Case Studies of Two Projects Pertaining to Information Technology and Assistive Devices

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Abstract - **We examine the introduction of engineering design to high school and first-year college students via real community service-learning projects (CSLP). CSLP was chosen because the goal in the course is two-fold: (1) to introduce students to basic engineering principles and (2) to provide them with the opportunity to see the application of such concepts in society. CSLP aims to simulate a design environment in which students with limited technical backgrounds and diverse interests strive to develop viable solutions to actual problems while developing professional skills through client interaction. We provide a detailed discussion on two long-term projects, with approximately 210 student participants, applied both in the high-school and first-year college setting affiliated with the Wildlife Conservation Society and New York City Department of Parks and Recreation, respectively, pertaining to information technology and assistive devices. This approach has been successful in implementation and sustainability. Client satisfaction with the results has lead to the beginning implementation stages. High-school student experiences has led to an increased interest in the pursuit of higher engineering education while first-year college evaluations indicate most felt a renewed interest about their intended major. Future improvements to facilitate sustainability of this program include smoothening the transition process between teams.**

Index Terms – assistive devices, engineering design, information technology, service-learning projects

INTRODUCTION

Many engineering programs are incorporating service-learning projects into their curricula. Pedagogical implications have been a driving force for this move from traditional lecture methods. Service-learning projects can easily address the typical range learning styles in engineers: auditory, intuitive, deductive, passive and sequential [1].

Service-learning programs at universities have succeeded in offering students practical experience, context, and motivation for engineering [2]. Community service-learning projects (CSLP) were chose at Columbia to successfully meet the demands of a multi-faceted multidimensional engineering course. The need exists to introduce engineering students at an early stage to basic engineering design principles while simultaneously providing them with the opportunity to see the application of such concepts in a real-world setting. CSLP allows for this process to occur while stimulating a design environment in which students with limited technical backgrounds and diverse interests strive to develop viable solutions to actual problems while developing professional skills through client interaction.

Students in CSLP are placed on teams consisting of five students each. Each team is assigned to a project that best suits the interests and skill set available. We determine student aptitude and interest based on an assessment survey completed by all students prior to assignment to a team [3].

The course is taught to meet the needs of the different entities involved: students, instructors, and community partners [4]. Students are given the opportunity to experience the application of design principles discussed in class and to develop professional skills when meeting with clients and interpersonal skills when meeting amongst their own team members. Instructors demonstrate the real-world application of the principles while the community clients benefit from the students' work and ideas.

ASSISTIVE DEVICES

Awareness for issues regarding accessibility has seen a rise in the recent days. More organizations and institutions are trying to develop methods to help those with disabilities. Thus, the field of assistive devices has also gotten more spotlights.

We have therefore created a project category in our course dealing with assistive technologies. These projects focus on developing and redesigning equipment and areas to comply with American Disabilities Act (ADA) standards. Students are required to understand ADA standards and rules of compliance as part of their preliminary project research.

Our partnership with the New York City Department of Parks and Recreation commenced in Summer 2004 with the idea of building a "Playground for All Children" for children ages 5 - 11 in Marcus Garvey Park. While New York City has many playgrounds that are accessible for children with disabilities, very few have actual playground equipment for these children to actively and safely play with. A "Playground for All Children" is a special playground, which addresses the needs of all types of disabilities: hearing and visual impairments, learning, neurological, physical, psychiatric, speech and learning disabilities. These playgrounds provide a safe haven for children with specific (sometimes multiple) disabilities to enjoy recreational time. Since the closest playground with such offerings was located in Queens, the need arose to have one built in Manhattan for easier access for children.

I. Initial Design Proposals – High School Students

Forty high school students, mostly juniors, were the starting force for the project. Eight teams consisting of five students each were assigned to each of the different types of disabilities with one team responsible for overseeing the entire playground design. The main task given to the students was to develop at least one piece of feasible playground equipment for their given category of disability (Table 1). Students were required to comply with ADA rules and regulations in the design of their playground equipment. Furthermore, students were advised by occupational and physical therapists from a local public school designed to cater to children with disabilities, PS 79M, located conveniently across from the proposed playground site. These children would be the primary beneficiaries from the creation of such a playground.

