty technical advisor is then asked to rate the students individually, using the rubric seen in Figure 14. This is an overall rating; the faculty as a group agree that it would not be possible to rate each student individually on each of the seven ABET assessment points. The terms used here are qualitative in nature, as that is felt to be fairer than a strict quantitative number. The Capstone course instructor changes the qualitative rating to a quantitative value in order to record and report values. The numbers used are from Excellent = 10, Very Good = 9, down to Superficial = 4 and No Show = 0. The average score of the seven ABET assessment points is then multiplied by the individual students rating to give the student a score. It is felt that individual student effort makes up a large part of the team effort.

| **Individual** | |
|---|---|
| Please rate the degree to which each member fulfilled his/her responsibilities in completing their assigned tasks. These ratings should reflect each individual's level of participation, effort, and sense of responsibility, not his or her academic ability. The possible ratings are as follows: | |
| Excellent | Consistently went above and beyond – helped teammates, carried more than his/her fair share of the load. |
| Very Good | Consistently did what he/she was supposed to do, very well prepared and cooperative. |
| Satisfactory | Usually did what he/she was supposed to do, acceptably prepared and cooperative. |
| Ordinary | Often did what he/she was supposed to do, minimally prepared and cooperative. |
| Marginal | Sometimes failed to show up or complete assignments, rarely prepared |
| Unsatisfactory | Consistently failed to show up or complete assignments, unprepared |
| Superficial | Practically no participation |
| No show | No participation at all |

Figure 14 Second part of Technical Advisor Rubric & Student Self-Assessment

Students are given a chance to rate their own team, both at the end of the first semester, and then again at the end of the project. They get the same rubric rating form as the technical advisor does, Figure 14, with the instructions to "Please write the names of all your team members, including yourself, and rate the degree to which each member fulfilled his/her responsibilities in completing their assigned tasks." Again, they are not given a quantitative scale, but the more general qualitative scale to use, in the hope that they will be more accurate in their evaluation.

Students also rate themselves at the end of the Capstone course, which is the end of their undergraduate education, with this survey, Figure 15. This is not technically a rubric, but the form provides the program with good summative feedback. The results of the survey provide an additional element, an indirect measure, to add to the assessment of all the ABET student outcome assessments that are done directly.

| ABET Student Outcomes | | Very Confident or Satisfied | Somewhat Confident or Satisfied | Neutral | Not Confident or Unsatisfied | Very Unconfident or Unsatisfied |
|---|---|---|---|---|---|---|
| (a) | ability to select and apply the knowledge, techniques, skills, and modern tools of their disciplines to broadly-defined engineering technology activities | 5 | 4 | 3 | 2 | 1 |
| | | etc. | | | | |
| (p) | ability to analyze, design, and implement electronic systems | 5 | 4 | 3 | 2 | 1 |

Figure 15 Student Self-Assessment Survey

## Summary

RCampus, a website set up as a collaborative learning environment, where faculty can share and discuss rubrics, makes these statements about the expectations and benefits of rubrics[4]:

- Clarify constraints with students, colleagues, other evaluators, administrators, and yourself.
- Communicate expectations with students: A rubric tells students what is expected of them, the grading criteria, what counts and what doesn't, how many points they will earn for each task, and how their work is graded.
- Bring objectivity to subjective scoring.
- Easy scoring and recording of it.
- Communicate grades with students: A graded rubric helps students understand how they were graded and what their areas of strength and weakness are.

If you, as a faculty member, are developing your own rubrics, Rocco[8] suggests these guidelines:

- Outline your expectations.
- Divide expectations into traits for a quality performance or product.
- Decide on a hierarchy of traits.
- Decide on the rubric format.
- If you are using a holistic rubric, create sample products for each level of competence.
- Share and discuss the rubric with students.
- Use the rubric.
- Modify the rubric as needed.

We use rubrics consistently in our EET program, but as we go through our continuous improvement process, we often see that the rubric we are using is measuring the wrong aspects of what we want, or is the wrong kind of rubric. We continually are reassessing how we measure student progress.

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# Assessing Experimental Design in Civil Engineering

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Abstract

One requirement for ABET (Accreditation Board for Engineering and Technology) accreditation for undergraduate Civil Engineering is related to experimental design. Determining and implementing an appropriate assessment metric for this requirement presents challenges in the laboratory setting due to the inexperience of students and interrelated experimental variables to be modified within the constraints of equipment capabilities. A straightforward implementation of an experimental design assessment is presented for a junior-level CE course, Hydraulics and Hydrology. A detailed description is included for the assessment process involving the design of experiments to investigate rainfall-runoff processes using a bench-scale hydrology table. The presentation includes methods for (a) communicating the design process to students, (b) setting expectations for classroom theory to be investigated, (c) working within the capabilities of equipment, and (d) assessing the student-led design process.

## Introduction

Experimental design is an important skill for undergraduate engineering students to acquire. Hands-on exposure to the constraints of experimental variables, equipment capabilities, and the resolution of measurement techniques at the stage of experimental design gives students an opportunity to think critically about how theories and equations apply in real world engineering situations. Exposure to experimental design also allows students a concrete, physical illustration of the ways in which interrelated experimental variables depend on one another. For these and other reasons, the Accreditation Board for Engineering and Technology (ABET) outcomes specify that students, by the end of their undergraduate engineering education, demonstrate:

> *"An ability to design and conduct experiments as well as to analyze and interpret data"* – ABET Engineering Outcome B[1].

While the Civil Engineering specific ABET Program Criteria deemphasizes the design aspect of experimentation (since professional civil engineers are not often involved in experimental design[1]), the ABET general criterion for all engineering programs must nonetheless be demonstrated.

Towards this end, the new Department of Civil Engineering (CE) at the University of Minnesota Duluth has chosen to implement the assessment of ABET Outcome B (ability to design and conduct experiments) in its Hydraulics and Hydrology laboratory course. The department has four sophomore-level courses with significant laboratory components that give students hands-on experience. This paper outlines the curriculum setting for assessing the ABET experimental design outcome, introduces the experiment on which the assessment is made, and describes the assessment process from planning and communicating to students through compiling assessment results.

**Curriculum Setting**

Several required lab courses, taught at the 3xxx level, could have been suitable for assessing experimental design in the UMD Civil Engineering Curriculum. However, finding an appropriate laboratory exercise for design assessment was difficult since most experimental methods in Infrastructure Materials and Soil Mechanics follow well-specified standard methods. Exercises in Transportation Engineering involve complex computer programs are difficult to design without in-depth knowledge of the software. In contrast, most lab exercises in Hydraulics and Hydrology involve collecting and analyzing data from field or laboratory settings that illustrate the theories taught in the lecture portion of the class. Rather than following a standard method precisely, this type of experimental setting leaves the potential for allowing students some freedom in designing an experiment that will illustrate and verify the underlying principles taught in the class. Hydraulics and Hydrology, therefore, was chosen for the assessment of student's competence in experimental design.

The Hydraulics & Hydrology course is structured around 10 laboratory exercises that provide students with hands-on experience in topics ranging from pressurized pipe flow to open channel flow to rainfall-runoff response. As a required course in CE, it is offered every semester and the schedule is altered in the Spring semester to accommodate weather considerations in Northern Minnesota. Table 1 outlines the laboratory exercises for the Hydraulics & Hydrology course and the associated topics.

**Table 1** Laboratory exercises for CE 3225 Hydraulics & Hydrology

| Lab Exercise | Course Topic |
|---|---|
| EPA Net simulation (computer) | Pressurized pipe flow applications |
| Pump Demonstration Lab | Pump performance & water distribution |
| Stream Velocity (field lab) | Open channel flow |
| Hydraulic jump (flume) | |
| Weir discharge (flume) | |
| Slug test (field) | Groundwater & well hydraulics |
| Well drawdown (water table) | |
| N/A | Hydrologic cycle |

| Lab Exercise | Course Topic |
|---|---|
| Hydrograph lab (water table) | Rainfall/runoff/ hydrograph |
| CE building monitoring system | |
| Hydrologic statistics (computer/GIS) | Probability/frequency analysis |

Most lab exercises for the course are carried out in groups of 3-4 to give all students in lab sections of ~15 students plenty of time with equipment. Lab reports are also written in these groups, providing students with experience working in teams, but making individual assessment challenging. Some lab exercises, especially those that are computer based, are carried on an individual basis, but they do not lend themselves to experimental design assessment due to the nature of the exercises and software used. A decision was made to assess experimental design capabilities using a group lab towards the end of the semester, the Rainfall/Runoff Hydrograph Lab. Although students completed the lab exercise in groups, individual reports were required which gave each student the opportunity to think through and document their own experimental design process.

**Lab Exercise Description**

The Rainfall/Runoff Hydrograph lab makes use of the hydrology table pictured in Figure 1. The sand-filled hydrology table has several capabilities, but the ones utilized in this experiment are the rainfall and river simulators. A steady flow of water is maintained using one of the system's two independent flow valves while the second valve is used to simulate a precipitation event by sprinkling water evenly over the table surface. A water collection system is used to continuously monitor the river flow exiting the table and data collected from the system is used by students to quantify the river response of the small-scale "watershed" to a simulated precipitation event.

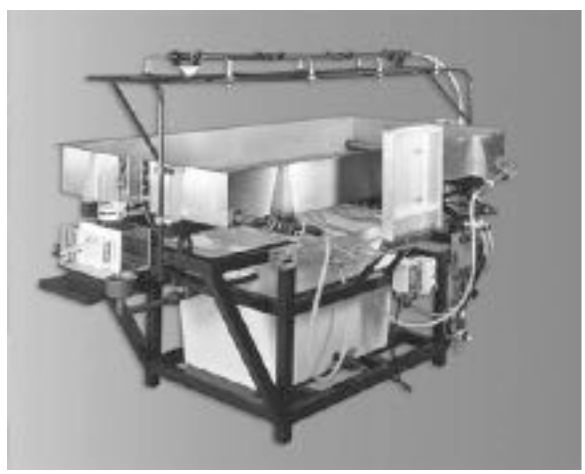

**Figure 1** Armfield Advanced Hydrology Demonstration Unit.

The principle to be demonstrated is a method for predicting the response of a river following a rainfall event given the "Unit Hydrograph" for the system. A Unit Hydrograph represents the response of a watershed-river system to one 'unit' of precipitation for a specified duration. For the laboratory system, the “30 second Unit Hydrograph” was defined for students as the river’s response to 1mm of precipitation over a duration of 30 seconds (2mm/min for 0.5min). Unit hydrograph analysis is a well-developed hydrologic tool used to predict the river response from hypothetical or future storms using the principle of superposition. River flow is assumed to scale linearly with intensity and the effects of subsequent increments of rainfall duration are superimposed to predict the total stream response. The Unit Hydrograph analysis process is illustrated in Figure 2.

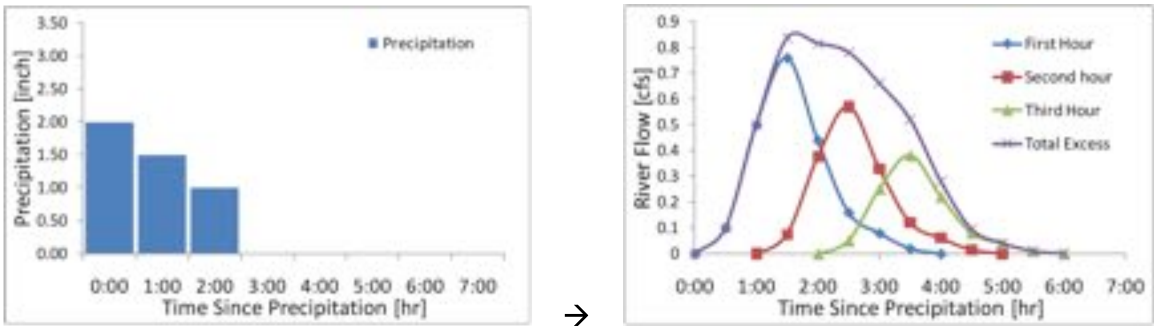


**Figure 2** Illustration of Unit Hydrograph analysis. Response from each precipitation duration is scaled and summed to predict total river response.

Students were instructed to design a set of three or four short duration (<15min) experiments on the Hydrology table whose results would demonstrate the theory behind Unit Hydrograph analysis. A Unit Hydrograph is intended to represent and capture the effects of all “unchanging characteristics” of a watershed, and students were also asked to run one experiment by changing one characteristic of the watershed by adding an impervious layer, adding vegetation (carpet) or changing the slope of the watershed.

