Preparing the Engineer of 2020 through the Wright Innovative Design Experience in Undergraduate Education

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Abstract

This paper presents a novel approach in preparing the engineers of the future to address tomorrow's challenges in technology and society by (1) cultivating innovative characteristics such as cognitive and analytical skills, ingenuity, and creativity necessary for future engineers who are global citizens and leaders in business and public service; (2) addressing the context within which engineering education must help students in professional, geopolitical, economical; and societal needs in the future; and (3) understanding how the evolution of technological advances will impact the world and the engineering profession in the future.

These issues are addressed through the Wright Innovative Design Experience (WIDE) program with the key focus in the design of assistive devices. There are four objectives in the WIDE approach: (1) expose students to applied and innovative design projects in assistive technologies for people with disabilities; (2) encourage students to participate in an integrated inter-disciplinary curriculum that facilitates service learning and civic engagement by working with people with disabilities; (3) allow students to work in teams on hands-on inter-disciplinary projects; and (4) involve students in methods of technology transfer and entrepreneurial skills necessary to transition from academic to professional environments.

Program Description

Overview

In the year 2000, the US Census Bureau reported that there were 54 million (over 20%) Americans with disabilities[1]. The unemployment rate for this group between the ages of 18 and 65 is an astounding **60%**, and the average life span is predicted to increase as the population increases from approximately 35,000,000 to 54,000,000 by the year 2020. These statistics show a potential that the number of people with disabilities are going to increase proportionally. When this case is considered globally, the numbers are even severe. This shows an immediate global requirement in the design of devices in assistive technologies to aid people with disabilities.

Research has demonstrated that through assistive technologies more people with disabilities can be assisted to become a part of regular learning environment[2]. The design and manufacture of these designs does not depend on one major field of engineering, but through collaboration of several. The engineering education community must take advantage of serving the disabled through an integrated curriculum that allows the engineering students to participate in creative assistive technology design projects. Involvement in student-focused integrated curriculum will help students re-conceptualize their view of engineering in a context that addresses societal needs that are driven and influenced by the global market place for engineering services of the future[3].

In a traditional Senior Design Project (SDP), students choose a faculty advisor and obtain the project to work on. With the project identified, students take courses required and work towards completion of the project. This approach has several drawbacks such as: a) limiting the bounds through working in one discipline, b) focused on improvement rather than innovation, c) absence of requirement for a business plan etc. A new student-focused curriculum is required to address these drawbacks. Undergraduate education is a stimulation and nurture process where students are open and eager to learn new things. It is up to faculty mentors to provide opportunities to actively involve and guide the students. Engineering education on one hand requires the adaptive grasping of basic theories; on the other hand, emphasize hands-on experiences, innovative ideas and creativity that meet societal needs. A practical approach is to improve student participation in innovative design methods and education. The

ultimate objective of student-focused curriculum for undergraduate students, in our opinion, is to inspire and teach them the methodologies of creative design, e.g., problem identification, critical thinking, problem formulation, literature reading, survey, problem solving, communication skills, independence, collaboration, formulating a business plan and entrepreneurship, technology transfer and intellectual property etc.

Fig. 1 shows the proposed WIDE program. Through this program, engineering students will be exposed to a new student-focused curriculum that allows them to work in multi-disciplinary teams with projects focused on assistive technologies. Assistive technologies is chosen to be main area of focus due to several reasons with some of them being,

- Addresses the global requirement to aid people with disabilities,
- Deals with the societal aspects of engineering,
- Helps aspiring engineers to have a better understanding of the problems faced in the daily life of people with disabilities, thus showing the importance of engineering in the society to solve problems,
- The requirement for these designs is predicted to increase dramatically in the near future,
- Requires collaboration of multiple disciplines.

The outcomes of exposing students to the WIDE Program will be effective in (a) enhancing academic performance and increasing recruitment and retention of professionals in engineering; (b) focusing on academic excellence and preparing undergraduate students entering engineering and technology as inventors, entrepreneurs, researchers, public servants, etc; (c) emphasizing on both competence and contribution of innovative designs in the engineering and technology community at large; and (d) enhancing the students abilities to participate in a collaborative and diversity setting. In the WIDE program, students will work in teams of 3 undergraduates and will be mentored by graduate students, faculty members and engineers currently working in the industry. At least one student member of each team will come from a diversity group, defined here as underrepresented minority, persons with disability, women, and/or an individual from a different a culture. Depending on the project, student teams will be formed such that only one student from each engineering discipline is included in the team. The WIDE Program also provides an aid in emphasizing success by removing artificial barriers, rewarding performance, and providing non-threatening environments to undergraduate students committed to engineering and technology research[4].

