Engineering Capstone Design Courses at Florida Atlantic University

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***Abstract*– This paper describes a sequence of two capstone design courses in the mechanical engineering program at Florida Atlantic University. In the first course, "Engineering Design", lectures on specific engineering related topics such as: Ethics, Codes and Standards, Team Dynamics, Statistical Design and Fatigue and Fracture Design, are given. At the same time students are asked to find a topic for the team project they will execute the next semester. They are encouraged to approach local companies, healthcare facilities, or other institutions in order to identify a real need that will be addressed in their project. During the semester the proposed idea is refined, through brain storming sessions and presentations, and at the end of the semester a full proposal is generated by the students, for evaluation by three faculty members. During the second course, "Design Project", students design, fabricate and test the "product" they had proposed. During the semester a few lectures are given on topics such as: Patents, GD&T, Actuators, Sensors etc. Also, three progress reports and presentations are given by the students which are evaluated by three faculty members. At the end of the semester a final report and a presentation as well as demonstration are given. A sample of students' design projects that resulted from these course are presented in the paper. The structure of these two courses is specifically designed to contribute to meeting the majority of the program educational outcomes as required by ABET.**

Keywords—Senior design course, Capstone design course.

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I. Introduction

Capstone engineering design courses are offered in almost all engineering colleges in the United States and around the world. These courses are effective vehicles to prepare engineering students to become future engineers who can practice in an increasingly complex real world with competence. In this section, we review first some of the efforts reported in the literature on improving capstone design courses and then summarize the remaining of the paper.

An important issue in offering a successful capstone course sequence is to have challenging and real-world projects that can be completed by a small group of students in a year or so. Such projects will offer students valuable educational experience which will benefit the students greatly when they are employed in the near future. Different from many researchers who reported to engage with industry as partners, in [1], the authors described a partnership between the students from the Colleges of Engineering and Education at San Diego State University and a group of sailors with disabilities. It aims to develop technology solutions to allow physically challenged individuals to safely and independently participate in various aquatic recreational activities.

Another issue for capstone design is to equip students with necessary knowledge and skills that are vital for completing multi-disciplinary design projects. In [2], the authors presented results of their pilot study on teaching students how to use toolkits which are often practiced in industry. The particular toolkits they proposed were TRIZ (a systematic problem solving approach) and Sketching Importance, which help students in creativity and on design ideation. The results of the ideation exercises with the toolkit are assessed and scored for Novelty, Variety and Quantity.

Yet another issue facing engineering educators is how we educate engineering students to systematically solve open-ended real-world design problems with various complexities. To answer the questions of what is best way to teach design and what are the characteristics of realistic design problems which provide excellent learning opportunities, the authors in [3] proposed method to teach students a systematic approach to the design process. The authors claimed, which was backed by their preliminary study, that the complexity of the design problem is a critical factor in teaching design methods. There is a correlation between the complexity of the design problem and the opinions of the students. Their results also indicated that students who worked on more complex design problems were more likely to use design tools such as functioning modeling in the future.

Engineering education research long discovered that capstone designs involving multiple disciplines will be more effective in preparing students to practice in the future in the real world. For example, the authors in [4] proposed an approach to multidisciplinary capstone design, which involved a systems engineering framework. Researchers also explored the correlation between prior industrial experience and students' initial and final performance in design course sequence. In [5], it was shown that the design process knowledge of students entering their senior year without any industrial experience to be no different than that of first-year students at the end of an introduction to engineering course. On the other hand, seniors with industrial experience showed noticeable differences compared to the first-year students. On the other hand, after a successful design course experience, the differences between these two groups of students are reduced considerably. Their results indicate that a capstone experience increases students' understanding of the importance of needs identification, the overall layout of design including iteration, and relative time allotments of different design activities. A related issue is project management. At the University of Victoria [6], researchers reported that they used capstone

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design as a tool to teach students on how to manage their design projects effectively.

Finally, to offer a successful capstone design course sequence, it is essential to how to access students scientifically and efficiently. In [7], authors reported that the Department of Computer Science and Engineering at Qatar University has produced a framework for managing and assessing capstone design projects based on the ABET criteria. According to the authors, "the key element in their framework is a web-based application named easyCapstone, which automates key workflows particularly for managing the project registration, the submission of deliverables, scheduling project presentations, assessing students work and providing timely personalized feedback to students." With easyCapstone, students can maintain a project blog to document the project progress, project issues and relevant resources.