Although this lab exercise provided a convenient, well-bounded set of experimental variables that could be manipulated by students to design a successful set of experiments, the types of calculations involved in Unit Hydrograph analysis are very different than those used in the rest of the class. For most of the topics in the class, theories which underlie homework and laboratory exercises take the form of continuously-defined numbers and deterministic equations or sets of equations which were manipulated to solve for one or more dependent variables. For Unit Hydrograph analysis, calculations involve simple mathematical functions such as scaling and summing sets of data, but require some level of comfort with discrete sets of numbers and mathematical operations as well as spreadsheet calculations. While this discrepancy from previous mathematical tools did not affect the assessment of experimental design in the lab, some students did not catch on quickly to the different, discrete mathematics involved in the calculations and made mistakes in data analysis.

**Assessment Process**

*Communicating expectations to students*

After the concepts of Unit Hydrograph Analysis were covered in class with concrete examples, students were provided a lab handout (2 concise pages), similar to one they receive before every other lab, which described the objectives and experimental procedures as well as the required data analysis and discussion questions for the lab report. In addition to the usual questions related to theory and analysis, two additional questions were added to the discussion requirements for the lab report:

1. *Describe the process of choosing experimental design variables to illustrate concepts related to unit hydrograph analysis. Why did you choose the variables the way you did?*
2. *…*
3. *…*
4. *Did the experiments you designed successfully illustrate the concepts of unit hydrograph analysis? What would you do differently if given another opportunity?*

The answers to these questions provide the material for assessing the student's ability to think critically about experimental design in fulfillment of the ABET Objective B. Students were informed that the lab report for this lab exercise would be completed on an individual basis and used as an assessment tool for ABET. Students were also informed that the ABET assessment would take place using a grading scheme independent from the scheme used to assign a grade for the report, and would be used by the department to demonstrate student competence in experimental design.

*Guidance on design variables & expectations*

The lab handout included an additional section (~1 page) that (a) briefly summarized the expectations for number and type of experiments and (b) defined the variables that could be modified by giving appropriate equipment limitations. The following is a summary of the summary of experimental design variables given to students:

***Appendix A: Experimental design variables***

*Use the following as a guide to design your experiments. The standard watershed has a 1% slope, no impervious cover, and no vegetation.*

*Your group will design experiments that will allow you to investigate the application of unit hydrograph analysis. You should design four different experiments:*

- *3 varying rainfall characteristics (duration and intensity) on the standard watershed,*
- *1 varying the watershed properties.*

*The following information will give you some parameters to work with when choosing your experimental variables. Once you have your 4 experiments chosen, guess the resulting shape of the unit hydrograph. Present your planned experiments and expected results to the instructor for feedback*

***Rainfall Characteristics:***

- *Three unique combinations of rainfall duration and intensity should be chosen*
- *Intensity:*
    - *A flow of 2 L/min corresponds to 1 mm/min of rainfall over the watershed area* $1\frac{mm}{\min} = \frac{2000\frac{cm^3}{\min}}{20{,}000cm^2} = 0.1\frac{cm}{\min}$
    - *Flows between 0.5 L/min and 3 L/min will give reasonable responses for this watershed*
- *Duration:*
    - *The unit hydrograph is for a 30second rainfall duration*
    - *Choose storm durations to be a multiple of 30s*
- *For the third storm, vary both duration and intensity to give a realistic storm*

***Watershed Characteristics:***

- *The final experiment should use one of the three storms from before, but change one or more of the watershed characteristics to determine the effect on the shape of the hydrograph*
- *The parameters available for changing the watershed are:*
    - *Slope (between 0.25% & 2.5% will give results in reasonable time-frames)*
    - *Impervious cover (plastic is available to cover ~30% of the watershed)*
    - *Vegetation (a piece of carpet can be used to simulate vegetative cover)*

During the final 20-30 minutes of the lecture before the Hydrograph Lab, students gathered with their 3-4 person groups and worked to design a set of experiments within equipment limitations that would successfully illustrate Unit Hydrograph analysis. Students were instructed to think critically about the known effects of independent variables involved in Unit Hydrograph calculations. Each group of students was required to hand in a description of experiments by the end of the class period that they would implement in the lab on the following day along with the expected river response.

*Creating and implementing a metric for assessment*

The grading scheme used for most lab reports was modified to accommodate assessment for ABET Outcome B. All lab reports for the course are graded by assigning points to 5 different categories:

***Lab Report Grading Sheet***

| | |
|---|---|
| *Overall Understanding* | */15:* |
| *Organization / Structure* | */5:* |
| *Calculations / Data Analysis* | */10:* |
| *Presentation / Readability* | */10:* |

*Interpretation / Discussion* *_/10:*
***Total*** ***50***

Points for two of these categories (Overall Understanding and Organization/Structure) are assigned based on an overall reading of the report and assessment of its organization. Points for the other three categories (Calculations/Data Analysis, Presentation/Readability, and Interpretation/Discussion) are assigned by looking for specific items in the report that were outlined in the initial lab handout. An example of this normal laboratory assessment is illustrated in Table 2.

**Table 2** Example of standard assessment matrix used for all lab reports.

| | **Calcs/Data Analysis** | **Pts** | **Presentation/ Readability** | **Pts** | **Interpretation/Discussion** | **Pts** |
|---|---|---|---|---|---|---|
| Overall Report | | | Theory presentation | 2 | Overall discussion quality | 2 |
| | | | Overall readability | 2 | Correct data interpretation | 2 |
| Predictions & comparisons | calculate total streamflow | 2 | present precip event summary | 3 | | |
| | | | present comparisons | 2 | how did predictions work? | 2 |
| | calc predicted | 5 | | | | |
| Total streamflow / changed watershed | | | present changed watershed | 1 | how did changed watershed work? | 1 |
| Design process | what should have happened | 3 | | | comment on design process | 3 |

The metric for assessing ABET Outcome B was developed to incorporate each element of the outcome including an evaluation of each action: *design, conduct, analyze,* and *interpret* [2]. While students have had experience with conducting experiments, analyzing and interpreting data by this point in the course, the design component was new for them. The formalized assessment matrix with definitions for Excellent, Very Good, Adequate, and Poor performance is outlined in Table 3. An attempt was made also to choose assessment questions that spanned the breadth of Bloom's taxonomy from lower level skills (comprehension) to higher level skills (synthesis/evaluation) [3].

**Table 3** Formalized assessment matrix for ABET Outcome B.

| | | **Design:** Formulates the control and evaluating alternatives of the experiment | **Conduct:** Facilitates use of modern data collection techniques (computer for data logging) | **Analyze Data:** Selects and uses appropriate, self-explanatory graph formats for data | **Interprets Data:** Interprets results with regard to how they relate to the theoretical state of nature or system |
|---|---|---|---|---|---|
| Excel-lent | 4 | *Chooses control and variables to examine each aspect of experiment (intensity, duration, watershed properties) independently* | *Understands and documents method for obtaining data with computer and explains how the data collected relates to the desired quantity (streamflow)* | *Produces a concise number of graphs which illustrate the effects of modifying independent variables experimentally* | *Substantial discussion of how results illustrate principles of hydrograph analysis including superposition, precip delay, and unchanging properties. Judgement about how well experimental results support theory & why* |
| Very good | 3 | *Chooses control and variables to examine 3 of 4 experiment aspects (intensity, duration, watershed properties) independently* | *Understands and documents method for obtaining data with computer* | *Produces graphs which illustrate the effects of modifying some independent variables experimentally* | *Brief discussion of how results illustrate the principles of hydrograph analysis superposition, precip delay, and unchanging properties.* |
| Ade-quate | 2 | *Demonstrates clear knowledge of a need to design experiment to examine effects of variables* | *Uses computer generated data to get to desired quantity (streamflow)* | *Uses graphs that show all experimental results with correct labels, titles, axes, etc.* | *Some discussion of how results illustrate the principles of hydrograph analysis including one or more of: superposition, precip delay, and unchanging properties.* |
| Poor | 1 | *Demonstrates no knowledge of the reasons for choosing experimental variables appropriately to examine effects* | *Serious mistakes made in analysis of computer generated data* | *Mistakes made in graph text or incorrect data plotted* | *Missing discussion of how results support theory of hydrograph analysis* |

## Results

The results of implementing this ABET assessment in the first two semesters of Hydraulics and Hydrology yielded concrete data on the performance of students in the area of experimental design, but also brought out some general lessons for assessing a skill that is not practiced repeatedly in a course. One lesson learned is that the expectation of documenting the design process to students must be stressed and required as a component of the lab report. During the first year of the course, in an effort to separate the ABET assessment from the course grade assessment, the importance of documenting the design process in the lab report was not emphasized enough to students. As a result, little discussion of the design component of the experiment was included in the lab report. For the second semester, a discussion of experimental design was required in the lab material and this resulted in a much better response in students' lab report discussion.

Another productive portion of the lab exercise which was improved upon during the second year was the iterative process of designing experiments. Following the initial classroom design that students participated in with their small groups, designs were shared with partner groups immediately prior to starting the experiment during the lab meeting time. Students were able to hear how other groups had thought about the design and then choose between several alternative designs before proceeding. This gave students from groups who had struggled with the design process peer-level feedback and helped them to see the benefits of the designs proposed by other groups. For students who had already come up with a good experimental design, this process gave them an opportunity to practice communicating the reasons for their design and an exposure to some alternative perspectives.

The results of the ABET assessment according to the rubric outlined in Table 3 are included below in Table 4. Overall, scores increased during the second year of implementation, likely due to a clearer presentation of expectations to students.

**Table 4** Results from ABET assessment for experimental design in first two semesters of Hydraulics & Hydrology.

| | Fall 2010 | Spring 2011 |
|---|---|---|
| Design… | 3.1 | 3.5 |
| Conduct… | 3.5 | 3.6 |
| Analyze… | 3.3 | 3.6 |
| Interpret… | 2.9 | 3.4 |

## Conclusions

Although some small modifications to the assessment methodology may be necessary for the 2011-2012 school year, the foundation for successful assessment is largely in place. The primary lesson learned during the design and implementation of an ABET assessment methodology for experimental design (Outcome B) was that communicating clear expectations to students in preparation of asking them to demonstrate a skill that is not typically assessed in a class is critical to success. Additionally, a group design exercise followed by individual descriptions of the design process appeared to work successfully for assessing individual capacities for experimental design. The UMD Department of Civil Engineering will rigorously document assessment methods and data will be collected in more than 12 courses during the 2011-2012 school year in support of program assessment in the fall of 2012. The process outlined herein will be directly used in this effort, will be useful in communicating expectations to future instructors for the course, and could also provide a guide to other instructors needing to implement an assessment of experimental design in another course.

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# Streamlining Program Assessment for ABET: What to do with all that data

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***Abstract*—One of the most daunting tasks of ABET accreditation is preparation of program assessment reports. Since these are necessarily a distillation of data from numerous sources (including all courses that have been assessed) the process can be laborious and error-prone. This paper presents a software solution called Program Assessor developed by the author at the Department of Computer Science at The University of Minnesota Duluth (UMD) that automates the process of data compilation, analysis, summarization and report generating.**

***Index Terms*—Engineering education, ABET, accreditation.**

The challenge of ABET accreditation is one that no engineering program can take lightly. It involves the collection of direct measures from every course in a program and from a variety of other sources to document and provide evidence to support the claim that course and program objectives are being met. The data stream feeding into this process comes from multiple sources, in multiple formats and must somehow be managed and made sense of. Ultimately it must be condensed down into meaningful summaries of objectives, outcomes and performance criteria satisfaction at both the course and program level.

The stream of data does not end with program accreditation either. Accreditation involves ongoing monitoring of courses and of the program itself. Besides evidence that objectives and outcomes are being met it also requires documentation of the process of continuous quality improvement. This entails an endless cycle of assessment and reassessment at both the course and program level.

Mastering this data streaming process and automating the tasks involved in the use of such data are crucial to the survival of programs and the maintenance of the sanity of those involved. This paper presents one method that we have devised to be particularly easy to employ and a powerful tool for taking control of these tasks.

## I. Introduction

The ABET accreditation process is familiar to most US engineering programs and has guided engineering education for over 75 years. Although the particulars of the process are subject to annual changes, the overall thrust of the endeavor remains the same – documentation of processes that assess and continually review how well program outcomes and performance criteria are being met.