The hearing impairments team focused on the tactile and visual senses that a child with auditory disabilities may rely heavily on. The main design is a life-size, seven-key organ that plays musical notes while displaying the seven colors of the spectrum appealing to visual senses as well as auditory (Table 1).

Children with learning disabilities have trouble following patterns and are not able to grasp simple directions. Thus, this team created an enlarged version of a memory game with eight blocks. Each block has characters on four faces with a tube. An added incentive of the game was that it was also wheelchair accessible, allowing those with physical disabilities to also partake (Table 1).

Neurological disabilities affect the function of the central nervous system mentally, physically, perceptually or in motor-skill-oriented operations. Thus, designs for playground equipment needed to be simple but stimulating. The team produced the sound levers device. When one lever is pulled, the hammer or the locking arm is thrown, swinging the hammer to one of the two bells. The locking bar insures that whenever either of the levers is pulled, the hammer will hit a bell (Table 1).

The physical disabilities team was assigned to pay particular attention to motor disorders and quadriplegia/paraplegia when designing their playground equipment. To do so, the team developed a slide complex that includes two ramps (and up and down ramp) and two slides specifically designed to accommodate children in wheelchairs (Table 1). The complex also includes two different panel games: car game accessible from the top platform and a tic-tac-toe game close to the ground.

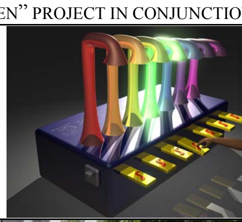
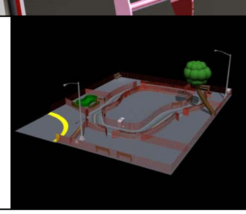
The psychiatric disabilities team designed a wheelchair accessible train with four cars and locomotive. Designs and activities are found throughout all trains with wave-like holes in walls. The locomotive car has many tactile features for children to explore (Table I).

Children with speech and learning disabilities have disorders, which affect their ability to communicate and understand. The team produced numerous designs to mentally and physically stimulate children with these disabilities. However, the most appealing one was the wheelchair swing. This unique swing does not require that the child be removed from his or her wheelchair (Table 1).

The visual impairments team designed the Nĕmo Spring Toy which is specifically for the blind (Table 1). It is a modified version of the traditional spring toy appealing to tactile sensations with different types of surface. Bright colors are used as well for less severe cases of visual impairment.

TABLE I

3D IMAGE RENDERINGS FOR DESIGNED PLAYGROUND EQUIPMENT CREATED BY SUMMER HIGH SCHOOL STUDENTS IN 2004 FOR THE "PLAYGROUND FOR ALL CHILDREN" PROJECT IN CONJUNCTION WITH THE NEW YORK CITY DEPARTMENT OF PARKS AND RECREATION FOR MARCUS GARVEY PARK.

Hearing Impairments – "Light Organ"		Learning Disabilities – "Memory Game"		Neurological Disabilities – "Sound Levers"	
Physical Disabilities – "Slide Complex"		Psychiatric Disabilities – "Wheelchair Locomotive"		Speech and Learning Disabilities – "Wheelchair Swing"	
Visual Impairments – "Nĕmo Spring Toy"		Overall Park Design			

The task of the overall design team was to create the general layout for the playground (Table 1). This would be accomplished by designing equipment such as special sandboxes and custom wheelchair accessible water fountains in addition to the other pieces of equipment designed by the other teams.

Students produced complete 3D image renderings, which were given to the New York City Department of Parks and Recreation for each of the designed playground equipments.

II. Implementation of Design – First-year Engineering Students

The completion of the summer term served as motivation to continue the playground project. Administrators from PS 79M and the New York City Department of Parks and Recreation were enthusiastic about seeing the park actually built. Thus, actual implementation and prototyping were the next steps.

The following semester students, Fall 2004, were given the arduous task of producing small-scale prototypes. However, this time the students involved would be first-year engineers. Community partners from the New York City Department of Parks and Recreation picked the designs proposed by the summer high school students in conjunction with the therapists from PS 79M. The ideas and designs for the Slide Complex, Wheelchair Swing, and Light Organ were chosen.

