

# **Project Based Learning Design Projects for Introduction to Engineering Design Courses**

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## **Abstract**

Over the last four years, the Introductory Engineering Science (ENES 101) course has been revised from a traditional lecture and design-on-paper course, to an active learning lecture and project based learning engineering design course. The design teams are required not only to research, design, construct, evaluate, test and present their product, but also to develop a mathematical model of their product's performance. Successful engineering design projects have included human powered pumps, water balloon launching devices, hot air balloons, wooden block transport devices, hemodialysis systems and chemically powered vehicles. ABET evaluations have been collected for this course over the last four years and this data has been used to evolve the course, as well as to formulate the design criteria for the design projects. In addition, a new "Success Seminar" component was added to one section of this course last year, and due to the positive impact on students' academic success in the following semester, the "Success Seminar" component has been added to two sections of the course this year.

The success of the revision of the introduction to engineering design course has led to partnerships with various area high schools, where the equivalent of ENES 101 is taught in the high school environment. As a result of these partnerships, the high school students have a better appreciation of engineering and over 90 % of these high school students are majoring in engineering in college (5 – 60 % per class per high school at UMBC). UMBC has assisted the high schools in teaching summer workshops for middle school girls, establish an "Engineering Olympics" for their feeder middle schools and start FSEA (Future Scientists and Engineers of America) after school clubs. Many of the high school engineering teachers have partnered with UMBC for several NSF engineering education grants which have been awarded.

## **Introduction**

The University of Maryland Baltimore County has undertaken various initiatives to improve engineering education and awareness. The first initiative was to revamp the Introduction to Engineering Course (ENES 101) from a traditional lecture and design-on-paper course, to an

active learning lecture and hands-on engineering design course. The revised ENES 101 course was presented and discussed during a three-day summer workshop to introduce high school teachers and counselors to the field of engineering. This workshop led to the faculty at Eastern Technical High School's request for the development of a formal partnership with UMBC to teach the equivalent of the ENES 101 course in the high school environment. It is not the intent of the partnership to be a recruiting tool for UMBC, but rather to expose high school students to a college level introductory engineering course. This partnership and its expansion to other high schools is the second initiative. The third initiative is the establishment of a new variation (ENES 101Y) of the Introduction to Engineering course which is committed to helping new UMBC engineering students understand the academic expectations at a research university, develop their individual success strategies, and connect with the many resources that are available on campus to help ensure success.

## **Background**

The high school level Introduction to Engineering course was developed based on the interest and ideas that emerged from a workshop conducted at UMBC in July 2001. The objective of the workshop was to better equip high school teachers and counselors to identify, guide, and prepare prospective students at each of their schools for a career in engineering. The three-day workshop was developed and presented by the author and was modeled after work done by Raymond Landis<sup>1</sup>, former Dean of Engineering and Technology at California State University, Los Angeles. Invitations to the workshop with a brochure and application form were sent to area high schools in Maryland. Each participant received a \$150 stipend, meals, and Maryland State Department of Education (MSDE) continuing education credits. The workshop was sponsored by a grant from the University System of Maryland through their K-16 Disciplinary Alliance and matching funds from UMBC's College of Engineering (COE). Twenty-eight mathematics, technology, and science high school teachers and counselors attended and explored the spectrum and reach of engineering in society.

The approach taken in presenting many of the topics was to provide fun 'hands-on' activities, during which the participants competed for a variety of 'prizes,' including UMBC t-shirts, key chains and gift certificates. Pre and post-surveys were conducted to assess the knowledge, abilities, and understanding of engineering, career opportunities, high school preparation, success strategies, incorporating projects to introduce high school students to engineering and advising students for an engineering career. Results<sup>2</sup> of these surveys and more details of the summer workshop were presented at the ASEE 2003 Annual Conference.