As a result of this need for accountability engineering departments have struggled to put in place effective means of program assessment based on direct measures. Direct evidence, in the form of student projects, exams, reports, and other measures, are used to substantiate the program's claims that its outcomes are being satisfactorily met.

ABET requires specific evidence that engineering programs have enabled a series of 11 abilities in its graduates. These abilities (known as "a through k") form the basis of all engineering program assessments. Providing evidence that a program has satisfied a-k requires a large amount of data gathering, analysis and synthesis. There are a number of ways to approach the data processing tasks. Much of the data can be manually gathered, but without statistical software it is difficult to manage the process. Solutions range from inexpensive desktop software packages that manage some of the critical tasks to expensive, fully-integrated, commercial, web-based solutions.

## II. Literature review

A number of assessment-related software solutions have been presented in various engineering education forums. A number of the most recent and well-established ones are mentioned here. Although the list is not exhaustive, it does represent the wide range of solutions that are available. It should be noted that non-engineering disciplines often have their own accreditation boards and are responsible for similar program assessment reports. Many of these disciplines, especially the field of education, have developed tools to automate the process and provide the feedback necessary to foster continuous quality improvement.

There are several major types of automated program assessment tools. Web-based tools are desirable because they are easily deployed to those who need them and because they may allow for collaborative interaction. Heinze et. al. [1] use web-based automated assessment to allow students to take mock FE exams online and, in this way, develop an awareness of their strengths and weaknesses as they prepare for the real thing. These results are not factored into the ABET assessment process but provide students with a solid understanding of the extent to which ABET abilities have been mastered. Such information could be advantageously used by departments to assess the strengths and weaknesses of their seniors prior to taking the FE exams.

An example of a web-based tool that directly addresses the departmental need for ABET reporting is the ECAT system developed by Deborah Trytten [2]. This system summarizes the extent to which each of the ABET outcomes are being met using tallies of assignments which relate to each outcome. ECAT can provide evidence that each outcome was assessed although it cannot facilitate an evaluation of the level of performance relative to each outcome.

The problem of gathering actual student performance measures and integrating them into a system from which ABET outcome evaluation can be made is described by Booth [3]. He proposes the development of a database system to do this. Ultimately an online database, incorporated with student and departmental reporting tools may be the most efficient and effective means to solving the accreditation reporting dilemma.

Rather than using the online database model, Burge and Leach [4] have developed a Microsoft® Excel spreadsheet that is used to condense student performance data into results that apply to ABET outcomes. The results average the scores for each outcome. This is a desktop solution that is easy to use and efficiently produces summary reports for the departmental user.

A more integrated approach, but a costly one, is to have assessment integrated into student e-portfolios. McNair et. al. [5] describe such a system in relation to ABET outcomes that relate to profession skills. Fully integrated systems that consolidate student work, as incorporated in e-portfolios into departmental reports are as yet only implements in expensive proprietary software and would be a good candidate for an Open Source project.

Each of these approaches has its advantages and disadvantages. The software program described in this paper is an Excel spreadsheet, similar in concept to Burge and Leach but much more extensive in its reporting capabilities and without some of the problems inherent in the averaging of student data (discussed later in this paper).

## *III. Program assessment*

ABET program assessment is a complex undertaking. Every educational program has certain objectives in mind. From the ABET standpoint, important evidence that a program is successfully achieving its objectives comes from its graduates. Evidence of the degree to which graduates were adequately prepared for their chosen field comes ideally from those who are 3-5 years into their careers. Surveys of alumni and other similar instruments often are used to provide this information. This information can be incorporated into a final program assessment report for accreditation purposes as indirect evidence of program objective fulfillment.

Such information is valuable but not timely. If a problem exists in an engineering program it is always better to know sooner rather than hearing from graduates 5 years later. For this reason the outcomes of current student learning are the primary focus items of program assessment.

Student learning outcomes are associated, and often synonymous with, ABET-designated abilities (often called the ABET a-k because of their formal listing in ABET literature). Those abilities are:

(a) an ability to apply knowledge of mathematics, science, and engineering

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

(d) an ability to function on multi-disciplinary teams

(e) an ability to identify, formulate, and solve engineering problems

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Direct-measures are used to legitimate a program's claim that each of these is satisfactorily enabled in students upon graduation. This means that, at a minimum, one direct measure would be required for each of the eleven outcomes. One measure may not be considered sufficient to justify a claim that the outcome has been achieved. It is common to 'triangulate' outcomes by requiring several different measures as evidence. Thus, a minimum of 22 or perhaps 33 measures would be more appropriate (two or three specific assessments of student performance per outcome).

Student learning outcomes are broad statements of abilities students are expected to have upon graduation. Each student learning outcome is achieved through the mastery of a set of related skills. These critical skills, known as performance criteria, are monitored in the accreditation process as well. Program performance criteria are specific tasks and capabilities that students must demonstrate proficiency in as they acquire the abilities that define each outcome. There criteria are most often identified by program faculty consensus. For example, a program might decide that there are three performance criteria (a1, a2, a3) related to student outcome a. Direct evidence must be gathered to demonstrate that each performance criteria has been satisfied by graduating students in addition to evidence that outcome a has been met overall.

The number of performance criteria required may be as little as one, but more often consists of a set of three or four items. It is less work if there are fewer of these but it is usually the decision of faculty as to what these essential skills are and, in some instances, faculty may generate a long list. If each outcome had only three performance criteria then a total of 33 direct measures would be required, at a minimum. If each criterion relies on more than one piece of direct evidence to legitimate the claim that it has been satisfied then the amount of data grows rapidly.

Table 1 indicates the number of direct measures required by different configurations in which there are eleven (a-k) outcomes. Each of the eleven outcomes (a-k) must have 1 or more performance criteria. Each Performance criteria must have one or more direct measures that provide evidence of performance.

Table 1. Direct measure totals *(columns 1,2,3,4 indicate direct measures reported per criteria)*

| *Criteria per outcome* | *1* | *2* | *3* | *4* |
|---|---|---|---|---|
| 1 | 11 | 22 | 33 | 44 |
| 2 | 22 | 44 | 66 | 88 |
| 3 | 33 | 66 | 99 | 132 |
| 4 | 44 | 88 | 132 | 176 |
| 5 | 55 | 110 | 150 | 220 |
| 6 | 66 | 132 | 198 | 264 |
| 7 | 77 | 154 | 231 | 308 |

Table 1 illustrates the data proliferation problem that programs must address in order to submit an accreditation report. Even a small number of performance criteria and a few direct measures for each can add up to hundreds of data values that must be stored and analyzed. These are not the only reports of course. An additional set of reports for each of the student outcomes (a-k) is also required, based on the direct measures that directly support it. This makes ABET data reporting a formidable challenge.

## *IV. Program assessment data requirements*

Direct evidence of student performance is gathered from a variety of sources, most often coursework, exams, projects, and other graded instruments. These are easily provided by course assessments. Indirect evidence of criteria and/or outcome satisfaction, in the form of student survey responses, faculty course evaluations, outside review and other sources can be used as supplementary evidence. As a result, it is not uncommon for a single course to be able to provide dozens of items of direct evidence.

For some instructors, the more direct measures that can be incorporated into a course assessment the better. When this is done the effect is to greatly multiply the amount of data consolidation work that must be done.

The emphasis on quantity increases the data processing unnecessarily. Although a course might employ numerous quizzes, exercises, homework assignments, and other direct measures, only the most substantive assessments need to be reported. Using only the best performance indicators, rather than all, or dozens of them, can reduce the number of data items required to a handful in most instances.

In addition to the number of direct measures, the manner in which these results are reported is also worth paying attention to. Ideally, these results should be compiled and reported using percentages derived from rubric category frequencies.

Rubric categories, such as “Unsatisfactory, Minimally satisfactory, Satisfactory and Exemplary” are typically used to group results for each measure based on varying levels of performance. In this way it is possible to determine how many student performances there are in each category. The category frequency counts can then be turned into percentages for the purposes of comparison. Rubric category percentages are much more descriptive than arithmetic means because they provide more than one measure of performance. Table 2 presents a typical course assessment report spreadsheet showing the rubric category frequency tallies for a number of direct measures from several courses.

Table 2. Typical results of direct measure assessments

| Assessment | Outcome | Criteria | Unsatisfactory | Minimal | Satisfactory | Exemplary |
|---|---|---|---|---|---|---|
| Exam II | a | a1 | 30 | 19 | 35 | 16 |
| Exam I (Part I) | a | a1 | 21 | 25 | 41 | 13 |
| Exam I (Part II) | a | a1 | 11 | 17 | 50 | 22 |
| Exam I (Part IV) | a | a1 | 9 | 29 | 43 | 19 |

The spreadsheet shown in Table 2 is only a small excerpt of a real course assessment data collection with the results of course assessments from fall 2007 to spring 2010. In this case, there were eleven student outcomes (a-k) and 31 performance criteria (a1, a2, b1, b2, etc). One course may have multiple assessments tied to a single performance criterion. A single course may also have assessments tied to more than one performance criterion.

This is the point at which the assessment problem becomes most difficult. In order to determine whether a performance criterion (such as criterion a1) has been met, the direct measures of performance related to criterion a1 must be collected from all courses reporting direct measure results related to criterion a1. Figure 1 illustrates what such a report looks like when generated by the Program Assessor software.

Student Outcome a. an ability to apply knowledge of computing and mathematics appropriate to the discipline.

| Criteria a1. Students understand information representation | Exemplary | | Satisfactory | | Minimal | | Unsatisfactory | |
|---|---|---|---|---|---|---|---|---|
| | % | n | % | n | % | n | % | n |
| Weighted Aggregates | 26.5% | 107.0 | [illegible] | [illegible] | 19.1% | 77.0 | [illegible] | 44.0 |
| CS 150 - Exam II, Fall, 2007 | 31.8% | 28 | 40.9% | 36 | 13.6% | 12 | 13.6% | 12 |
| CS-150 - Exam I (Part I), Fall, 2007 | 16.0% | 16 | 44.0% | 44 | 24.0% | 24 | 16.0% | 16 |
| CS 150 - Exam I (Part II), Fall, 2007 | 21.7% | 20 | 52.2% | 48 | 17.4% | 16 | 8.7% | 8 |
| CS-150 - Exam I (Part IV), Fall, 2007 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 20 | [illegible] | 4 |
| CS 260 - Final, Part I, Spring, 2008 | 47.5% | 19 | 30.0% | 12 | 12.5% | 5 | 10.0% | 4 |

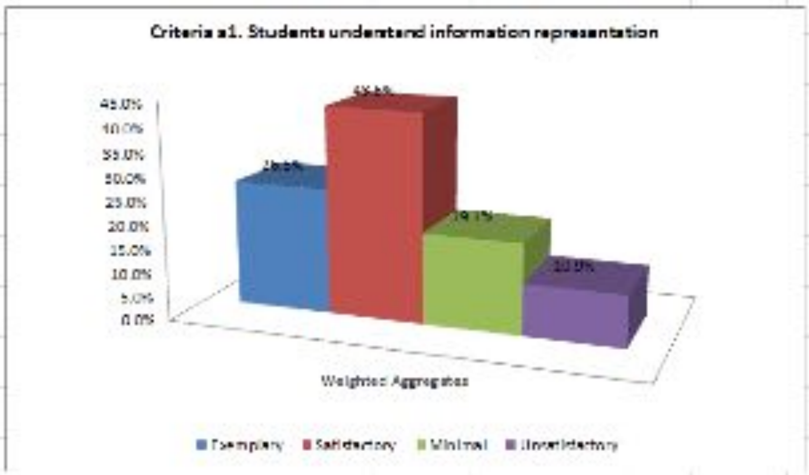



Figure 1. Detailed direct measure report for program performance criterion a1.

Figure 1 lists the direct measures in support of criterion a1 down the left side of the table. Each measure lists the course identification number, assessment name, semester and year. The performance results are broken down by category (Exemplary, Satisfactory, Minimal, Unsatisfactory) both as n values and percentages. The n value is the number of students performing on a particular assessment at the given level. The percentage is the percentage of all students who performed at that level. Thus, for the first direct measure we find that:

- The measure was derived from course CS-150
- The specific assessment event was Exam II
- The semester and year this data comes from is Fall 2007
- The percentage of students performing at an exemplary level was 31.8%
- The actual number of students performing at the exemplary level was 28

Similar percentages and n's are provided for all other performance categories for this measure. All direct measures include these same items of information. In the example shown in figure 2 there are 4 assessments from CS-150 and one from CS-260 that relate to criterion a1. The overall results are shown at the top of the table. These are percentages based on the total n's for each performance category unless some direct measures have been weighted differently from others, in which case the results reflect the weighting.