The student teams were given the same support and guidance that the high school students were given the summer before. The main difference being that these students had more time since they were allotted one complete academic term, approximately fourteen weeks, for the completion of their prototype.

Each chosen design was assigned to two different teams. This was does intentionally to achieve two feasible solutions for each design. While producing the mini-prototypes, the teams amended the initial design solutions to attain feasibility in actual implementation. Undoubtedly, each team would have a different idea for implementation of the proposed design and thus no two designs were alike even though the same initial concept had been assigned. Figure 1 shows the two different designs proposed for the Wheelchair Swing.

At the end of the Spring 2005 academic term, the New York City Department of Parks and Recreation and PS 79M unanimously agreed that the Wheelchair Swing was novel and actual implementation was imperative. Fall 2005 marked the beginning of the actual prototyping for the swing. Students worked with machinists to create a full-size prototype of the swing (Figure 2).

The following term, Spring 2006, the student team was responsible for implementing and testing the swing with actual students with disabilities from the PS 79M school. The project was deemed a success since results from the user-study were extremely favorable (Figure 2).

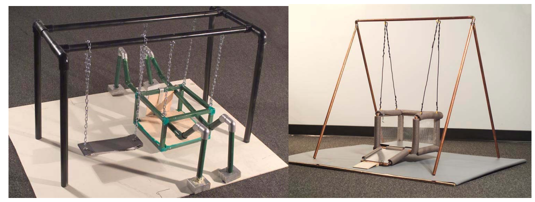


FIGURE 1
TWO DIFFERENT DESIGNS PROPOSED FOR THE SMALL-SCALE PROTOTYPE BY STUDENTS IN SPRING 2005 FOR THE "WHEELCHAIR SWING."

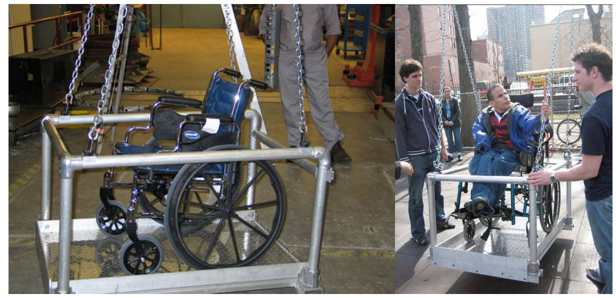


FIGURE 2
ACTUAL FULL-SIZE PROTOTYPE OF "WHEELCHAIR SWING" (LEFT). THE DESIGN WAS TESTED WITH STUDENTS FROM PS 79M TO DETERMINE ACTUAL FEASIBILITY OF USAGE (RIGHT).

INFORMATION TECHNOLOGY

The role of information technology, automation, visualization, learning technologies and systems is an increasingly important aspect of effective design practice. Information technology projects require the use of advanced technologies, namely computers, to convey information to interested parties. Effective dissemination of information through the use of the World Wide Web is helpful. Thus, these projects are imperative in teaching students good engineering design skills.

I. Interactive Accessibility Maps – First-year Engineering Students

The issue of accessibility at the zoos arises primarily from its age. The zoo contains buildings and paths that were built decades ago and were not designed with accessibility in mind. Currently, the WCS is doing as much as they can, such as changing signs in the zoo and revising their website to address these issues. Still, a need existed for a simple yet comprehensive website for each of the five zoos and aquariums in the New York City area dedicated solely to provide information for people with disabilities. The website should be highly accessible, inclusive of relevant information, and be easily maintained and updated. This would be the first point of concern since there was an immediate need to address the current accessibility situation at the zoos. Students were required to meet ADA needs for any information provided to visitors online as well as for the creation of their web-

FIGURE 3
TWO POTENTIAL DESIGN SOLUTIONS PROPOSED BY FIRST-YEAR COLLEGE STUDENTS IN DESIGNING ACCESSIBILITY MAPS FOR THE WCS. FIGURE ON LEFT IS GENERAL OVERVIEW OF ZOO MAP, WHILE FIGURE ON RIGHT SHOWS A DETAILED DESCRIPTION ON MOUSE-OVER OF A SPECIFIC ATTRACTION.

materials.