Another measure of the success of this workshop was the interest it generated in follow-up collaborations between UMBC and local high schools. A few examples include:

- Invitations for UMBC to make several high school career day presentations.
- Numerous high school class visits and tours of UMBC's College of Engineering.
- UMBC's participation in the establishment of a High School Engineering Academy.
- New partnerships forming the basis of grant proposals to NSF in Engineering Education Program and the Maryland High Education Commission (MHEC).

- The formation of a high school level Introduction to Engineering course and the subsequent pilot field introduction of this course in a partnership between UMBC and Eastern Technical High School.
- Expansion for the high school partnership with additional high schools.

It is the last of these activities, the high school level Introduction to Engineering course, that became the second initiative for improving the Freshman Engineering Experience.

### **The First Initiative – Revision of the Introduction to Engineering Course at UMBC**

The Introduction to Engineering course (ENES 101) at UMBC was revamped in 2000 and has its origins in work done by Dally and Zhang<sup>3</sup>, and in work the author did while teaching in the Freshman Engineering ECSEL<sup>4</sup> program at the University of Maryland, College Park. ENES 101 includes an overview of engineering and an introduction to various topics within engineering. The emphasis of the revision of the course was to make it a project based inquiry experience. The students must work in interdisciplinary teams to design, build, evaluate, test, report (both a formal written report and oral presentation) and develop a mathematical model for a specified product. ENES 101 is a three-credit freshman engineering course which consists of two fifty-minute class sessions and a two-hour discussion session each week over a 16 week semester. The current enrollment in this course is approximately 180 students in the fall semester and 120 students in the spring semester. The discussion sessions are limited to 30 students. The course has three primary components: engineering topics, design tools, and the design project. A new variation of this course was added in the fall 2003 and expanded in the fall 2004 semester, as part of the First-Year Success Courses initiative at UMBC, and is the third initiative (and will be discussed below).

Since the majority of the students in the course are incoming freshman, the first few classes are devoted to educating students on how they can be successful<sup>5-7</sup> in studying engineering, discussing the engineering profession, providing academic strategies for success, and informing students how they can broaden their education. Also as part of the course each student is required to participate in at least one function sponsored by a student professional engineering society (AIChE, ASME, IEEE, SAE, etc.). This is a chance for the students to make connections with upperclassmen in their major and become acquainted with the various opportunities available through professional engineering societies. A variety of engineering topics are covered during class including unit conversion and dimensional consistency, data analysis and representation, strength of materials, introduction to statics, introduction to fluid mechanics, introduction to heat transfer, and computer programming. Depending on the design project topic, some of the topics are studied in more depth. A workbook, written by this author, is given to each student and covers the course topics complete with example problems. These example problems supplement problems covered during class.

The students are instructed in the use of various design tools during the weekly two-hour discussion sessions. Most of the sessions are held in the dedicated COE freshman computer lab. Undergraduate Teaching Fellows<sup>8</sup>, who are senior-level engineering students, lead the discussion sessions. The Fellows are recruited by the author and have demonstrated both collaboration and

leadership in the classroom and their ability to work well with students due to their previous experience in taking ENES 101 at UMBC. The design tools include Microsoft Word, Microsoft Excel, computer aided design (CAD), computer programming, and Microsoft PowerPoint. *ESource The Prentice Hall Engineering Source* series of textbooks is used for the lecture material homework's and discussion session exercises & homework assignments. The Teaching Fellows are responsible for grading the weekly homework assignments (prepared by the author), which includes material covering both the design tools and class topics. Student teams meet during discussion sessions as well as outside of class to work on their design projects.