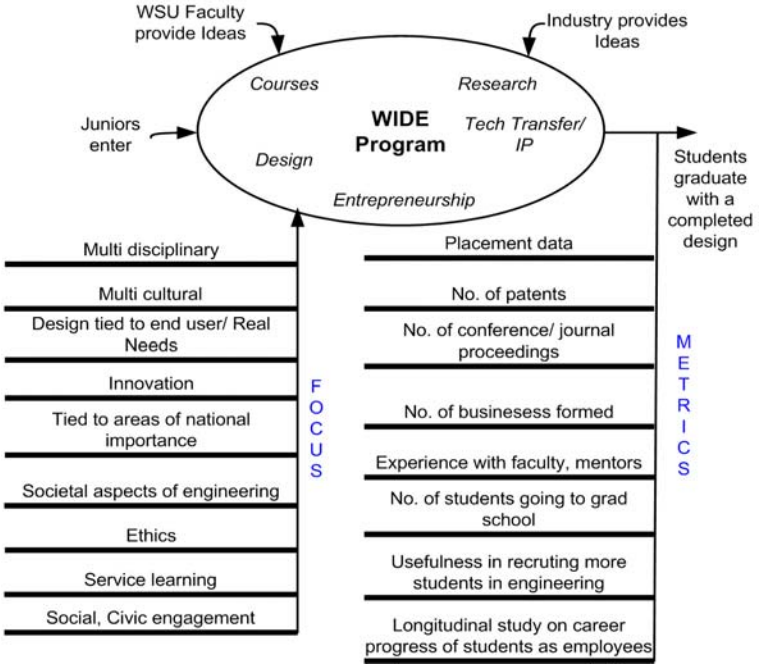

Figure 1: Structure of the WIDE Program

Design Experience

The design aspect of this program will focus on exploration of selected significant problems in the area of assistive technologies. A salient feature of this program is integrating theory and practice. Dale[5] in his paper stated that students retain a majority (90%) of what they learn through direct experience. The participating juniors will interact with many people with disabilities and identify the problems people with disabilities are facing. With the problems identified, juniors with the help of mentors will formulate a design plan that solves a problem. Also, as problem identification and formulation may be challenging for undergraduate students initially, faculty will collaborate with local industries to formulate a few problems that the industry is facing, and present them to the participating students. In this process, students will be required to rigorously analyze all the problems, and choose one that suits their interests. A guideline of the requirements in this selection process will be provided, which states that the design should be, 1) tied to the requirement of the end user; 2) innovative; 3) related to areas of national importance; and 4) demonstrate the societal aspects of engineering. This selection process not only allows a good choice of problems to choose from, but it also demonstrates the significance of engineering in the social aspect of human life.

In a SDP, the faculty mentor traditionally advices students on what project to work on, which inherently limits the bounds of projects to the mentors' research focus. One of the drawbacks in SDP is that, it focuses on single discipline restricting bounds of the design project. Research showed that, though students created successful projects that could be marketed in the industry; they fell in the dark due to absence of a successful business plan.

The WIDE program overcomes these drawbacks as shown in Fig. 1. In the WIDE program, the design projects will be decided by the students who work in collaboration with the industry. This not only expands the horizons of projects students can choose from, but also provides an opportunity to work on the cutting-edge technologies. As students enter this program in the junior year, they will be required to take related courses before they embark on the design. Other focus areas of the program are the significance of engineering economy and entrepreneurship. With the successful completion of the required course work, analytical solutions for the design problem will be derived if applicable. On the other hand, solutions will also be evaluated through extensive simulation studies by exploring the parameter space. Then, practical implementation/ solutions under real environments will be devised. Students will learn wherever applicable, through this *"end-to-end"* approach, the entire process of problem solving and methodologies. In addition, students will also be required to discuss and compare their design work experiences with other participants in order to identify some commonalities of design methods. The central theme of the program is to strike a proper balance between theoretical rigor and practical hands-on experiences.

Sample Design Projects for WIDE Participants

Wheelchair Stability Mechanism

When playing wheelchair basketball, many persons with disability fall backward when they reach back for catching the ball. The reason behind this is that, wheelchairs are not designed to tolerate a person's local movements. Thus when weight distribution changes significantly (e.g., extending the upper body and hands) the wheelchair looses its stability. A student team will design, prototype, validate, and prepare market plan for wheelchair safety/stabilization mechanism.