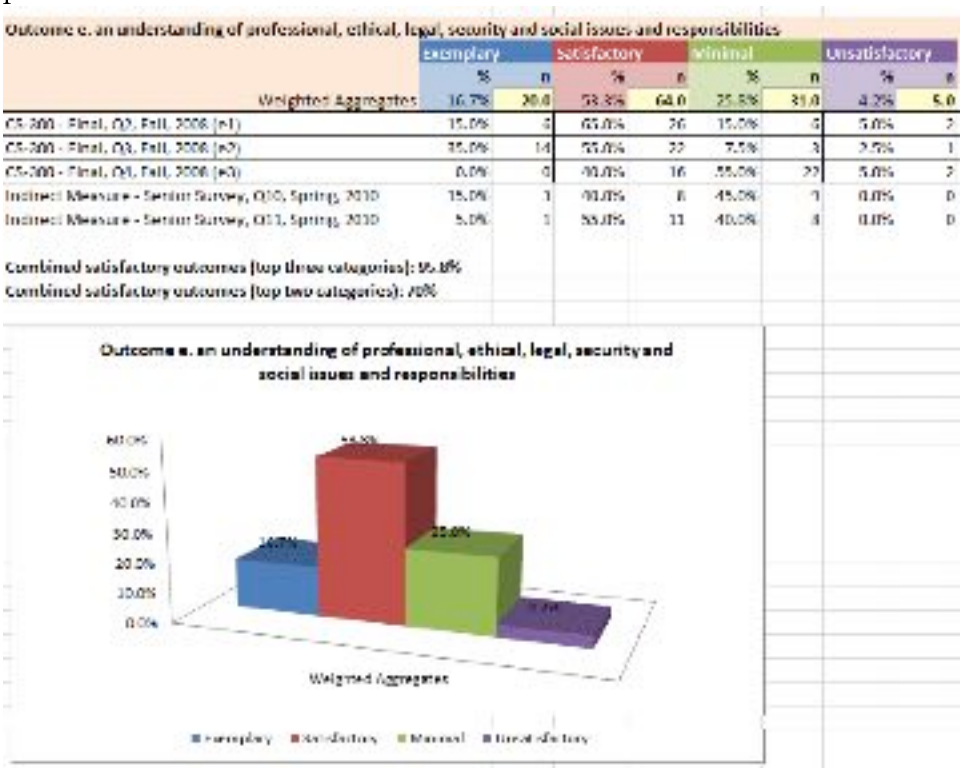
From Figure 1 we learn that overall the level of performance demonstrated by the direct measures of criterion a1 is:

- Exemplary – 26.5% (n = 107)
- Satisfactory – 43.6% (n = 176)
- Minimal – 19.1% (n = 77)
- Unsatisfactory – 10.9% (n = 44)

Note that these are the results for one performance criterion only. There will be a separate report like this for each performance criterion. Program Assessor automatically generates these reports, drawing from the original course assessment spreadsheet and grouping by performance criterion.

Performance data drawn from individual direct measures must also be used to support claims that student outcomes have been met. This report is similar to that shown in Figure 1 with the difference being that it uses all of the direct measures pertaining to all of its criteria. In other words, the data from direct measures used to justify criterion a1 may be combined with data from all of the direct measures used to support criteria a2, a3, and all other a-related criteria. As a result, this compilation could be very large. One way to reduce the size is to be more selective about which direct measure data is used. It is not true that all direct measures used to support criteria need to be included in the report that supports student outcome satisfaction.

Figure 2 illustrates, in a manner similar to that used in Figure 1, how the supporting data is presented. In this case the student outcome is ABET outcome e.



Outcome e. an understanding of professional, ethical, legal, security and social issues and responsibilities

| | Exemplary | | Satisfactory | | Minimal | | Unsatisfactory | |
|---|---|---|---|---|---|---|---|---|
| | % | n | % | n | % | n | % | n |
| Weighted Aggregates | 16.7% | 20.0 | 53.3% | 64.0 | 25.8% | 31.0 | 4.2% | 5.0 |
| CS-300 - Final, Q2, Fall, 2008 (e1) | 15.0% | 6 | 65.0% | 26 | 15.0% | 6 | 5.0% | 2 |
| CS-300 - Final, Q3, Fall, 2008 (e2) | 35.0% | 14 | 55.0% | 22 | 7.5% | 3 | 2.5% | 1 |
| CS-300 - Final, Q4, Fall, 2008 (e3) | 0.0% | 0 | 40.0% | 16 | 55.0% | 22 | 5.0% | 2 |
| Indirect Measure - Senior Survey, Q10, Spring, 2010 | 15.0% | 3 | 40.0% | 8 | 45.0% | 9 | 0.0% | 0 |
| Indirect Measure - Senior Survey, Q11, Spring, 2010 | 5.0% | 1 | 55.0% | 11 | 40.0% | 8 | 0.0% | 0 |

Combined satisfactory outcomes (top three categories): 95.8%
Combined satisfactory outcomes (top two categories): 70%



Figure 2. Detailed direct measure report for student performance criterion e.

Figure 2 lists the direct measures in support of student outcome e down the left side of the table. Each measure lists the course identification number, assessment name, semester and year. The performance results are broken down by category (Exemplary, Satisfactory, Minimal, Unsatisfactory) both as n values and percentages. The n value is the number of students performing on a particular assessment at the given level. The percentage is the percentage of all students who performed at that level. Thus, for the first direct measure we find that:

- The measure was derived from course CS-300
- The specific assessment event was the final exam, question 2
- The semester and year this data comes from is Fall 2008
- The percentage of students performing at an exemplary level was 15.0%
- The actual number of students performing at the exemplary level was 6

Similar percentages and n's are provided for all other performance categories for this measure. All direct measures include these same items of information. In the example shown in Figure 2 there are 3 direct assessments from CS-300 (an ethics course). The overall results are shown at the top of the table. These are percentages based on the total n's for each direct measure performance category unless some direct measures have been weighted differently from others, in which case the results reflect the weighting.

From Figure 2 we learn that overall the level of performance demonstrated by the direct measures of criterion a1 is:

- Exemplary – 16.7% (n = 20)
- Satisfactory – 53.3% (n = 64)
- Minimal – 25.8% (n = 31)
- Unsatisfactory – 4.2% (n = 5)

Note that these are the results for one student outcome only. Program Assessor generates a separate report like this for each student outcome. It is also important to note that, although only direct measures are used in the computations, the performance results for indirect measures are also included. This allows the reviewer to incorporate other perspectives into an evaluation of how well this particular outcome has been achieved. In Figure 2 there are two lines identifying indirect measures. These were the answers to senior survey questions in which students were asked to rate their understanding of ethical, legal, security or social issues.

## *V. Program assessment outputs*

We have seen how direct measure data are used to describe the proficiency of students in a single performance area (Figure 1) and how a similar approach is used to give evidence for proficiency in a student outcome area (Figure 2). At the program level, it is also instructive to know how each of the performance criteria for a particular student outcome match up. Figure 3 indicates what such a report looks like. The data in each line of the table comes from the results of different criterion reports (such as Figure 1). For example, if student outcome a has two performance criteria (a1 and a2) then the results for a1 and a2 can be displayed in relation to one another for comparison purposes. This is shown in Figure 3.

| Student Outcome a. an ability to apply knowledge of computing and mathematics appropriate to the discipline. | | | | | Satisfaction (%) | |
|---|---|---|---|---|---|---|
| | Exemplary | Satisfactory | Minimal | Unsatisfactory | Top 2 | Top 3 |
| a1. Students understand information representation | 26.5% | 43.6% | 19.1% | 10.9% | 70.0% | 89.1% |
| a2. Students understand induction and recursion | 28.1% | 50.0% | 15.0% | 6.9% | 78.1% | 93.1% |

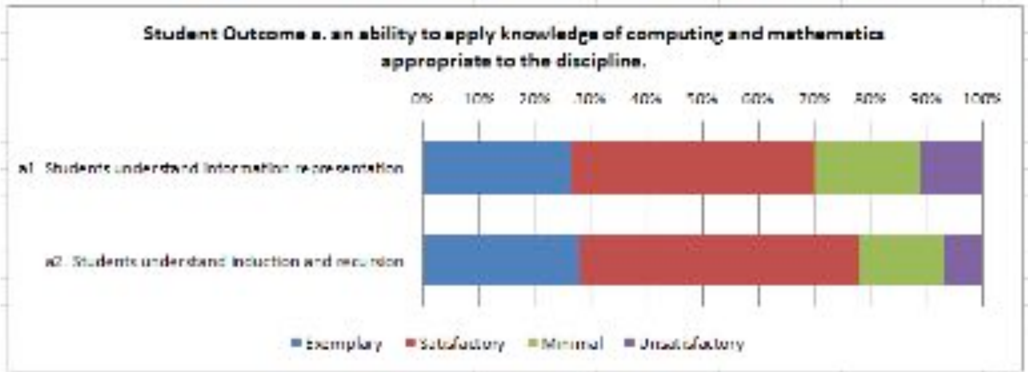



Figure 3. Comparison of performance criteria results for student outcome a.

Figure 3 provides side-by-side profiles of a1 and a2. By comparing the corresponding percentages for each category the distribution of achievement can be evaluated for the group as a whole as well as individually. Strengths and weaknesses are easily recognizable when data is displayed in this manner. The percentages used in the comparison derive from the individual results (ie. Figure 1).

At the heart of ABET accreditation is the evidence that each of the abilities (a-k and others) is being enabled. These student learning outcomes are displayed together in Figure 4.

| Program Outcomes | | | | | Satisfaction (%) | |
|---|---|---|---|---|---|---|
| | Exemplary | Satisfactory | Minimal | Unsatisfactory | (top 2) | (top 3) |
| a. an ability to apply knowledge of computing and mathematics appropriate to the discipline | 27.0% | 45.4% | 17.3% | 5.0% | 72.3% | 90.2% |
| b. an ability to analyze a problem, and identify and define appropriate computing requirements | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| c. an ability to design, implement, and evaluate a computer-based system, process, component, or program | 22.1% | 52.0% | 18.7% | 5.2% | 74.1% | 93.8% |
| d. an ability to function effectively on teams to accomplish a common goal | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| e. an understanding of professional, ethical, legal, security and social issues and responsibilities | 16.7% | 53.3% | 25.8% | 4.2% | 70.0% | 95.8% |
| f. an ability to communicate effectively with a range of audiences | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| g. an ability to analyze the local and global impact of computing | 50.5% | 40.0% | 3.0% | 6.5% | 90.5% | 93.5% |
| h. recognition of the need for and an ability to engage in continuing professional development | 15.0% | 65.0% | 17.5% | 2.5% | 80.0% | 97.5% |
| i. an ability to use current techniques, skills, and tools necessary for computing practice | 19.3% | 50.7% | 22.1% | 5.7% | 72.9% | 94.0% |
| j. an ability to apply math foundations, algorithmic principles, and cs theory that demonstrate students | 15.7% | 64.5% | 9.4% | 10.4% | 80.2% | 89.6% |
| k. an ability to apply design and development principles in the construction of software systems | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| l. an ability to understand the scientific method and apply it in a laboratory setting | 24.1% | 55.5% | 8.3% | 3.4% | 80.7% | 88.8% |

Figure 4. Comparison of student outcome results for student outcomes a-l.

Figure 4 shows the percentages of exemplary, satisfactory, minimal and unsatisfactory performance. The definition of what constitutes satisfaction of a student outcome is somewhat subjective and is often refined over time as satisfaction percentages are evaluated with an eye to continuous improvement. Two such measures are indicated in the columns on the right side of Figure 4. One indicator of satisfaction uses only the top two performance categories (exemplary and satisfactory). A second performance measure uses the top three categories (all except the unsatisfactory percentages).

Figure 5 displays these measures of outcome satisfaction as horizontal bars. Each student outcome has a blue bar (indicating the percentage of outcomes in the top two categories) and a red bar (indicating the percentage of outcomes in the top three categories). This form of presentation easily allows the evaluator to scan the results and determine the strongest and weakest outcomes.