Each year a different design project is selected and the students must research, design, construct, and develop an analytical model and then test, evaluate, and report on the product. The goal is to select a product that is fun<sup>9</sup>, inexpensive to construct, simple, and yet requires fundamental engineering principles. Safety is the primary concern, and the design specifications are structured to include safety precautions. The projects are also structured to have "bragging rights" associated with the product performance. This has resulted in friendly competition among the teams. Successful projects have included: human powered pumps, catapults or trebuchets for launching water balloons, hot air balloons<sup>10</sup>, wooden block transport devices<sup>11</sup>, a hemodialysis system, and a chemically powered vehicle<sup>12</sup>. Each of these projects will be described in more detail in the following section. The projects are introduced during class by having the students participate in hands-on reverse engineering activities [they took apart simple soap dispensers for the human powered pump project or toy catapults for the catapult or trebuchet project to see how they work<sup>13</sup>]. The homework assignments also have problems that lead the students in the right direction for the modeling and product performance calculations that are required. It has been rewarding to see the creative designs<sup>14</sup>, as well as the interest the teams have taken in the projects. Many teams have created videos they made during the construction and testing of their projects. UMBC's Office of Information Technology has also filmed the design process over the course of the semester and has produced "Video: Teamwork, Design, and Making Things Work! Undergraduate Design Class" produced by Bob Kuhlmann and Damion Wilson of UMBC's New Media Studio <http://www.umbc.edu/engineering/cbe/>. In addition, UMBC's New Media Studio has also produced videos of each of the other five design projects, and they will be featured during the presentation. Local interest in the design projects has also occurred with local television coverage (WBALTV and FOX45 News) and articles in local newspapers ('In experiment, it's ready, aim, inspire' by Alec Mac Gillis in *The Baltimore Sun*, May 8, 2002). This publicity has resulted in numerous contacts from area high schools that are interested in partnering with UMBC, as well as calls from prospective students and parents.

The first homework assignment consists of a team application form for each student to complete. Information regarding the students' major, high school attended, GPA, SAT scores, and access to a car are requested. The students are also required to identify their skills in writing, graphics, leadership, teamwork, analysis, drafting, planning and research/library, as well as their strengths and weaknesses. This information is then used to assign the teams<sup>15</sup>, which consist of 4-6 team members. Teams are balanced using the following criteria: major<sup>16</sup>, background, academic performance, gender and ethnicity<sup>17</sup>, and access to transportation off campus to purchase materials for the construction of the project. The team application also requires the students to write about themselves: how they became interested in their major, what their long-term career

goals are, and what they did over the last summer or winter break. This additional information is used solely by the author to get to know the students on a more personal level since the class sizes are large. After the team assignments are made, (by the end of the second week of the semester), class time is then spent learning to effectively build and work in a team<sup>18, 19</sup>.

Communication skills are stressed as part of the design project experience. Each team must complete a logbook (design notebook)<sup>20</sup> over the course of the semester; the first team assignment is to interview each team member and log the interviews. The remainder of the entries serves as documentation of team meetings, evolution of design, modeling, evaluation approaches, and actual performance. Each team must also submit a final written report summarizing their efforts. Guidelines for the report, as well as a detailed grading rubric<sup>21</sup> are handed out and discussed during class. The teams are encouraged to turn in a preliminary draft of their report for comments prior to submitting their final report. UMBC also has a Writing Center located in the Learning Resource Center on campus that provides assistance to the students in the preparation of their reports<sup>22</sup>. Each team is also required to make a formal oral presentation using PowerPoint at which each team member is required to present. Specific guidelines for the presentation are discussed in class and the students are given a grading rubric for the presentation. Each team member must also complete a peer evaluation for themselves and each team member, which is part of the students' grade for the course.

### **The Project Based Learning Design Projects**

The primary concern for each of the design projects is safety; considerable amount of time is spent each semester discussing safety issues specific to each project. Since the primary criterion for each design project is safety; each design product must operate without any hazards. The following is a brief description of the design specifications of each of the successful projects.

#### ***Human Powered Pump***

In the fall 2000 the design teams were challenged to design, construct evaluate and test a human powered pump. This project was modified after a design project the author used while teaching ENES 100 (Introduction to Engineering Design) at the University of Maryland College Park in the ECSEL<sup>4</sup> program. The design projects had to draw water from a large tank of water and pump it up a vertical height of 10 feet, and deliver the water to a second empty tank. Each team had 15 minutes to set up/assemble their pump and then were allocated 10 minutes of pumping time; each team member was required to pump an equal amount of time. The pumping rate was measured and compared to predicted performance.