Each of the student teams had their own recommendation about the method that would best suit the needs of the WCS. Through advise from ADA experts, community client partners, and instructional advisors, a unanimous decision was made for each team to use Macromedia Flash to design the web-materials to maintain uniformity (Figure 3). In addition, the WCS provided student teams with its current website template to aid with uniformity. Furthermore, students were asked to create printer friendly versions of the information provided on the designed website so that visitors could print any needed information for their visit to the zoo.

The following semester, Spring 2005, a group of first-year engineers were assigned to develop a personal digital assistant (PDA) that will provide zoo-goers with portable, easily accessible information to enhance their experience at the zoo. The goal was to develop a handheld device that would provide patrons with useful content that is not applicable or possible to implement on the zoo website, leaflets, or brochures. Specifically, the objective was to design a handheld device that would deliver patrons dynamic content that could be found on a home computer (such as the interactive maps created by the students in the previous academic term) while they are at the zoo. At the same time, the device would contain any standard information on a printed pamphlet (such as exhibit facts and locations and disability services). An actual prototype of such a device was created for the Central Park Zoo (Figure 4).

II. Redesign of Parks – High School Students

Summer 2005 marked the start of the second part of the multi-part project. Forty-five industrious high-school students were assigned to the second part of the initial project. These students were to conduct an ADA audit of the Bronx Zoo and propose redesigned solutions to the areas that lack compliance to ADA. The implementation of these recommendations would take longer and thus was the second part of the multi-

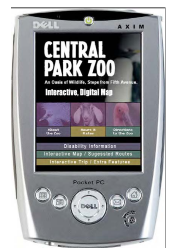


FIGURE 4
ACCESSIBLE PDA PROJECT FOR THE WILDLIFE CONSERVATION SOCIETY (WCS). PROTOTYPE OF PDA WITH ACCESSIBILITY MAP CREATED FOR CENTRAL PARK ZOO.

part project with the WCS.

Similar to the prior summer, students would be required to submit 3D image renderings of proposed solutions to WCS for possible implementation. Most student teams focused on different means of transportation at the Bronx Zoo as their primary concern, while others attempted to solve accessibility issues at particular attractions. For instance, two student teams proposed design solutions to aid the physically disabled as well as auditory and visually impaired. The addition of ramps for easy access on and off the shuttle and LED displays and speakers to announce upcoming stops were all simple proposed solutions (Figure 5).

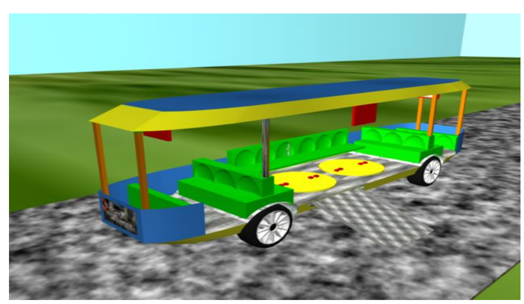


FIGURE 5
AMENDMENTS MADE TO EXISTING ZOO SHUTTLE AT BRONX ZOO TO ADHERE FURTHER TO ADA COMPLIANCE.

Common solutions for accessibility with regards to different zoo attractions included better signage and more accessible pathways within individual attractions such as the World of Darkness and Prairie Dog Exhibits.

An interesting project attempted by two student teams also included designing of a special carriage that would enable those in wheelchairs to experience the "Camel Ride" attraction at the Bronx Zoo in which people are given the actual experience of riding a camel. Students proposed contraptions that could safely be attached to the camel and securely hold the wheelchair in place (Figure 6). The most unique characteristic to this particular project involved the idea that those confined to wheelchairs could get the same experience

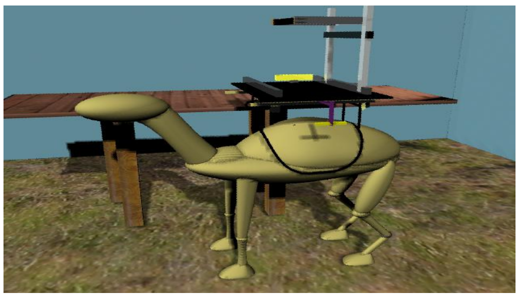


FIGURE6
PROPOSED SOLUTION TO ALLOW PEOPLE IN WHEELCHAIRS TO SAFELY AND SECURELY PARTICIPATE IN THE "CAMEL RIDE" ATTRACTION AT THE BRONX ZOO.

as those who are not without having to be lifted out of their wheelchair. Also, many times, i.e. in the case of pony/horse rides, those in wheelchairs are confined to take a carriage ride instead. This does not provide for the same sensation of actually riding the animal. The design proposed by the students would offer a solution to this as well.