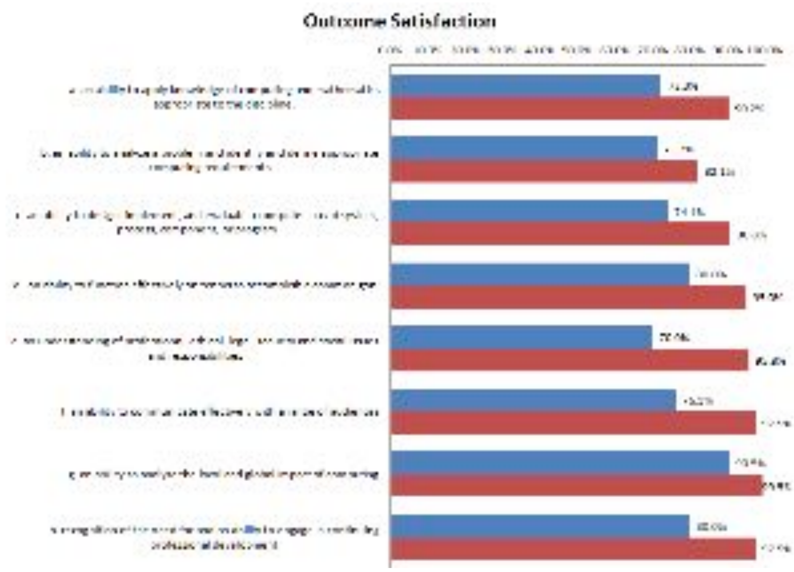



Figure 5. Comparison of outcome satisfaction measures for selected student outcomes.

It is also of fundamental importance to be able to use student outcome data to examine relationships over time. This constitutes a form of monitoring of the continuous improvement process. Figure 6 shows the data from two collection cycles (Fall 2007-Spring 2010 and Fall 2010 – Spring 2011). The second cycle is not yet complete, but some courses have begun providing data and this can be compared to previous results to see if things seem to be improving or not. Improvement is subjective and in this comparison it is based only on descriptive, not inferential statistics. However, descriptive results (such as the bar chart shown in Figure 6) are the starting point of more detailed inquiry.

In Figure 6 the percentages and n's for a particular student outcome category (outcome e) are displayed. Data for this table comes from tables such as that shown in Figure 2. The measure of performance for this outcome has been designated as the sum of the top two performance categories (exemplary and satisfactory). The bar chart illustrates the top two performance sum for each of the two data collection cycles for this student outcome. The first cycle produced a performance measure of 70%. In other words, 70% of students achieved either exemplary or satisfactory performance in this area. The second cycle produced 76.1%. Although we cannot determine if this increase is statistically significant we have some evidence that the trend is proceeding in the desired direction and will continue to monitor the differences between the values as more data for this outcome is acquired in the second data collection cycle.

| Outcome e. an understanding of professional, ethical, legal, security and social issues and responsibilities | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Exemplary | | Satisfactory | | Minimal | | Unsatisfactory | | Satisfaction (top 2) | |
| Cycle | % | n | % | n | % | n | % | n | % | Difference |
| [1] Fall 2007 - Spring 2010 | 16.7% | 20 | 53.3% | 64 | 25.8% | 31 | 4.2% | 5 | 70.0% | N/A |
| [2] Fall 2010 - Spring 2011 | 19.7% | 23 | 56.4% | 66 | 20.5% | 24 | 3.4% | 4 | 76.1% | 6.1% |


Figure 6. Continuous improvement monitoring by comparing data collection cycle results

*VI. Conclusion*

Program Assessor has proven to be a valuable resource for ABET accreditation reporting in the Department of Computer Science at UMD. It requires a minimal amount of up-front data entry (course assessment rubric performance results as shown in Figure 1) and no further data entry. It requires no Excel skills or coding. Once the data is in, reports such as those shown in Figures 2-6 are generated automatically at the touch of a button. In our department we have adopted 12 program student-learning outcomes and a total of 31 various performance criteria. In the most recent ABET report prepared by our department almost 300 direct measures of student performance were provided by faculty for inclusion in the accreditation analysis. Compiling detailed reports of how well the computer science program achieved each student outcome and performance criteria would be incredibly time-consuming if done by hand. All these reports are virtually instantaneous with the Program Assessor software however.

The ability to avoid laborious data tasks is important when program assessment is at stake. It not only removes a huge faculty and administrative burden, it also allows both faculty and administrators more time to reflect on the results. Automated reporting serves the accreditation process best by facilitating reflection and improvement. We have found that the real value of Program Assessor is that it moves the assessment agenda along from the mundane to the important issues, allowing more time to discover the strengths and weakness of the program and much less time crunching the numbers that reveal them.

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# Personality Type Demographics and their Relationship to Teaching and Learning

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## ABSTRACT

Assessment is the next most important activity that follows teaching-learning in the classroom. Assessment plans must be carefully strategized from a top-down perspective complemented by bottom-up realities. The assessment plan strategy must include elements of robustness which would make the results from implementation of the plan as insensitive as possible and hence more reliable to unavoidable variations. Examples of robustness assessment include assessment at the individual student level and teaching/learning based on the personality type demographics of students. This paper focuses on planning, implementing, and assessing the personality type demographics of undergraduate students in different majors. This must be accomplished in the context of logistics of time, access, and feedback to such studies. The paper also gives specific examples of personality type demographic assessment plan development, implementation, and outcomes from courses in four different programs in three different colleges. Teaching/Learning ideas that can better adapt to the personality type demographics are also addressed.

## INTRODUCTION

In quality education, assessment is perhaps the next most important aspect that follows teaching- learning in the classroom. Every major and minor program needs to strategize and plan an assessment methodology. The assessment methodology must be then implemented, data collected, analyzed, and interpreted, eventually leading to improvements in the teaching/learning process. Both a top-down and bottom-up approach is necessary to realize good assessment outcomes. As a top-down approach, programs have their own assessment strategies that constantly evolve to meet the mission and goals of the university, college, and department and the requirements of any formal or informal accrediting agencies. "Robust" assessment is one key strategy that can enhance the assessment outcomes. The author of this proposal presented this novel strategy of robust assessment at the International Conference on Education in Hawaii in January 2008. [1] Robust assessment minimizes the adverse effects of variables on the reliability of assessment results by identifying, understanding, and controlling the influence of such variables. The "personality type" demographics of students in a program are one of several variables that must be assessed and effectively utilized to improve teaching-learning. Such an assessment is an example of a bottom-up approach that supports the top-down strategy of robust assessment. Personality types greatly influence team dynamics or interaction. This is particularly important in courses wherein teams or groups of students work on projects. This paper presents the planning/methodology, implementation, anticipated outcomes, and results to achieve the objectives given next.

## OBJECTIVES

- identify the personality type demographics of students in project based courses in representative programs in each of the three colleges at UW-Platteville

- identify ways to improve team dynamics and teaching/learning to suit the personality demographics

## METHODOLOGY AND RESULTS OF IMPLEMENTATION OF THE METHODOLOGY

Four major tasks were identified as part of the planning/methodology. These tasks are given next. Under each task, the results of implementing that task are also described.

**Task1: Identify team project based courses in representative programs from each of the three colleges at UWP**

After discussing with several faculty members in the three colleges of EMS (Engineering, Mathematics, and Science), BILSA (Business, Industry, Life Sciences, and Agriculture), and LAE (Liberal Arts and Education) about possible team based courses that can best represent this study in the short-term, the following courses were chosen as shown in Table 1 below. The table also shows additional information about these courses specific to the 2011 Spring semester of study.

**Table 1 Courses Chosen for Personality Type Demographics Study**

| # | College | Course Number | Course Title | Number of Teams |
|---|---|---|---|---|
| 1 | EMS | MECHNCHL 4930-01,02,03 | Senior Design Project | 12 |
| 2 | EMS | CIVILENG 4930-01 | Civil and Environmental Engineering Design Project | 14 |
| 3 | BILSA | AGINDUS 4500-01,02 | Agribusiness Management | 11 |
| 4 | LAE | THEATER 1130-01 | Introduction to the Theatre | 6 |
| 5 | LAE | THEATER 1130-02 | Introduction to the Theatre | 7 |

As can be seen in the above table, all sections of each particular course have been combined in the study except for the two sections of the Introduction to the Theatre class. This was because it was felt that more insight can be gained by treating these two sections separately due to the fact that students from several different majors enroll in this course unlike other courses which are primarily taken by respective majors.

**Task 2: Get approval from the Institutional Review Board**

A rigorous protocol had to be submitted to the Institutional Review Board (IRB) for Human Subject Research (a UWP University Committee) so that students can participate in a selected personality type test. Approval was received through due process.

**Task 3: Select and Administer the Personality Test**

Well-known personality test instruments with varying combinations exist including Keirsey's four-combination temperament scale [2] and Myers-Briggs [3] sixteen-combination scale. Keirsey Temperament Sorter (KTS-II) was chosen for students to understand their preference personality type in the four-combination Keirsey scale of Artisans, Idealists, Rationals, and Guardians. Their website keirsey.com [4] gives some idea of the popularity of this particular survey instrument.

As for better inference from the personality type test, a survey questionnaire consisting of ten questions was carefully planned on the basis of the underlying principles of not only the four-combination Keirsey scale but the sixteen-level Myers-Briggs model as well. The ten-question survey questionnaire requires that response to only Question I be entered from the on-line test result of the personality type (as Artisan or Idealist or Rational or Guardian) at keirsey.com. The responses to all the remaining nine questions II through X are the opinions of the students about themselves. The survey questionnaire that the students complete is given below.

## QUESTIONNAIRE

QUESTION I

What is your Temparament (or personality type) **as per the result of the test** you took at keirsey.com?

(**Check one**)

ARTISAN: ____ IDEALIST: ____ RATIONAL: _____ GUARDIAN: _____

To each of the following questions II through X, select an answer that best describes you in **your opinion**:

QUESTION II: In communicating, are you _________________________ (Abstract or concrete?)

QUESTION III: In achieving goals, are you _________________________ (Cooperative or Utilitarian)?

QUESTION IV: What are you most proud of about yourself? (Select ONE from the following):

a. Of the degree to which you are graceful in action
b. Of the degree to which you are empathic in action
c. Of the degree to which you are competent in action
d. Of the degree to which you are reliable in action

QUESTION V: What do you respect the most about yourself? (Select ONE from the following):

a. Of the degree to which you do good deeds
b. Of the degree to which you are daring
c. Of the degree to which you are benevolent
d. Of the degree to which you are autonomous

QUESTION VI: What are you most confident of about yourself? (Select ONE from the following):

a. Of the degree to which you are strong willed
b. Of the degree to which you are respectable
c. Of the degree to which you are adaptable
d. Of the degree to which you are authentic

QUESTION VII: Are you more of an extrovert (E) or an introvert (I)? ______(E or I?)

QUESTION VIII: Do you notice information more by Sensing (S) or by intuition (N)? ______ (S or N?)

QUESTION IX: Do you make decisions more by thinking (T) or by feeling (F)? _____ (T or F?)

QUESTION X: Would you like to live in a world run more by judging (J) or by perceiving (P)? ______ (J or P?)

It is appropriate at this point to discuss the underlying principles/theory/literature that served as drivers to generate these specific questions to effectively administer, gather & analyze data, and interpret results of the survey.

One school of thought about the 4-level Keirsey model is that the four personality types stem from the four combinations of two possible responses to each of two questions as follows:

In communicating, are you abstract or concrete?

In achieving goals, are you cooperative or utilitarian?

The personality type preference ("preference" because all of us have all four personality type behavior in us but prefer one of these more to varying degrees over the rest) is based on the particular combination of responses to the above two questions as shown in Table 2a below:

**Table 2a**

| Communicating | Achieving Goals | Personality Type Preference |
|---|---|---|
| Abstract | Utilitarian | Artisan |
| Abstract | Cooperative | Idealist |
| Concrete | Utilitarian | Rational |
| Concrete | Cooperative | Guardian |

Obviously, many specific traits have been lumped into the simple model shown in the above table of four possible response combinations to two questions. The actual test at Keirsey.com uses responses to about seventy (70) questions to determine the personality type much more rigorously. But the two-question simple model gives broad categorizations of communicating and goal achieving preferences of each personality type which in and of itself can be valuable to a person as an individual or as a team member. These two questions are therefore included as Questions II and III in the survey.

Several different perspectives understandably exist about the fascinating and complex field of study of personality types. Deeper or finer characteristics of different personality types are proposed by different authors. Obviously, meaningful statistical correlations between such deeper/finer characteristics and personality types are less likely than broader characteristics. Large sample sizes would be required even if such correlations could be extracted for such deeper/finer characteristics. A short-term study such as the one done here with small sample sizes cannot obviously yield meaningful statistical inferences on deeper or finer characteristics. Yet, the author decided to include Questions IV, V, and VI seeking the students' choices to questions on deeper or finer characteristics that are proposed as possible correlations to the 4-level personality types. The author hopes to continue collecting responses to these questions over time to have enough sample size to make meaningful inferences.