#### ***Catapult or Trebuchet***

This design project required the students to design, construct, and test and evaluate a catapult or trebuchet used for launching water balloons (2 cups in volume, provided by the author) for distance and accuracy. The catapult or trebuchet was required to use a pivoting throwing arm which could not exceed four feet in length, and the water balloon was required to pass within six inches from the base of the design at the initial firing position. To ensure safety, all team

members were required to be at least five feet away from the catapult or trebuchet at the time of the launch (in other words, the release pin had to be activated by pulling on a rope or by some other means). The goal of the design was to launch the water balloon as far as possible with the first five balloons and as accurate as possible with the next five balloons. The accuracy shots were at a three foot diameter target, which had to be placed a minimum of 30 feet from the catapult or trebuchet. An additional water balloon was provided for each team to launch at the professor (the author), there were **NO** penalties for hitting the professor.... just bragging rights. The students had so much fun launching balloons at the professor, that many additional water balloons were provided to each of the teams for ‘target’ practice at the professor... this was described in *The Baltimore Sun* article as “The project testing was like the dunking booth at the county fair, only better, Professor Taryn Bayles was kind enough to rush into the line of balloons launched by machines that misfired”<sup>23</sup>, and FOX45 News station dubbed her as the “Wacky Professor at UMBC” while airing video clips of her being drenched by the various design projects.

### ***Hot Air Balloon***<sup>10</sup>

The fall 2002 semester design project was to design, construct, model, predict the performance, test and evaluate a hot air balloon. The hot air balloon was powered by a ground-based heat gun (provided by the author), it was required to stay aloft a minimum of 12 seconds, carry a minimum payload of 10 grams, and was restricted in size to fit into a volume of 2 meters by 2 meters by 2 meters. In addition, the cost of the materials used in the design could not exceed \$30.00. Each team was allotted 15 minutes to setup the balloon at the launch site, 5 minutes of preheat time (using an ordinary hair dryer), up to five minutes of thermal heating using the heat gun, which was followed by the actual launch. The preheat time using the hair dryer was not required, but optional. Each team was also required to create a mathematical model implementing Excel or FORTRAN that predicted how long their balloon would stay aloft. Inputs to the model had to include the payload, balloon surface area and volume, balloon material properties, inside air temperature of the balloon at lift off, etc. Each mathematical model was checked by the author prior to the design project testing. Through this mathematical modeling the students cultivate the connection between mathematics and engineering, as well as understanding the fundamental engineering principles that make their hot air balloons work. Due to the success of the ‘bragging rights’ that were incorporated in the previous years design project, all of the subsequent design projects have incorporated ‘bragging rights’. The ‘bragging rights’ for product performance were assessed using the performance metric:

$$\mathbf{Time\ aloft\ \times\ payload\ \times\ model\ accuracy}$$

Where model accuracy is calculated using the SMALLER of:

$$\left| \frac{\text{Predicted Time Aloft}}{\text{Actual Time Aloft}} \right| \quad \text{or} \quad \left| \frac{\text{Actual Time Aloft}}{\text{Predicted Time Aloft}} \right|$$

### ***Wooden Cube Transport Device<sup>11</sup>***

The next design project was to design, construct, model, predict the performance, test and evaluate a device that would transport a 1-¾ inch wooden cube through a large horizontal displacement as possible using only the energy of a sealed 2-liter bottle, and the maximum height of any portion of the bottle could not exceed 8 feet above the ground. The size restriction of the device was that it had to fit within a 3 foot by 3 foot by 3 foot volume prior to assembly; each team had five minutes to setup the device at the launch site, followed by the actual launch. Once again, all team members were required to be at least five feet away from the device at the time of the launch. The device was also required to avoid any liquid or gas discharge. The launches consisted of 5 shots for distance, 5 shots for accuracy at a 3 foot diameter target (which was a minimum of 20 feet away), and one launch at the professor. Each team was also required to develop a mathematical model that predicted how far the wooden block would be launched. 'Bragging rights' for product performance were assessed using the performance metric:

$$\text{Distance traveled} \times \% \text{ accuracy of hitting the target} \times \text{model accuracy}$$