Figure 2: Wheelchair Basketball team

Radio Frequency (RF) Navigation

Given a set of Radio Frequency IDentification (RFID) tags with overlapping range and a RF reader, one can determine location and orientation in a predefined space. A team will produce a plan for placing of RFID tags in several buildings in the university; determine readout from various locations, and produce decision tables for optimized route planning. Wheelchairs equipped with RF readers can be programmed for travel to specific locations guided by the RF signal picked up by readers.

Timetable

Fig. 3 shows the proposed timetable of WIDE program which will last for five quarters period with students entering in their junior year. The first three quarters focuses on technical aspects of the program, and the last two quarters focuses on personality development, and preparation for further career. In the summer of the first year, students also participate in a co-op program to better utilize the knowledge they gained.

Close to the end of winter quarter, the faculty advisor and individual from the industry will deliver a presentation on design projects that might be of interest to the students. Students will be given a weeks' time to choose the project they will work on. During this time, the university faculty and graduate students will work closely with the juniors to help them identify a project that suits their interests and primarily, requirements of the industry. With the project identified, students will take courses to have a better exposure to the technical aspects of the design project. These courses will be interleaved with the demonstration of laboratory facilities and research tools as required. Simultaneously, juniors will also work with graduate students to learn the design tools necessary for the project. Through out the duration of the program, juniors will meet the faculty mentor once every week to discuss the progress and plan the week ahead. At the end of fall quarter, juniors will be required to give a preliminary presentation on their respective standing in the project.

With the successful completion of course work in the spring quarter, students return to school in fall as seniors, start design and implementation of the project and work towards its completion by the end of winter quarter. The design activities will be supplemented by workshops and invited guest lecture series by distinguished speakers from both industry and academia. As industrial experience is equally important as academics, students will be required to participate in a co-op program in the first summer quarter. During this time, students will not only gain technical expertise, but also improve their networking and understanding of the societal aspects of life.

After the successful completion of the co-op program, students will return to the university as seniors and work to (a) implement the project through the valuable insights gained in the co-op program; (b) present their work in student competitions, poster presentation, conference or journal proceedings; (c) present the design projects and work with the local high-schools students to enlighten them on current technology; (d) participate in the workshops and seminars that help them in preparing for graduate school, full-time job, entrepreneurship, technology transfer, and business planning. This program promotes an excellent climate for faculty and student interaction, collaboration between the university,

local industries and the high-schools to prepare the students for professional, industrial environments, civic, and social duties.

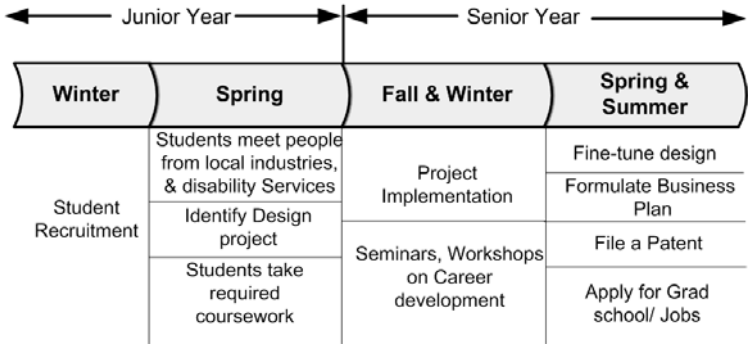

Figure 3: Timetable for WIDE Program

To encourage peer competence, two of the four student teams participating will be provided financial assistance in the summer quarter after graduation for formulating a business plan and filing a patent. Research has shown that, with the increase in diversity and complexity of new products, time-to-market the design decrease dramatically. This requires engineers working in the industry to have a good understanding of intellectual property, technology transfer, and entrepreneurship. To accommodate this requirement, senior students will undergo a series of workshops that emphasize these areas. With the rapidly increasing competition in the current job market, students need to find ways by which they can enhance their job security and be in a better position compared to their peers. As Professional Engineer certification provides these advantages, students should lay the foundation by taking the Engineer-In-Training exam in the senior year. Simultaneously, they will also attend workshops that help them in resume and cover letter writing, applying for graduate school, intellectual property, technology transfer, and patent filing. As social and civic engagement is as important as technical knowledge, in the spring quarter, students should present their work in local high school students and expose the high school students to the innovative technologies. They will also visit community centers for people with disabilities to showcase their design project and to seek feedback.