At Florida Atlantic University, our recent effort in engineering capstone designs has been mainly focused on encouraging student to design real world projects that aid elderly and persons with disabilities, and on enhancing undergraduate engineering education through hands-on experience [8]. According to surveys given in the literature [9-13], individuals with physical disabilities who are confined to a wheelchair may experience lower self-esteem and self-acceptance, and greater social isolation than those without disabilities. Students are encouraged to use their knowledge to improve the life and therefore the self-esteem of people with disabilities. In their capstone project, students utilize and adapt available technologies to create devices to assist persons with disabilities from the users' perspective. To this end, at the first course of the Engineering Design sequence, students are first referred to healthcare facilities and local schools that host students with learning disabilities in order to gather information regarding to real needs, available solutions, and what the latest technologies can offer. Once such preliminary information is gathered, a number of brain storming sessions are conducted to help students select and refine the most promising ideas. Teams are formed thereafter and resources are allocated to support the required hardware and software for the projects.

In the remainder of the paper, the structure of the capstone design course sequence in mechanical engineering at Florida Atlantic University is overviewed with an effort to show how the courses are designed to achieve student learning outcomes. Sample of the projects are then presented.

II. Course I – Engineering Design

Engineering Design is the first course in a two-course senior design sequence in the Mechanical Engineering program at Florida Atlantic University. It covers a wide variety of topics and makes a significant contribution to meeting the program educational outcomes as specified by ABET.

Initially the course focuses on a discussion of the design process, including the different levels and types of design, creative thinking, innovation, information gathering, codes and standards, engineering ethics, societal considerations, and teamwork. An initial mini-project is used to break-the-ice between students and gives them their first experience in creative design in a team environment. An additional team building experience includes a ropes/obstacle course where the students are divided into teams to perform different challenges that require them to create a team solution and rely on each other for success.

The main focus of the course is the development of a proposal for the senior design project. These proposed projects are evaluated and approved by three faculty members with different specialties. At the beginning of the semester students are asked to talk with local industries, healthcare professional, faculty etc. in order to identify needs that might be a candidate for their senior design. Students initially present their project ideas in any area of mechanical engineering to the faculty. Only a few of these ideas are considered feasible and are approved for further development. Students then must select the project that interests them and form teams of usually three members. Throughout the semester these teams are required to make presentations to update the faculty on the progress of their proposals. A final formal oral presentation along with a formal written project proposal are required at the end of the semester. The teams will then continue with their project through the following semester in Design Project, the second course in the sequence.

Throughout the semester additional topics are covered through lectures and assignments. These include statistical design and analysis procedures, materials selection, failure analysis, brittle fracture, and fatigue analysis design procedures. High-cycle fatigue, low-cycle fatigue, and fatigue crack growth are covered, along with stress-corrosion cracking and environmental effects. These topics are included to stress the idea of design to prevent failure, and the necessity to consider the useful design life of the structure.

A. Course Outcomes

The expected course outcomes are listed below. The outcomes are directly related to the lectures and the activities taken place during the semester. In order to maintain accreditation from ABET - Accreditation Board for Engineering and Technology each of the outcome satisfies some of the objectives required by ABET. The letters in parentheses indicate the correlation of the outcome with the appropriate program outcomes a-k as specified by ABET (see Appendix A).

- The students will be able to formulate and analyze problems, and synthesize and develop solutions based on fundamental principles. (a,c,e,k)

- The students will design basic mechanical components or processes to meet desired specifications using appropriate engineering tools and techniques. (a,c,e,k)
- The students will demonstrate an understanding of professional, societal and ethical responsibility. (f,h,j)
- The students will function effectively in teams and communicate their ideas to their peers. (d,g,j)
- The students will recognize the need to engage in life-long professional development and learning. (i,j)

III. Course II – Design Project

During this semester students carry out the proposal they had submitted in the "Engineering Design" course. Although Gantt chart and the different task were allocated in the proposal, it is reviewed aging the responsibility for each task is reassigned to the teams' members. During this time the instructor "plays" the roll of consultant who guides the teams in resolving design issues. He meets each team at least once a week and keeps the project on track.

Also, he has to resolve common logic problems, such as machine shop availability, that usually arise in the first few weeks.

In addition lectures are given on topics related to design and help in the implementation of the project which were not covered in other courses. Lectures on the following topics are given:

- Actuators and their selection – covering pneumatic, hydraulic and electric actuators and their control.
- Microcontrollers and their interfacing – covering the basic structure of microcontrollers and their interfacing to discrete input/output devices, analog sensors and how to drive DC and AC motors.
- Geometric Dimensioning & Tolerances (GD&T) – covering the basics of information required in production drawings.