Where model accuracy is calculated using the SMALLER of:

$$\left| \frac{\text{Predicted Distance Transported}}{\text{Actual Distance Transported}} \right| \quad \text{or} \quad \left| \frac{\text{Actual Distance Transported}}{\text{Predicted Distance Transported}} \right|$$

### ***Hemodialysis System***

In the fall 2004 two new design projects were used in ENES 101, the first project was the design, construction, modeling, prediction of the performance, testing and evaluation of a device that would simulate a hemodialysis system. This design project is modeled after a design challenge developed by the author and others that is part of a NSF funded IMD grant (ESIE-0352504). The goal of the system was to remove as much of the impurities as possible from simulated blood while using a minimum amount of dialysate (water). The cost of the system had to be less than \$50.00. The device was tested using a volume of 400 ml of simulated blood; the minimum concentration of impurities in the dialysate was required to be 0.0015 mg/ml. The students were allowed to purchase (at cost) dialysis membranes from the author which had 3 different diameters, with 2 different MW cut-off pore sizes. Each team was given 500 ml of simulated blood for testing prior to the actual hemodialysis system testing. A mathematical model was required to be developed by each team and the 'bragging rights' for product performance was assessed using the performance metric:

$$\text{concentration of impurities} \times \text{dialysate cost index} \times \text{model accuracy} \times \text{device cost index}$$

The dialysate is valued at \$ 20.00 per liter and the cost index is calculated using:

$$\frac{\text{Minimum dialysate cost of a hemodialysis system that meets the design requirements}}{\text{Your Team dialysate cost}}$$

The model accuracy is calculated using the SMALLER of (i.e. the ratio that is less than one):

$$\left| \frac{\textit{Predicted Dialysate Concentration}}{\textit{Actual Dialysate Concentration}} \right| \quad \text{or} \quad \left| \frac{\textit{Actual Dialysate Concentration}}{\textit{Predicted Dialysate Concentration}} \right|$$

The device cost index is calculated using:

$$\frac{\textit{Minimum TOTAL design cost of a hemodialysis system that meets the design requirements}}{\textit{Your Team TOTAL design cost}}$$

### ***Chemically Powered Vehicle<sup>13</sup>***

The second design project used in the fall 2004 semester was to design, construct, model, predict the performance, test and evaluate a vehicle that is powered with a chemical energy source which would transport a given volume of water (between 50 and 300 ml), a specified horizontal distance (between 30 and 80 feet). The actual volume and distance were selected at random one hour prior to the actual testing. The cost of the vehicle was minimized, and the size restriction of the vehicle was 18 inches x 12 inches x 12 inches. The objective of this design is a demonstration of the ability to control a chemical reaction. The only energy source for the propulsion of the vehicle is a chemical reaction. The vehicles had to operate safely inside a building and only gases or water was allowed to be released from the vehicle. (i.e., no explosives, nor rocket launchers, etc.). Each vehicle was given two opportunities to traverse the specified distance; the average distance of the two attempts was used in the bragging rights determination. Teams were allowed to adjust ‘fuel’ or reactants that participate in the vehicle’s chemical reaction. Again, a functional mathematical model was required prior to testing and the “bragging rights” for product performance were assessed using the performance metric:

$$\textit{distance traveled (ft)} \times \textit{volume transported (ml)} \times \textit{model/distance accuracy} \times \textit{vehicle cost index}$$

Where model/distance accuracy is calculated using the SMALLER of:

$$\left| \frac{\textit{Specified Distance Transported}}{\textit{Actual Distance Transported}} \right| \quad \text{or} \quad \left| \frac{\textit{Actual Distance Transported}}{\textit{Specified Distance Transported}} \right|$$