Questions VII, VIII, IX, and X, well known in the literature, have been chosen to seek the students' responses to identify their particular individual personality type in the sixteen-level Myers-Briggs model. As can be seen in the questionnaire, these four questions each have two choices. Picking one choice for each of these questions therefore results in one particular personality type from 2 X 2 X 2 x 2 =16 possible combinations or types. It should be noted that in the IRB protocol no on-line Myers-Briggs testing was proposed because the focus in the proposal was more on the Keirsey model for better understanding of group demographics. The Myers-Briggs model is more useful for inferences at the individual level. But the author intends to add an on-line Myers-Briggs testing in future studies for which a new IRB protocol will be submitted. This will provide additional inferences regarding the students' own assessment and an actual test assessment of the individual personality type in the 16-level Myers-Briggs model. Additionally, any correlation done using the students' self-assessment can be repeated for the actual test assessment.

Before presenting results of the personality type surveys in the five courses identified in Table 1, historical major developments in personality type studies are discussed next to provide a contextual framework for the results in this task phase and for the analysis of the results to follow in the next task phase.

The earliest rigorous work on personality types dates back to the work of Carl Gustav Jung (1875-1961)[5]. Isabel Briggs Myers (1897-1980), together with her mother Katherine Cooks Briggs, extended Jung's theory of personality types, adding two important aspects. These were the recognition of the existence and roles of the auxiliary processes and the addition of the Judging (J) and Perceiving (P) preference[6, 7, 8]. Thus Jung's eight types (2*2*2) were extended to the Myers-Briggs' sixteen types (2*2*2*2). Sixteen "Myers-Briggs Type Indicators" (MBTI) arise from every possible combination of one selection from each pair of dichotomies as shown in the table below. (ISTP and ENTJ are two example types of the possible 16). The abbreviations E, I, S, N, T, F, J, and P as shown will be used throughout this report.

**Table 2b**

| | | | |
|---|---|---|---|
| Extroversion | E | Introversion | I |
| Sensing | S | Intuition | N |
| Thinking | T | Feeling | F |
| Judging | J | Perceiving | P |

The MBTI has been and continues to be used worldwide and is an instrument developed specifically as a tool for the general population, and is therefore inherently benign. As a founding principle, no one type is any better or worse than any other and the test candidate has the final say as to his or her type designation[6]. In its basic form, MBTI is a 93-item instrument used worldwide for psychological type classification and is available in many different languages. The MBTI has been around for over 60 years and has been used in a number of occupational settings. MBTI instrument intends to find an individual's preference to the four dichotomies mentioned above as follows[9]:

Putting attention and getting energy by spending more time

- in the outer world of people and things (E) or
- in the inner world of ideas and images (I)

Paying more attention to

- information that comes in through the five senses (S) or
- the patterns and possibilities seen in the received information (N)

Making decisions by putting more weight on

- objective principles and impersonal facts (T) or
- personal concerns and the people involved (F)

Liking to live in a world of a more

- structured and decided lifestyle (J) or
- flexible and adaptable lifestyle (P)

The choice between E or I is about orientation, S or N is about cognitive perceiving function, T or F is about cognitive judging function, and J or P is about attitude of the functions. Myers stated that the interaction of these orientations, functions and attitudes are what makes up the personality types.

The Keirsey Temperament Sorter II (KTSII) is an instrument developed by David Keirsey[10], a contemporary of Isabel Myers. The test is available online as a 70-item instrument that has only two possible responses for each item[11]. Keirsey follows the MBTI tradition of using 16 types but condenses through a tree-like structure into four temperament groupings called Artisans, Idealists, Rationals, and Guardians. Fundamentally, the Keirsey model theory looks at the four possible combinations between abstract or concrete in communicating and cooperative or utilitarian in achieving goals. Artisans prefer concrete communication and utilitarian goal achievement traits, idealists prefer abstract and cooperative traits, rationals prefer abstract and utilitarian traits, and guardians prefer concrete and cooperative traits. Linkage of the four KTSII types to the sixteen MBTI types is another classification. Artisans prefer S and/or P, idealists prefer N and/or F, rationals prefer N and/or T, and guardians prefer S and/or J. Just like MBTI, KTSII is widely used in industry and education. In general, the KTSII Temperament Sorter can provide a better insight into group demographics due to the broad but relatively not so deep 4-level categorization whereas any study based on the Myers-Briggs model provides a better insight into individuals' personal assessment due to the specific or relatively deep 16-level categorization. It should be noted though that KTSII does offer insights into individuals' personal assessment and the Myers-Briggs based model does offer insights into group demographic information.

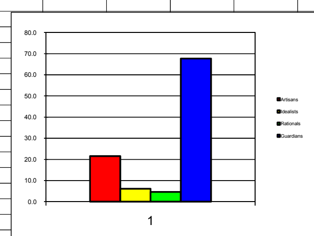
Having discussed the brief historical context of the KTSII and Myers-Briggs models, results from the surveys conducted in the five courses identified earlier are tallied below. Tables 3, 4, 5, 6 and 7 show the raw tallies respectively from the five courses listed in Table 1. “Ghost” team labels in randomized order have been used for each course to maintain anonymity as required by IRB regulations. The results have been tallied in different categorical breakdowns as follows:

- Artisans, Idealists, Rationals, and Guardians
- SPs, NFs, NTs, and SJs
- ESTPs, ISTPs, ESFPs, ISFPs, ENFPs, INFPs, ENFJs, INFJs, ENTPs, INTPs, ENTJs, INTJs, ESTJs, ISTJs, ESFJs, and ISFJs
- Extroverts (E) and Introverts (I); Sensing (S) and Intuitive (N); Thinking (T) and Feeling (F); Judging (J) and Perceiving (P)

Analysis and interpretation of the results are discussed in the next phase, namely Task 4.

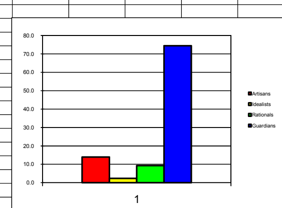
## TABLE 3

| Mechnchl | | | | | | | | TABLE 3 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4930 | 01, 02, 03 | | | | | | | | | | | | | |
| | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | Total | % |
| | A | B | C | D | E | F | G | H | I | J | K | L | | |
| **Artisan** | 1 | 1 | 2 | 2 | 2 | 0 | 1 | 1 | 1 | 2 | 0 | 1 | **14** | **21.5** |
| **Idealist** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | **4** | **6.2** |
| **Rational** | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **3** | **4.6** |
| **Guardian** | 4 | 4 | 3 | 3 | 2 | 5 | 4 | 5 | 4 | 2 | 5 | 3 | **44** | **67.7** |
| | | | | | | | | | | | | | | |
| **Total** | | | | | | | | | | | | | | |
| **Rspncs** | **65** | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| SPs | | NF | | NT | | SJ | | | | | | | | |
| | | | | | | | | | | | | | | |
| ESTP | 5 | ENFP | 1 | ENTP | 5 | ESTJ | 4 | | | | | | | |
| ISTP | 13 | INFP | 3 | INTP | 15 | ISTJ | 3 | | | | | | | |
| ESFP | 1 | ENFJ | 1 | ENTJ | 4 | ESFJ | 1 | | | | | | | |
| ISFP | 1 | INFJ | 0 | INTJ | 8 | ISFJ | 0 | | | | | | | |
| | | | | | | | | | | | | | | |
| | 20 | | 5 | | 32 | | 8 | | | | | | | |
| | 31 | percent | 8 | percent | 49 | percent | 12 | percent | | | | | | |
| | | | | | | | | | | | | | | |
| Extroverts | 22 | 34 | percent | | Thinking | 57 | 88 | percent | | | | | | |
| Introverts | 43 | 66 | percent | | Feeling | 8 | 12 | percent | | | | | | |
| | | | | | | | | | | | | | | |
| Sensing | 28 | 43 | percent | | Judging | 21 | 32 | percent | | | | | | |
| Intuitive | 37 | 57 | percent | | Perceiving | 44 | 68 | percent | | | | | | |




## TABLE 4

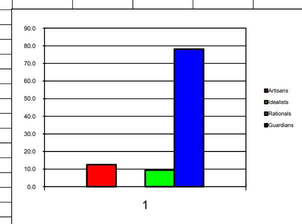
| CIVILENG | | | | | | | | | TABLE 4 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4930-01 | | | | | | | | | | | | | | | | |
| | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | Total | % |
| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | | |
| **Artisan** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 1 | 1 | **6** | **14.0** |
| **Idealist** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **1** | **2.3** |
| **Rational** | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | **4** | **9.3** |
| **Guardian** | 2 | 3 | 1 | 3 | 3 | 4 | 3 | 0 | 4 | 1 | 4 | 1 | 2 | 1 | **32** | **74.4** |
| | | | | | | | | | | | | | | | | |
| **Total** | | | | | | | | | | | | | | | | |
| **Rspncs** | **43** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| SP | | NF | | NT | | SJ | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| ESTP | 5 | ENFP | 1 | ENTP | 4 | ESTJ | 2 | | | | | | | | | |
| ISTP | 11 | INFP | 0 | INTP | 5 | ISTJ | 6 | | | | | | | | | |
| ESFP | 4 | ENFJ | 0 | ENTJ | 0 | ESFJ | 2 | | | | | | | | | |
| ISFP | 1 | INFJ | 0 | INTJ | 2 | ISFJ | 0 | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | 21 | | 1 | | 11 | | 10 | | | | | | | | | |
| | 49 | percent | 2 | percent | 26 | percent | 23 | percent | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| Extroverts | 18 | 42 | percent | | Thinking | 35 | 81 | percent | | | | | | | | |
| Introverts | 25 | 58 | percent | | Feeling | 8 | 19 | percent | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| Sensing | 31 | 72 | percent | | Judging | 12 | 28 | percent | | | | | | | | |
| Intuitive | 12 | 28 | percent | | Perceiving | 31 | 72 | percent | | | | | | | | |



# TABLE 5

| AGINDUS | | | | | | | | TABLE 5 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4500-01,02 | | | | | | | | | | | | | | | | |
| | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | Total | % |
| | A | B | C | D | E | F | G | H | I | J | K | | | | | |
| **Artisan** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | | | | **4** | **12.5** |
| **Idealist** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | **0** | **0.0** |
| **Rational** | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | | | | **3** | **9.4** |
| **Guardian** | 2 | 4 | 1 | 5 | 1 | 4 | 2 | 3 | 1 | 1 | 1 | | | | **25** | **78.1** |
| **Total** | | | | | | | | | | | | | | | | |
| **Rspncs** | **32** | | | | | | | | | | | | | | | |

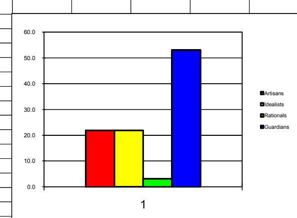
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SP | | NF | | NT | | SJ | | |
| ESTP | 2 | ENFP | 1 | ENTP | 4 | ESTJ | 1 | |
| ISTP | 7 | INFP | 0 | INTP | 3 | ISTJ | 3 | |
| ESFP | 0 | ENFJ | 0 | ENTJ | 4 | ESFJ | 2 | |
| ISFP | 1 | INFJ | 0 | INTJ | 3 | ISFJ | 1 | |
| | 10 | | 1 | | 14 | | 7 | |
| | 31 | percent | 3 | percent | 44 | percent | 22 | percent |
| Extroverts | 14 | 44 | percent | | Thinking | 27 | 84 | percent |
| Introverts | 18 | 56 | percent | | Feeling | 5 | 16 | percent |
| Sensing | 17 | 53 | percent | | Judging | 14 | 44 | percent |
| Intuitive | 15 | 47 | percent | | Perceiving | 18 | 56 | percent |