Two other lectures, which are not directly related to design, are given:

- Technical writing and presentation – this presentation helps student to write their progress and final reports as well as with the progress and final presentations
- Patent – covering the fundamentals of the American patent law, provisional, utility, design and plant patents, copy right and trademarks.

At the end of the semester, students have to deliver the following:

- A full written report.
- An oral presentation.
- A 2-page summary.
- Two minutes video.
- A fill FAU disclosure form.

3.1 Course Outcomes

Similar to the Engineering Design course, the course outcomes of this course are listed below and the letters in parentheses indicate correlation of the outcome with the appropriate program outcomes a-k as specified by ABET.

- The students will be able to formulate and analyze problems, and synthesize and develop solutions based on fundamental principles. (a,c,e,k)
- The students will design basic mechanical components or processes to meet desired specifications using appropriate engineering tools and techniques. (a,c,e,k)
- The students will demonstrate an understanding of professional, societal and ethical responsibility. (f,h,j)
- The students will function effectively in teams and communicate their ideas to their peers. (d,g,j)
- The students will recognize the need to engage in life-long professional development and learning. (i,j)

IV. Students Evaluation

In both classes the requirements from students are very high. In the "Engineering Design" students are graded on:

- Homework assignments.
- 2-3 presentations during proposal preparation
- Final proposal presentation (graded by three faculty members)
- Final written proposal (graded by three faculty members)
- Exams on topics covered in class.

and in "Design Project" course students are graded on:

- 3 progress report presentations (graded by three faculty members).
- 3 written progress reports (graded by three faculty members).
- Final presentation (graded by three faculty members).
- Final written report (graded by three faculty members).
- Project performance (graded by three faculty members).
- Peer review (provided by team members indicating the contribution of each team member to the project. It filled at each progress review and at the final submission).

This elaborated grading scheme, which is known to the students at the beginning of the semester, allows the team to delegate responsibilities according to the strength of each member.

The peer review evaluation puts pressure on each member to fulfill his part and to contribute to the success of the project. It helps the instructor to identify, at the first review, if there are personal problems within the team and try to resolve the issue.

V. Course Evaluation

Both courses are being evaluated by students as well by the instructors who were teaching the course. Students evaluating the course filling the following forms:

- FAU course evaluation form which is used for any course being taught at FAU
- Internal form in which students indicate (scores 1-5) to what the degree the course's outcomes have been achieved.

The instructors report on their perception how to what degree the outcomes were achieved by:

- Using the same internal form to report to what degree the particular outcome was covered in class. Here the instructor can provide his own comments views regarding to the course.
- Assess the course outcomes by the average grades of assignments related to a particular outcome.
- The three scores: students' assessment scores, instructor's assessment scores and the average grades for each outcome are presented in a table form in order to identify weak point that needs improvement.

The above information is used by a departmental committee that recommends changes or modification o these goals.

VI. Examples of Projects

The following are examples of projects that were designed, fabricated and demonstrated by students who completed the above sequence. The following is exerts from their 2-page summaries:

6.1 Thermal Relief System

The Hydro-Aid thermal relief system was designed like no other to be able to perform safe efficient hot and cold therapy. It will be the first therapy device to reach the market that is a completely self contained device with built in safety features to protect the user and the user's investment. Current existing devices are not capable of doing efficient hot and cold therapy and are required to be filled with ice and water, or hot water. It is very strenuous for an injured patient to manage these systems full of water and the user can easily spill the water and burn themselves.

The HYDRO-AID is a completely self contained, easy to use device that does efficient hot and cold therapy. The HYDRO-AID Thermal Relief System is designed to use Peltiers to heat and cool the water-glycerol mix within the system. This device is pre-programmed to have several temperature and time settings. The settings are based on medical research that defines safe cold and hot therapy temperatures. The device settings are as follows: Cold therapy - 65 ºF and 58 ºF; Hot Therapy - 104 ºF and 108 ºF; and Time of Treatment – 10, 12, 15 minutes.