The vehicle cost index is calculated using:

$$\frac{\textit{Minimum TOTAL design cost of a vehicle that carries the payload } \pm 25 \textit{ feet of the specified distance}}{\textit{Your Team TOTAL design cost}}$$



## **The Second Initiative - The High School Introduction to Engineering Course**

The high school course is essentially the same as UMBC's ENES 101 course. The same workbook, *ESource The Prentice Hall Engineering Source* series of textbooks, homework assignments, quizzes and exams are given, as well as the same design project and evaluation criteria. The differences between the two experiences are that the high school course is taught over a full school year, versus a semester; therefore, the students have more class time to work on their design projects and assignments. The high school teams usually have time to complete two different design projects (the current UMBC project and a previous project). In addition, the high school teams are composed of only two or three students since it has been the experience of the high school teachers that groups of more students are less effective.

As part of a field trip, the high school students are required to attend one of the design project testing days during the fall semester at UMBC. This gives them the opportunity to experience the climate and culture of a college campus as well as meet and talk with some of the college students and learn from their designs. The high school students also attend a UMBC visit day where they attend engineering classes, a COE discipline overview, a student panel discussion, and a campus tour. Interested students also attend the COE open house during Engineers Week. Also as part of this exchange, the author travels to the high school for the design project testing and the oral presentations.

## **The Third Initiative - First-Year Success Course ENES 101Y**

In August 2001, the University of Maryland Baltimore County began the planning process for the development of a Student Success Course model in order to strengthen the First-Year Experience for students. Both a steering committee and working group were established and developed the student success course goals for the First-Year Success Course, as outlined below:

### **Course Goals:**

- Clarify academic expectations (which include the understanding of the value of a liberal arts education and academic integrity) and develop in students the essential academic skills (time management, problem solving, communication, library skills, etc.) for success at UMBC
- Facilitate students' involvement as active members of the UMBC community
- Maximize students' personal development and self-awareness for major/career decision making and life long learning

Due to the comprehensive coverage of the above topics (as compared to what is covered in the first few classes of the ENES 101 course), a new section, ENES 101Y, was offered in the fall 2003 semester. Students enrolled in this section attended the same ENES 101 lectures and discussion sessions, but they also attended one extra fifty minute class each week to cover the 'student success course' and received 4 credits for ENES 101Y (versus 3 credits for ENES 101). There were 22 students enrolled in ENES 101Y during the fall 2003 semester. The results<sup>24</sup> of the impact of this course was presented last year at the 2004 ASEE Annual Conference. Due to the positive impact on student's academic success in the following semester, the Success

Seminar component has been added to two sections of the course in the fall 2004 semester with an enrollment of 56 students.

## **Results and Conclusions**

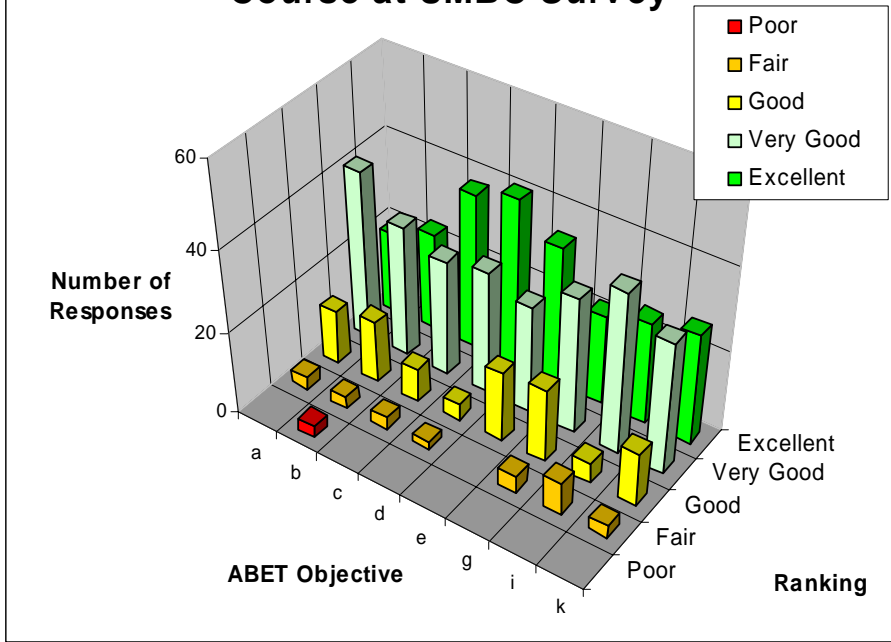
UMBC has revamped the introduction to engineering course to include a hands-on, project-based inquiry experience in the design of a specified product. The author also developed and taught a three day summer workshop to introduce the field of engineering to high school teachers and counselors. This has resulted in numerous follow-up collaborations between UMBC and local area high schools. One such collaboration was a partnership to teach the Introduction to Engineering course in the high school setting.