# TABLE 6

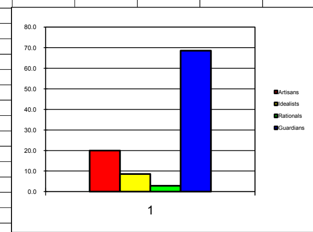
| THEATER | | | | | | | TABLE 6 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1130-01 | | | | | | | | | | | | | | | | |
| | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | Total | % |
| | A | B | C | D | E | F | | | | | | | | | | |
| **Artisan** | 1 | 2 | 1 | 0 | 1 | 2 | | | | | | | | | **7** | **21.9** |
| **Idealist** | 1 | 1 | 0 | 1 | 2 | 2 | | | | | | | | | **7** | **21.9** |
| **Rational** | 0 | 0 | 0 | 0 | 1 | 0 | | | | | | | | | **1** | **3.1** |
| **Guardian** | 2 | 3 | 4 | 4 | 2 | 2 | | | | | | | | | **17** | **53.1** |
| **Total** | | | | | | | | | | | | | | | | |
| **Rspncs** | **32** | | | | | | | | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SP | | NF | | NT | | SJ | | |
| ESTP | 3 | ENFP | 4 | ENTP | 6 | ESTJ | 1 | |
| ISTP | 2 | INFP | 2 | INTP | 6 | ISTJ | 1 | |
| ESFP | 1 | ENFJ | 1 | ENTJ | 1 | ESFJ | 2 | |
| ISFP | 1 | INFJ | 0 | INTJ | 1 | ISFJ | 0 | |
| | 7 | | 7 | | 14 | | 4 | |
| | 22 | percent | 22 | percent | 44 | percent | 13 | percent |
| Extroverts | 19 | 59 | percent | | Thinking | 21 | 66 | percent |
| Introverts | 13 | 41 | percent | | Feeling | 11 | 34 | percent |
| Sensing | 11 | 34 | percent | | Judging | 7 | 22 | percent |
| Intuitive | 21 | 66 | percent | | Perceiving | 25 | 78 | percent |




# TABLE 7

| THEATER | | | | | | | | TABLE 7 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1130-02 | | | | | | | | | | | | | | | | |
| | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | Total | % |
| | A | B | C | D | E | F | G | | | | | | | | | |
| **Artisan** | 2 | 2 | 1 | 0 | 1 | 1 | 0 | | | | | | | | **7** | **20.0** |
| **Idealist** | 0 | 1 | 1 | 1 | 0 | 0 | 0 | | | | | | | | **3** | **8.6** |
| **Rational** | 0 | 0 | 0 | 0 | 0 | 1 | 0 | | | | | | | | **1** | **2.9** |
| **Guardian** | 4 | 3 | 6 | 3 | 4 | 3 | 1 | | | | | | | | **24** | **68.6** |
| | | | | | | | | | | | | | | | | |
| **Total** | | | | | | | | | | | | | | | | |
| **Rspncs** | **35** | | | | | | | | | | | | | | | |
| SP | | NF | | NT | | SJ | | | | | | | | | | |
| ESTP | 1 | ENFP | 3 | ENTP | 5 | ESTJ | 2 | | | | | | | | | |
| ISTP | 4 | INFP | 3 | INTP | 4 | ISTJ | 0 | | | | | | | | | |
| ESFP | 5 | ENFJ | 1 | ENTJ | 0 | ESFJ | 1 | | | | | | | | | |
| ISFP | 4 | INFJ | 0 | INTJ | 2 | ISFJ | 0 | | | | | | | | | |
| | 14 | | 7 | | 11 | | 3 | | | | | | | | | |
| | 40 | percent | 20 | percent | 31 | percent | 9 | percent | | | | | | | | |
| Extroverts | 18 | 51 | percent | | Thinking | 18 | 51 | percent | | | | | | | | |
| Introverts | 17 | 49 | percent | | Feeling | 17 | 49 | percent | | | | | | | | |
| Sensing | 17 | 49 | percent | | Judging | 6 | 17 | percent | | | | | | | | |
| Intuitive | 18 | 51 | percent | | Perceiving | 29 | 83 | percent | | | | | | | | |




## Task 4: <u>Analyze and Interpret the Data</u>

Results extracted from students' response to Question I of the Questionnaire regarding the on-line KTS-II test result of personality type of each student in the five courses listed in Table 1 are summarized below in Table 8a through 8e (extracted from Tables 3 to 7). <u>The tallies in the last four rows are for Artisans, Idealists, Rationals, and Guardians respectively for each course</u>.

**<u>Table 8a: Mechnchl 4930-01,02,03, College of EMS</u>**

| TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | TEAM | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | | |
| 1 | 1 | 2 | 2 | 2 | 0 | 1 | 1 | 1 | 2 | 0 | 1 | **14** | **21.5** |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | **4** | **6.2** |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **3** | **4.6** |
| 4 | 4 | 3 | 3 | 2 | 5 | 4 | 5 | 4 | 2 | 5 | 3 | **44** | **67.7** |

**<u>Table 8b: CivilEng 4930-01, College of EMS</u>**

| Team | Team | Team | Team | Team | Team | Team | Team | Team | Team | Team | Team | Team | Team | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 1 | 1 | **6** | **14.0** |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **1** | **2.3** |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | **4** | **9.3** |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 1 | 3 | 3 | 4 | 3 | 0 | 4 | 1 | 4 | 1 | 2 | 1 | **32** | **74.4** |

**Table 8c: Agindus 4500-01,02 College of BILSA**

| TEAM A | TEAM B | TEAM C | TEAM D | TEAM E | TEAM F | TEAM G | TEAM H | TEAM I | TEAM J | TEAM K | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | **4** | **12.5** |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0.0** |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | **3** | **9.4** |
| 2 | 4 | 1 | 5 | 1 | 4 | 2 | 3 | 1 | 1 | 1 | **25** | **78.1** |

**Table 8d: Theater 1130-01, College of LAE**

| TEAM A | TEAM B | TEAM C | TEAM D | TEAM E | TEAM F | Total | % |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 1 | 0 | 1 | 2 | **7** | **21.9** |
| 1 | 1 | 0 | 1 | 2 | 2 | **7** | **21.9** |
| 0 | 0 | 0 | 0 | 1 | 0 | **1** | **3.1** |
| 2 | 3 | 4 | 4 | 2 | 2 | **17** | **53.1** |

**Table 8e: Theater 1130-02, College of LAE**

| TEAM A | TEAM B | TEAM C | TEAM D | TEAM E | TEAM F | TEAM G | Total | % |
|---|---|---|---|---|---|---|---|---|
| 2 | 2 | 1 | 0 | 1 | 1 | 0 | **7** | **20.0** |
| 0 | 1 | 1 | 1 | 0 | 0 | 0 | **3** | **8.6** |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | **1** | **2.9** |
| 4 | 3 | 6 | 3 | 4 | 3 | 1 | **24** | **68.6** |

The composite percentage demographics of Artisans, Idealists, Rationals, and Guardians shown in the extreme right column of Tables 8a through 8e are shown next in Figures 1a through 1e respectively.

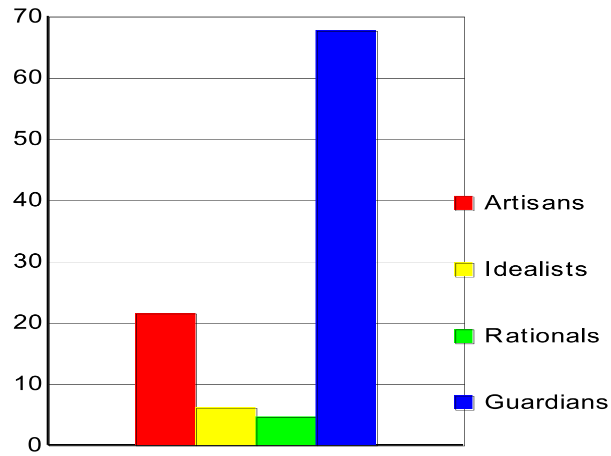



**Fig. 1a Bar-Chart of Personality Type Demographics of Mechnchl 4930-01, 02, 03**

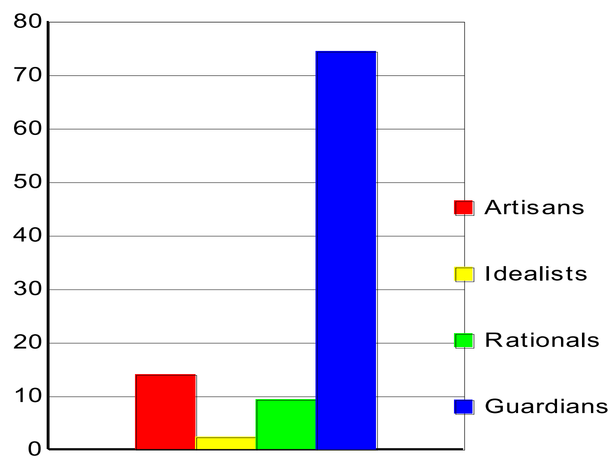



**Fig. 1b Bar-Chart of Personality Type Demographics of CivilEng 4930-01**

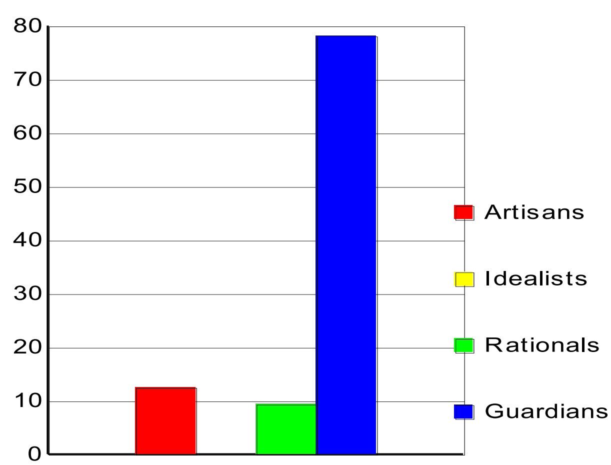


**Fig. 1c Bar-Chart of Personality Type Demographics of Agindus 4500-01, 02**

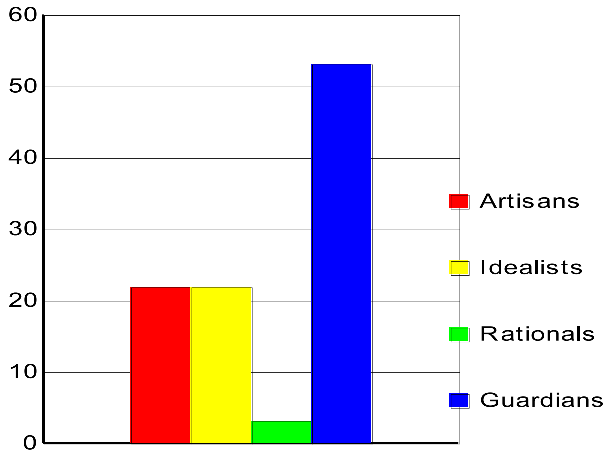



**Fig. 1d Bar-Chart of Personality Type Demographics of Theater 1130-01**

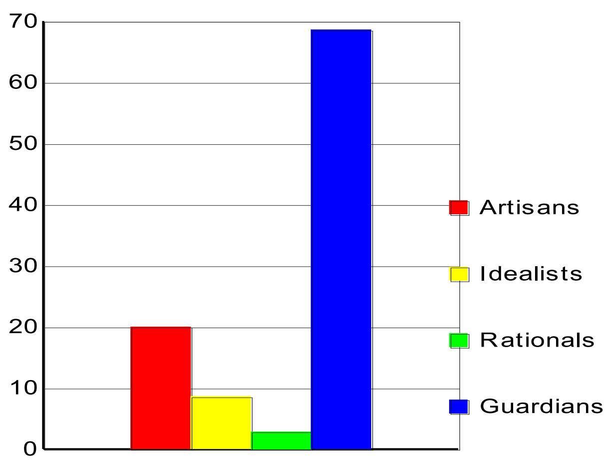



**Fig. 1e Bar-Chart of Personality Type Demographics of Theater 1130-02**

Some preliminarily strong but inconclusive inferences can be made from the cross-tabulation statistics of Tables 8a through 8e about the proportion of students that fall into each of the four personality types of the KTS-II model in the surveyed courses as follows:

a. Irrespective of major specific classes or not, majority of the students are guardians. The proportion of guardians is around 65% or more in engineering and business majors. The author is very confident of the position that 60% or more of mechanical engineering majors will be guardians at any time based on unpublished statistics collected over several years. Guardians are good team players, organized, concrete in communicating, and cooperative in achieving goals.
b. Idealists are only about 8 to 10% of the general population. It is noteworthy that the Introduction to Theater classes represent that distribution (more so in 1130-01) whereas idealists are significantly underrepresented in Engineering and Business classes. Idealists

bring harmony within teams, have broad and futuristic visions, are abstract in communicating, and cooperative in achieving goals.

c. Rationals form the lowest percentage in the general population (about 5 to 8%) which is reflected across all courses. Rationals are pragmatic, creative, problem solvers who are abstract in communicating and utilitarian in achieving goals.

d. Artisans are the second largest segment of the general population (about 30 to 35%) after guardians. This ratio is much better reflected in the theater classes than the engineering/business classes where the lower percentage of artisans than the national average goes to somewhat make up the higher percentage of guardians than the national average. Artisans are concrete in communicating, utilitarian in achieving goals, and can bring creative ideas for teams.