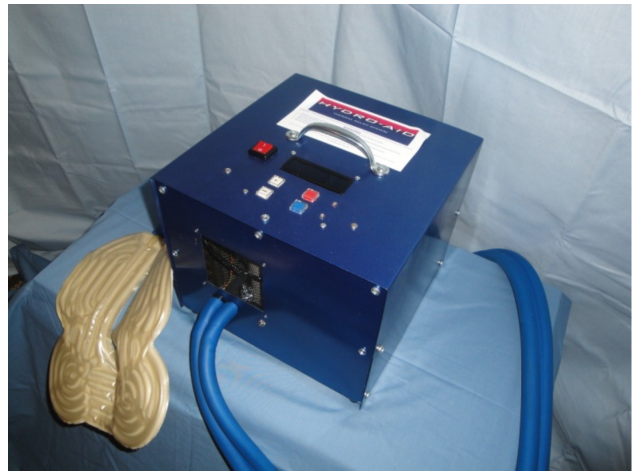

Fig. 1 The Hydro-Aid thermal relief system

6.2 Baby Bottle Clean and Sterile

Bacteria and viruses are prevalent in the daily lives of human beings, and the most susceptible are infants. It has been reported that unclean bottles may lead to infections and virus contraction in babies. As a preventative measure, modern day parents wash their children's bottles with soap and water and then sterilize them with steam. Currently, people will boil bottles or use a commercially available microwave or electric steamer. In order to expedite the process and relieve parents from the troublesome task of bottle washing, a device was constructed that can do it all. The BBCS 3000 will clean baby bottles with soap and water and then sterilize them with steam automatically. To limit the complexity of the system, only one baby bottle will be washed/sterilized at a time. The device will allow the user to select between several different programs of operations by interface consists of an LCD screen, and a keypad. The user is provided with four options; "Wash & Sterilize"; "Wash Only"; "Sterilize Only"; and finally "Self-clean." Upon selecting one of these options with the keypad, the machine will then perform the desired operation. Runtime ranges from 1-2 minutes to 8-10 minutes, depending on the program selected. The most typical selection, "Wash & Sterilize" takes between 8 and 10 minutes to complete.

6.3 Occupational Hand Therapy

The purpose of this project was to build a device that will properly rehabilitate and condition a patient's metaphalangeal joints. The project consists of a portable device that will allow the patient to place their hand into it and receive a repetitive motion of stretching simulating the same movement as an occupational therapist. This device is able to adjust different angles of travel. The completed product model is lightweight, user friendly, and easily used and serviced. The system consists of a four bar linkage driven by a stepper motor and is controlled by Labview and interfaced to the user by a touch screen for ease of use.

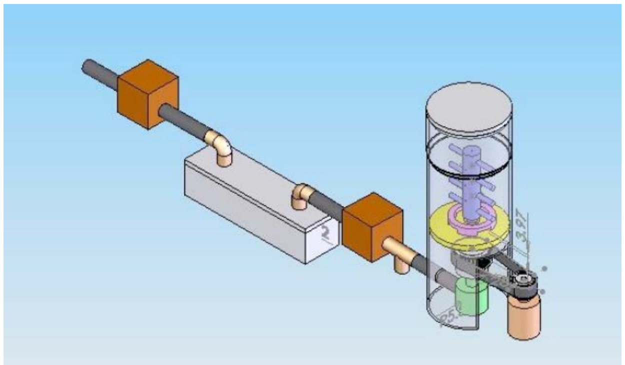

Fig. 2 Baby Bottle Clean and Sterile

The four bar linkage is comprised of a pre-built and assembled metaphalangeal joint stretching device which was used as the output arm for the linkage system.

The stepper motor controller used was a Phidgets bipolar motor controller. The controller comes with built in controls allowing the use of the Labview program for easy block diagram programming. The position control of the motor allows the user to control the angle of travel that the users hand goes through. The speed of the motor was set to a constant value for the smoothest operation. With this completed setup it allows the user to rehabilitate either the left or the right hand through different ranges of angles to finally reach a completely rehabilitated state of hand use.

6.4 Wheelchair Arm Assist

The purpose of this project was to provide a solution to aiding wheelchair bound individuals to obtain artifacts from various distances for which the individual would not normally be able to obtain on their own. For the person in the wheelchair, obtaining objects such as food, books, small appliances or any small objects will be difficult or just not physically possible to obtain. Using our engineering skills and knowledge a device was created to solve this problem. Aluminum clamps support the device to the wheelchair with a ball joint allowing the user to rotate the device in 360 degrees. Simple rocker switches are used to power the forward and rearward extension, as well as to power the claw. For ruggedness the device is coated in an industrial paint. The glossy finish of the paint is complimented with the brushed aluminum located throughout the device. Style and utility were kept in mind during the design. The forward mounted position and the ball joint support allows the user to comfortably point the device in the direction of an inaccessible object. The weight of the device is supported by the mount so the device can be easily operated. Using the buttons on the handle the person extends the aluminum rail forward to reach out to the object. When the rail has extended far enough for the user the claw can then be closed. With the object in the claws grasp the user can then bring the object to them.