As a metric of the effectiveness of the course at the college and high school levels, some key criteria established by ABET for assessing engineering programs were used. In order to receive accreditation, ABET requires that engineering programs demonstrate that their graduates have:

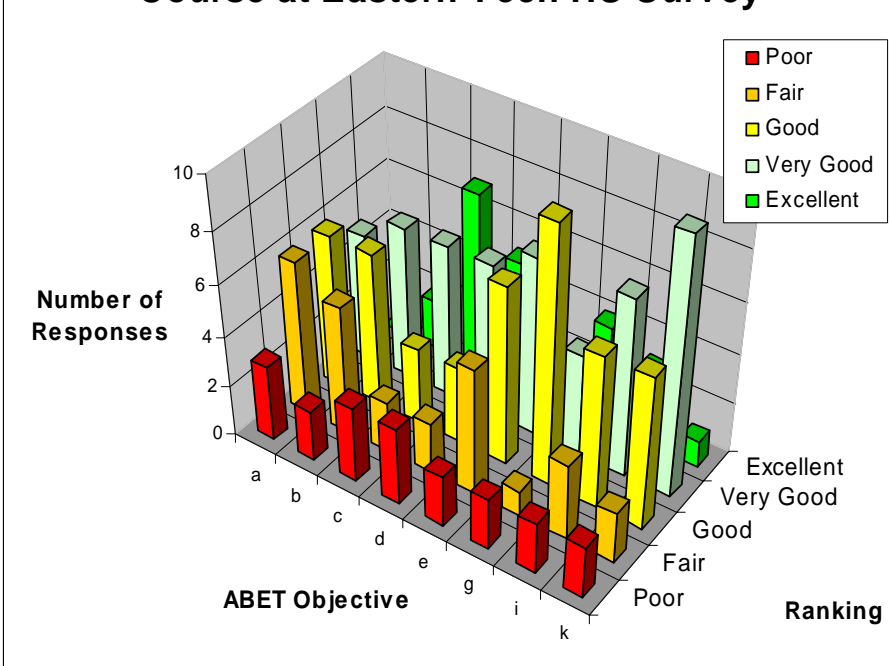
- (a) an ability to apply knowledge of mathematics, science and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) an ability to design a system, component, or process to meet desired needs
- (d) an ability to function on multi-disciplinary teams
- (e) an ability to identify, formulate and solve engineering problems
- (g) an ability to communicate effectively
- (i) a recognition of the need for, and an ability to engage in life-long learning
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Although it is unlikely that a single freshman engineering course can prepare students to satisfy the ABET criteria, it is a useful tool to gauge students' progress in their ability to utilize key engineering concepts and thought processes. To this end, students are asked to provide a self assessment, via a survey, of their progress in key ABET areas. Survey results from the fall 2002 UMBC freshman course are presented below in Figure 1 and the corresponding High School course survey from June 2003 (academic school year 2002-3) can be found in Figure 2.