Nature of Student Activities

Cohort Group Interaction with Mentors

A faculty mentor system will be implemented in which each faculty member advises undergraduate students on academic issues. Over a period of time, it was found that many students are anxious in research, and with proper support, excel in the field they pursue. These students will get hands-on experience and also contribute to the faculty's research. This experience for the students lays a foundation step towards pursuing graduate degrees. This undergraduate research program in the university will works cohesively with the WIDE program for better utilization of resources.

Design Group Seminar

The WIDE students will participate in their advisors weekly design seminars along with graduate mentors. Motivated by the concept of 'cooperative learning' and teamwork, students and the advisors will take turns to present papers on selected topics. In faculty-student interaction and group seminars, emphasis will be made on developing students' overall abilities of problem solving, cultivating their project management skills and leadership.

Workshops, National and Local Professional Meetings

During the duration of the WIDE program, students will participate in mandatory lectures, seminars, and workshop aimed at enlightening them in issues and activities related to the engineering profession. One of the most difficult endeavors in the engineering curriculum is encouraging students to

develop creative, independent thought and a deep level of understanding[6]. Technical writing is one of those skills that aid in this process. Few of the workshops students participate will focus on this area. Methods to pursue in critical thinking, analysis of a design will be taught in these workshops. Along with these aspects, students should also learn how to communicate their inferences to others in effective manner.

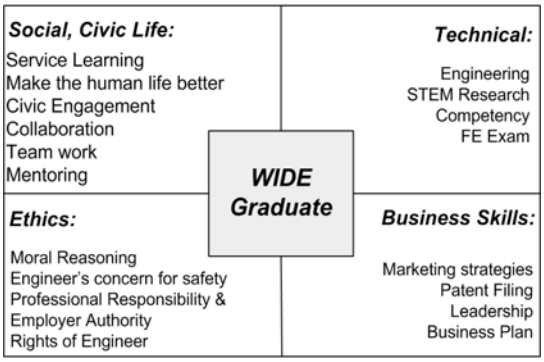

Figure 4: Skill set of a WIDE Graduate

Evaluation

Progress and Measuring Objectives

Each objective should have an evaluation component built into it and should be articulated in measurable terms. Objectives should be measured at each time an event is scheduled to be fulfilled. Methods of use may be in the form of interviewing faculty and students to see, for example, if the students improve their understanding of the design process, if the participants move toward the anticipated objective or enhance their academic skills, if a specific training approach/a classroom practice needs to be changed/improved etc. Methods used should include use of standardized test scores, student grades, student evaluations, student questionnaires, evaluation forms, observations, interviews, discussions, and self-administered questionnaires.

Measuring Long Term Impact

Specific outcomes for each of the goals and objectives, along with assessment measures for each should be spelled out. Evaluation methodologies should employ both qualitative and quantitative measures, and should be formative and summative. The Planning Council, and the staff, should take the responsibility of devising additional assessment measures as planned. It is important to note that the ultimate impact of the program should be gauged through the success of participating students in college, and in their chosen field of study.

Long term success measure is more challenging. To measure the long term success, a website or mailing list for WIDE program alumni should be designed so that they can communicate with each other as well as with the program coordinators about their current activities. The website and/or mailing list should also be used to track WIDE participants by sending out an annual questionnaire requesting them to describe any experience during the past year which was benefited by their WIDE program experiences. Specific tangible successes should be quantified. With the collected information, the program should be able to characterize to what extent meaningful opportunities to conduct design experiences were provided; if students are being retained in programs at an increasing rate; if the number of traditionally underrepresented students receiving degrees in science, mathematics, or technology is increasing, and so on.

References

1. L. Gitlow, “An introduction to low technology solutions: A tri-wall and switch construction workshop”, Technology and Persons with Disabilities Conference 2003.
2. T. Cavanaugh, “The Need for Assistive Technology in Educational Technology”, Educational Technology Review, Vol. 10, No. 1, 2002.

3. The Engineer of 2020: Visions of Engineering in the New Century, National Academy of Engineering, 2004.
4. M. E. Turner and A. R. Pratkanis. Affirmative Action as Help: A Review of Recipient Reactions to Preferential Selection and Affirmative Action. Basic and Applied Psychology, 15, 1994.
5. E. Dale, “Audio-Visual Methods in Teaching,” Holt, Rinehart, and Winston, 1997.
6. B. A. Korgel, “Nurturing Faculty-Student Dialogue, Deep Learning and Creativity through Journal Writing Exercises”, Journal of Engineering Education, Jan ‘02, vol. 91, no. 1, pp. 143-146.