Fig. 3 Hand rehabilitation device.

Fig. 4 Wheelchair arm assist.

6.5 Plastic Heat Exchanger

The Plastic Heat Exchanger is designed to resist the corrosive effects of chlorinated water in swimming pools. Current heat exchangers are made of copper, but the chlorine in the pool water causes corrosion in the copper. The only other currently available solution is titanium heat exchangers, but they are very expensive. This led to the design challenge of designing a heat exchanger that could resist the effects of chlorine. On the basis of the literature review, the most promising material was crossed-linked polyethylene (PEX). Its thermal conductivity is nowhere near that of standard copper, but it has the ability to resist the corrosive effects of chlorinated water in a pool environment. Most importantly, the PEX is much cheaper than any of the other alternative materials. A counter flow tube in shell heat exchanger design was chosen. Using the known parameters of the design requirements and certain assumptions, the size of the heat exchanger was determined. To size the heat exchanger, the size of the tubes, tube length, porosity and shell diameters had to be taken into consideration. Of the five different commercially available PEX sizes, it was determined that only one of those was feasible for design, the 3/8" nominal diameter PEX tube. This was determined by calculating the required tube bundle number, porosity and attainable shell diameters. The design was finally optimized and a 3" diameter shell was chosen since the tube bundle consisted of 19 tubes. Once the sizing was achieved the next step was flow simulation using the SolidWorks. The initial simulation gave promising results since it showed a temperature rise of 7 °C. Once these results met the design requirements, the construction phase began.

Once the actual heat exchanger was constructed, experiments were performed to see if it would deliver the design goal of a 5°C temperature rise. Three experiments were conducted and they all yielded the same results. There was a 10 °C temperature rise of the fluid. This greatly exceeded our expectations. The final efficiency of the constructed heat exchanger was 46.2%.

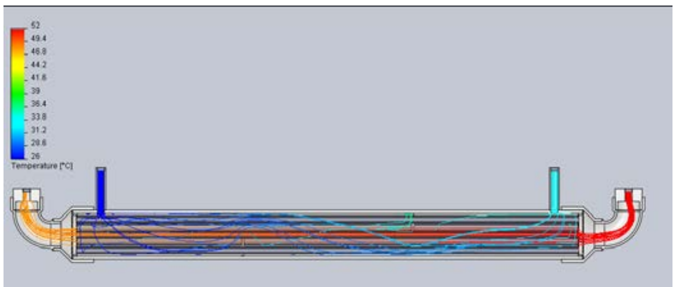

Fig. 5 Simulation results of the heat exchanger

6.6 Human powered water filtration

Nearly one billion people do not have access to clean drinking water and four million people die each year just from water-related diseases. This is due to water contamination making water sources hazardous and deadly to drink. A proposed solution to change these horrific facts is a human powered water filtration system. This system is designed to be very effective yet simple for those living in developing countries. This report explains the proposed solution by first discussing the specific problems needed to address, goes on to detail how the individual components work, and then describes the entire system as a whole, how it works, and how to operate and maintain it. The design is an entire water filtration unit. It is designed to be used anywhere in the world. The system tackles the most severe and most common problems in water contamination: biological and heavy metals. The unique aspect of this system is that it was designed to be operated by a human driving a crank. This crank is connected to a gearbox which gears up the speed so that a pump can be operated to drive the water filtration. The first stage of filtration is sediment filters which remove large particles. The second stage is the KDF filter. KDF is a granular media made of high purity brass which has the ability to remove heavy metals and certain chemicals as well as deactivate microorganisms in the presence of water. The third stage of the filtration unit is the biological filter. This filter will screen out all particles down to 0.1 micron. This removes all bacteria and parasites. The greatest aspect of this filter is that it can be reused over and over again after back flushing. This filtration unit was designed to last for many years without any replacement filters. A back washing valve system is incorporated around the biological filter for this purpose. The sediment filters were made to be taken apart and cleaned also for this reason. Vacuum and pressure relief valves were incorporated into the system to indicate when filters are clogged and need to be cleaned. This human powered water filtration system is easy to operate and easy to clean.