**Figure 1: Introduction to Engineering Course at UMBC Survey**



**Figure 2: Introduction to Engineering Course at Eastern Tech HS Survey**



The survey measures the students' self-perceived attitudes and comfort level in key ABET areas. The proof of their progress can be readily seen in the working products they design and produce in each of the engineering challenges. Examples are given here (more can be found on the ENES 101 website: <http://www.umbc.edu/engineering/101.html>). In fall 2000 the teams had to design a human powered pump that had to pump water up a vertical height of 10 feet, and Team JIJA 2000 is shown in Figure 3 (Figure 3-8 can be found at the end of this section) and their pumping rate was 7.4 gallons per minute. Figure 4 depicts Team Intellectual Fun from the fall 2001 semester. Their project was to build a trebuchet to launch water balloons. Their furthest water balloon launch was 84 feet, and their target accuracy was 80 %. Their most accurate launch resulted in drenching the instructor from a distance of 72 feet. In fall 2002 the project was to design, build and model a hot air balloon. Team Space Blanket Spin-offs is shown in Figure 5 and their balloon carried a payload of 52.5 grams and stayed aloft for 41 seconds. The fall 2003 project was to design a wooden block transport device. Team Blockbusters is shown in Figure 6 with their design of a trebuchet which successfully launched the wooden block 72 feet and their accuracy was 80 %. In the fall 2004, a hemodialysis system was design and tested, Team Blood Suckers is shown in Figure 7 with their design, and their concentration of impurities exceeded the minimum by a factor of 4.2. Also in the fall 2004 a chemically powered vehicle was designed and Team #1 is shown in Figure 8 with their vehicle, which carried a payload of 150 ml of water and traveled 54.5 feet and cost \$1.60.

Over ninety percent of the students in the first two high school classes that took part in this partnership are currently majoring in engineering in college (24 % and 60 % at UMBC). The Eastern Tech high school students that enrolled at UMBC and met the eligibility requirements, have received credit for ENES 101. In addition, UMBC has assisted<sup>25</sup> the high school in teaching a summer workshop for middle school girls, establishing an 'Engineering Olympics' for their feeder middle schools and starting an FSEA after school club. The high school has also partnered with us in writing several grants to the NSF (such as the NSF funded IMD grant (ESIE-0352504) and the high school teachers helped develop the hemodialysis design challenge. Several other area high schools and school districts have approached UMBC to establish a similar partnership.

The Learning Resources Center at UMBC has a program in place through which they ask instructors of first semester freshmen to identify students that are in danger of failing at the mid point of the semester. Over one third of the students in the fall 2003 ENES 101Y section were identified at the end of October, as failing the course. However, by the end of the semester and with the assistance of the success strategies, less than ten percent of the students in ENES 101Y failed the course. The most significant impact of the success seminar that was noted last year was that 50 % of the students in the ENES 101Y course improved their GPA's from the fall 2003 semester to the spring 2004 semester (versus less than 15 % for the students in the other sections of ENES 101).



Figure 3: Team JIJA 2000; Jennifer Gerlock, Irene Aninye, Andrew Gray and Jamie Medoff.



Figure 4: Intellectual Fun; Kristin Decker, Dagobento Dupuy, Jennifer Plummer, Christina Wise, Ty McCray and Mela Johnson.



Figure 5: Team Space Blanket Spin-offs; Michael Knapp, Lauren Hand, Kellie Suess, Regina Tan, Jonathan Odell and Chris Jacob.



Figure 6: Team Blockbusters; James Pallikal, Tammy Newcomer, Liquan Qiu, Jeffrey Kaufman and Kathleen McCrory.



Figure 7: Team Blood Suckers; George Aninwene, Stephanie Davis, Ariane Kouamou Nouba, Brad Gates and James Pallikal



Figure 8: Team #1: Ben Schultz, Jessica Warrington, Lauren Wilson, Kurt Krosnowski, Peter Lokey and Radek Matweecha

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