In order to check the degree of association between personality types and program majors, a Chi-square test as previously planned was conducted using different re-binned combinations of the contingency tables 8a through 8e. For example, a 4 X 2 contingency table relating artisans, idealists, rationals, and guardians to enrollments in non-LAE and LAE courses was set up as shown in Table 9 below (drawn from Tables 8a through 8e) and analyzed as follows:

**Table 9**

| | Artisans | Idealists | Rationals | Guardians |
|---|---|---|---|---|
| Enrolled in Non-LAE course | 24 | 5 | 10 | 99* |
| Enrolled in LAE course | 14 | 10 | 2 | 41 |

*A value of 99 has been used instead of the actual count of 101 due to a 2-digit restriction in the software

The results of the chi-square test [12] for the data in Table 9 are as follows:

**Data:**

| | A | B | C | D | |
|---|---|---|---|---|---|
| 1 | 24 | 5 | 10 | 99 | 138 |
| 2 | 14 | 10 | 2 | 41 | 67 |
| | 38 | 15 | 12 | 140 | 205 |

**Expected values:**

| | A | B | C | D |
|---|---|---|---|---|
| 1 | 25.6 | 10.1 | 8.08 | 94.2 |
| 2 | 12.4 | 4.90 | 3.92 | 45.8 |

**Chi-square = 10.3; Degrees of freedom = 3; Probability = 0.016**

Although the low probability value of 0.016 negates the null hypothesis of non-influence of personality types on enrollment in LAE or non-LAE courses, the inference is strictly not acceptable because two of the expected values as seen in the above results are below the rule-of-thumb limit of 5 for the Chi-square test to be valid. It can be seen that the low number of idealists and/or rationals compared to artisans and guardians as data is the root cause of the problem. Such data is reflective of small and unbalanced data. For such small, sparse, unbalanced data, the Fisher test is much better suited. [13,14]

The results of the Fisher exact test[15] for the data in Table 9 are as follows:

**Data:**

| | A | B | C | D | |
|---|---|---|---|---|---|
| 1 | 24 | 5 | 10 | 99 | 138 |
| 2 | 14 | 10 | 2 | 41 | 67 |
| | 38 | 15 | 12 | 140 | 205 |

**Expected values:**

| | A | B | C | D |
|---|---|---|---|---|
| 1 | 25.6 | 10.1 | 8.08 | 94.2 |
| 2 | 12.4 | 4.90 | 3.92 | 45.8 |

**The given table has probability of 7.7E-05**

**The sum of the probabilities of "unusual" tables *p* = 0.021**

The low value of p=0.021 negates the null hypothesis and thereby provides a strong inference that personality types of individuals affects their choice between non-LAE and LAE majors. It should be noted that this inference is likely to have been even stronger if the LAE courses 1130-01 and 1130-02 were to be taken only by students majoring programs in the College of LAE alone and not in other colleges as well. This conclusion is drawn from the additional data that was collected that 19 of the 67 students in the combined 1130 Theater course were interested in majoring in a program within the College of LAE. In other words, if just 19 of 67 students interested in LAE majors the 1130 course could significantly affect the association between personality type and choice of non-LAE and LAE majors, the effect would have been much more pronounced if all students in the 1130 course were majoring in LAE programs.

As for association between personality types and choice of majors within the college of EMS or in majors in EMS and BILSA, the Fisher tests revealed no strong association, thereby confirming the null hypothesis. For example, in checking the association between personality types and majors in Mechanical Engineering and Civil & Environmental Engineering, the data is shown in Table 10 (extracted from Tables 8a and 8b). The results of the Fisher test follow the table.

**Table 10**

| | Artisans | Idealists | Rationals | Guardians |
|---|---|---|---|---|
| Mechnchl 4930 | 14 | 4 | 3 | 44 |
| CivilEng 4930 | 6 | 1 | 4 | 32 |

The results of the Fisher exact test [15] for the data in Table 10 are as follows:

**Data:**

| | A | B | C | D | |
|---|---|---|---|---|---|
| 1 | 14 | 4 | 3 | 44 | 65 |
| 2 | 6 | 1 | 4 | 32 | 43 |
| | 20 | 5 | 7 | 76 | 108 |

**Expected Values:**

| | A | B | C | D |
|---|---|---|---|---|
| 1 | 12.0 | 3.01 | 4.21 | 45.7 |
| 2 | 7.96 | 1.99 | 2.79 | 30.3 |

**The given table has probability 6.9E-03. The sum of the probabilities of "unusual" tables** $p$ **= 0.484**

With a $p$ value of 0.484 from the results as seen above, the null hypothesis of non-association between personality types and choice of Mechanical or Civil Engineering cannot be negated. Inferences from Fisher Exact test inferences can improve with more sampling. As for the 16-level Myers-Briggs demographics of students in the five courses based on their own assessment in this model, the following results are summarized in Table 11a through 11e (extracted from Tables 3 through 7).

**Table 11a: Mechnchl 4930-01,02,03, College of EMS**

| SPs | NFs | NTs | SJs |
|---|---|---|---|
| ESTP: 5 | ENFP: 1 | ENTP: 5 | ESTJ: 4 |
| ISTP: 13 | INFP: 3 | INTP: 15 | ISTJ: 3 |
| ESFP: 1 | ENFJ:1 | ENTJ: 4 | ESFJ: 1 |
| ISFP: 1 | INFJ: 0 | INTJ: 8 | ISFJ: 0 |
| 31% | 8% | 49% | 12% |

**Table 11b: CivilEng 4930-01, College of EMS**

| | | | |
|---|---|---|---|
| ESTP: 5 | ENFP: 1 | ENTP: 4 | ESTJ: 2 |

| | | | |
|---|---|---|---|
| ISTP: 11 | INFP: 0 | INTP: 5 | ISTJ: 6 |
| ESFP: 4 | ENFJ: 0 | ENTJ: 0 | ESFJ: 2 |
| ISFP: 1 | INFJ: 0 | INTJ: 2 | ISFJ: 0 |

**Table 11c: AgIndus4500-01, College of BILSA**

| | | | |
|---|---|---|---|
| ESTP: 2 | ENFP: 1 | ENTP: 4 | ESTJ: 1 |
| ISTP: 7 | INFP: 0 | INTP: 3 | ISTJ: 3 |
| ESFP: 0 | ENFJ: 0 | ENTJ: 4 | ESFJ:2 |
| ISFP: 1 | INFJ:0 | INTJ: 3 | ISFJ: 1 |

**Table 11d: THEA 1130-01, College of LAE**

| | | | |
|---|---|---|---|
| ESTP: 3 | ENFP: 4 | ENTP: 6 | ESTJ: 1 |
| ISTP: 2 | INFP: 2 | INTP: 6 | ISTJ: 1 |
| ESFP: 1 | ENFJ: 1 | ENTJ: 1 | ESFJ: 2 |
| ISFP: 1 | INFJ: 0 | INTJ: 1 | ISFJ: 0 |

**Table 11e: THEA 1130-02, College of LAE**

| | | | |
|---|---|---|---|
| ESTP: 1 | ENFP: 3 | ENTP: 5 | ESTJ: 2 |
| ISTP: 4 | INFP: 3 | INTP: 4 | ISTJ: 0 |
| ESFP: 5 | ENFJ: 1 | ENTJ: 0 | ESFJ: 1 |
| ISFP: 4 | INFJ: 0 | INTJ: 2 | ISFJ: 0 |

As can be seen in Tables 11a through 11e, the sixteen level Myers-Briggs model often has too many levels to expect significant percentage of students falling into a few of these levels. But noteworthy numbers still tally for ISTP, ENTP, and INTP types across the board. Also, there are more ISTJs in engineering/business major courses than in courses with enrollment from different majors. Again, these are probable inferences that must be validated over larger samples over time. Even though dominant personality type presence cannot be discerned in the 16-level model, it is helpful to recognize the implications of the significant presence of ISTP, ENTP, and INTP types in team-based courses such as the ones being studied. For example, ISTPs are loyal to their peers and to their internal value system. Detached and analytical, they excel at finding solutions to practical problems. ENTPs are creative, resourceful, and intellectually quick. They are good at a broad range of things. They get very excited about new ideas and projects. They have excellent ability to understand concepts and apply logic to find solutions. But during team discussions they may tend to dominate. INTPs are logical, original, creative thinkers. They can become very excited about theories and ideas. Exceptionally capable and driven to turn theories into clear understandings. They highly value competence and logic. They tend to be individualistic. ISTJs are extremely thorough, responsible, and dependable. They are well-organized, hard working, and progress steadily towards identified goals. They can usually accomplish any task once they set their mind to it.

Literature regarding engineering teams suggests that ISTJs (Inspectors) and ESTJs (Supervisors) can be very good team leaders (Tier 0). Working under them could be a suitable development team combination of ISTPs (Operators), ESTPs (Promoters), INTJs(Mastermind), INTPs (Architects), ENTPs (Inventors), and ENTJs (Field marshals who can also be team leaders) (Tier 1). At the next level of Tier 2, choices could be a suitable combination of ISFJs (Protectors), ESFJs (Providers), INFPs (Healers), and ENFPs (Champions). At the next less important level of Tier 3 in engineering work, INFJs (Counselors) and ENFJs (Teachers) could be considered. At the fourth and final level, ISFPs (Composers) and ESFPs (Performers) can be placed. It should be recognized that such a model is not likely to suit a team working on putting together a theatrical performance. In such artistic environments, ISFPs (Composers) and ESFPs (Performers/Actors/Costume Designers) are far more important in the team hierarchy than they are in engineering work environments. The author has no professional qualification in the fine arts area to make any specific recommendations for courses in LAE. Instead, a detailed demographic feedback from the survey has been given to the faculty who teach the theater classes so that they can utilize the information to form teams and/or assign tasks that suit their needs based on the personality types. Similar comments about the author apply to courses in BILSA. In summary, having the right mix of personality types in team membership and assigning tasks to each of them that best suits their individual personality types will significantly improve team dynamics and performance. If teams cannot be formed based on personality types due to different reasons such as confidentiality or logistics, students must be cognizant about the subject of personality types, their effects on team dynamics, and possible conflicts that could arise due to too many members being of the same personality type – guardians in engineering majors such as mechanical engineering for example.

Personality type demographics can also be used to improve teaching-learning methods. For example, guardians (who are often the majority personality type in most, if not all, courses) like material to be presented in an organized manner. This may require teachers to be more methodical in their lectures and to supplement their lectures with more handouts. Care should be taken to also motivate guardians to put extra effort to be creative when situations warrant as in design problems. Care should also be taken to avoid over-saturating the teaching-learning strategies that adapt only to guardian type at the exclusion of other types. Surveys taken by students, feedback given to them similar to the key findings in this report, and encouragement given to them to further understand the topic and influence of personality types are different means of enhancing their learning of the subject. For example, students are asked to see a web site that provides a high-level description of the sixteen personality types[16] in the Myers-Briggs model and compare themselves to the particular description as per their particular individual personality type.

This paper is the result of furthering the knowledge about personality types, sharing with students and continued publishing and presentation [17]. The author intends to extend the study to students in other majors not only at UWP but also in other institutions in countries such as India and China about which not much information is available. Such information will be extremely valuable in the current context of global relations of the US with these countries.

## REALIZED OUTCOMES

Planning, implementation, analysis and interpretation of results of the personality type demographics as described above demonstrate that the following outcomes have been realized.

- Identification of ways to improve team dynamics
- Modification of teaching/learning styles to better suit the personality demographics
- Broadening of the knowledge-base on personality type of students in programs

- Publication of research results in conferences/publications

## IMPACT ON ACADEMIC PROGRAMS

This study has the potential to shape the process of building personality based teams for projects in courses that require them. Personality type results could potentially be used as an advising tool to help some students in the selection of a degree granting program to pursue. Knowledge of personality type demographics of students can also help the instructor to use suitable teaching-learning strategies and methods to match such demographics for enhanced learning outcomes.

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