Fig. 6 Human powered water filtration

VII. Concluding Remarks

In this paper we reported on the Mechanical Engineering Program capstone design courses. These courses with their evaluation mechanism are being taught for the last 3 years with great success. Most students are coming with innovative ideas which drive them to excel. Team work and cooperation are being practiced during the execution of the project. Topics, which have no place in traditional courses, are being coved. And, the most important, students are very proud in there achievement and leaving school with a good feeling.

Acknowledgement

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References

[1] May-Newman, K, P. Newman, C. Sax, C. and U. Miyares, "A Partnership for Senior Design Projects in Biomedical and Mechanical Engineering," *The 36th ASEE/IEEE Frontiers in Education Conference*, San Diego, CA, T2E-13, 2006.

[2] Erradi, A. "easyCapstone: A Framework for Managing and Assessing Capstone Design Projects," *The 7th International Conference on Computer Science & Education*, Melbourne, Australia, MoD1.1, 2012.

[3] Okudan, G., M. Chiu and C. Lin, Linda, L. C. Schmidt, and J. Linsey, "A Pilot Exploration of Systematic Ideation Methods and Tools on Design Learning," *The 9th*

International Conference on Information Technology Based Higher Education and Training, pp. 102-107, 2010.
[4] Li, K.F., A. Zielinski and F. Gebali, "Capstone Team Design Projects in Engineering Curriculum: Content and Management," *IEEE International Conference on Teaching, Assessment, and Learning for Engineering*, T1C-1, Hong Kong, 2012.
[5] Gruenther, K., J. Wilson, C. Plucker, H. Hashmi, and R. Bailey, "The Influence of Prior Industrial Experience and Multidisciplinary Teamwork on Student Design Learning in a Capstone Design Course," *The 37th ASEE/IEEE Frontiers in Education Conference*, Milwaukee, S1D-1, WI, 2007.
[6] J. Linsey, V.K.Viswanathan, and A. Gadwal, "The influence of design problem complexity on the attainment of design skills and student perceptions," *The Future of Global Learning Engineering Education*, Madrid, Spain, pp. 287-294, 2010.
[7] Keith, G., J. Nastasi and E. Hole, "A pilot for multidisciplinary capstone incopporating a systems engineering framework," *The 2012 ASEE Annual Conference*, W522, San Antonio, 2012.
[8] Zhuang, H., O. Mazory and Z.S. Roth, "Result-Oriented Engineering Capstone Designs to Aid Persons with Disabilities," *The 2013 ASEE Annual Conference*, W426, Atlanta, 2013.
[9] Antle, B., "Factors associated with self-worth in young people with physical disabilities," *Health & Social Work, 29*(3), 167-175, 2004.
[10] Appleton, P., P. Minchom, N. Ellis, C. Elliott, V. Boll, & P. Jones, "The self-concept of young people with spina bifida: A population based study," *Dev Med Child Neurol, 36*(3), 198-215, 1994.
[11] DeKlerk, H. & L. Ampousah, "The physically disabled woman's experience of self," *Disability Rehabilitation, 25*(19), 1132-1139, 2003.
[12] King, G., I. Shultz, K. Steel, M. Gilpin, & M. Cathers, "Self-evaluation and self-concept of adolescents with physical disabilities," *American Journal of Occupational Therapy, 47*(2), 132-140, 1993.
[13] Li, L. & D. Moore, "Acceptance of disability and its correlates," *J Soc Psychol*, *138*(1), 13-25, 1998.

APPENDIX A: ABET STUDENTS OUTCOMES

For baccalaureate degree programs, these student outcomes must include, but are not limited to, the following learned capabilities:

a. an ability to select and apply the knowledge, techniques, skills, and modern tools of the discipline to broadly-defined engineering technology activities;
b. an ability to select and apply a knowledge of mathematics, science, engineering, and technology to engineering technology problems that require the application of principles and applied procedures or methodologies;
c. an ability to conduct standard tests and measurements; to conduct, analyze, and interpret experiments; and to apply experimental results to improve processes;
d. an ability to design systems, components, or processes for broadly-defined engineering technology problems appropriate to program educational objectives;
e. an ability to function effectively as a member or leader on a technical team;
f. an ability to identify, analyze, and solve broadly-defined engineering technology problems;
g. an ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature;
h. an understanding of the need for and an ability to engage in self-directed continuing professional development;
i. an understanding of and a commitment to address professional and ethical responsibilities including a respect for diversity;
j. a knowledge of the impact of engineering technology solutions in a societal and global context; and
k. a commitment to quality, timeliness, and continuous improvement.