SUCCESSES

Both projects have been deemed a success. Both groups of students, high school and first-year college engineers, produced effective and feasible solutions to the problems and projects proposed to them.

In the case of the "Playground for All Children" in Marcus Garvey Park, the New York City Department of Parks and Recreation is currently reviewing and determining the feasibility of implementing the created prototypes.

For the WCS, the accessibility maps were implemented almost immediately. The possibility of implementing the PDA was being sought after. This was a bit more difficult due to budgetary constraints of purchasing a set of PDA's for each of the zoos and aquarium. Finally, the design proposals for modifying the Bronx Zoo to comply further with ADA standards are under review. Budget allocations are a deciding factor in actual implementation of these students' ideas.

Frequent surveys of involved students and community partners show favorable results. Student experiences have been positive. The impact on high school students is seen readily with most students involved in the Columbia University Summer High-School Program, applying to the engineering school at Columbia University for their undergraduate studies. Thus it is safe to presume that the experience has led these students to an increased interest in the pursuit of higher education in the engineering field. First-year engineering students indicate a renewed interest in their chosen academic pursuits with better understanding of real-world applications for their desired majors. Client satisfaction with the results of projects has yielded an extremely high rate of returning clients and multi-term projects leading to actual implementation of many designs.

CHALLENGES

Common challenges faced with projects and both groups, high school and first-year engineering students; include the extent of limited technical skills possessed. This makes it harder to proceed farther in most projects. Both groups have never had any advanced technical courses and most students have never had prior engineering design experience. Moreover, service-learning projects also require client interaction and the development of professional skills concurrently to understand and effectively communicate with the community partner to understand the actual project requirements. Thus, progress that is made comes with great cost of time. Also both students groups sometimes need significant outside help from instructors, advisors, and others in completing projects that are highly technical: specifically computer programming and machining. A way to solve the machining issues is for us to provide students with easy access to a machine shop and qualified machinists. The problem with this solution involves available funding for these projects. Most times the community organization has very little to no money to available to fund these endeavors. We have some institutional allocations as well as some grant funding to aid in the process. However, this is limited and thus not all projects can reach the prototyping phase.

Time constraints are a challenge too for both groups. The high school students are given a month, sixteen class days of instruction, to complete their projects. While the students spend four hours in class each day, much of this time is spent in lectures pertaining to engineering design, professional and team development, as well as the use of 3D design software to produce their final design renders. Thus, actual group work time is limited and existent only in small quantities. Furthermore, a good percentage of the summer students are commuters to the summer program and thus after class group meetings are nearly impossible. Those students are residing on campus for the summer program have extracurricular activities and curfews set by the institution and thus do not have that much free time to work on the project outside of class. Therefore, there is definitely not enough time to produce anything more than design sketches and ideas. An actual prototype and implementation project would be near impossible given the constraints.

In comparison, although the first-year engineers are given one academic term, approximately fourteen weeks, these students are involved in a full-course college level course load alongside other extracurricular activities. This causes problems with clashing schedules that may prevent a team from working together. Thus, much of the work is divided amongst the team in consideration for time.

Another challenge is the transition of materials between students teams at the end of an academic term. Many times student teams find themselves "redefining the wheel" in trying to understand the documentation left behind by the previous team. To aid in this process, we have developed a project archival tool that will easily store and disseminate all materials associated to projects [5].

RESOURCE REQUIREMENTS AND SUSTAINABILITY

With the level of content of completed projects by our community partners, we have no difficulty in identifying potential projects for our students. The resource requirements for successfully implementing service-learning project based courses are the same as that of our engineering design course since we have embedded the two together. Thus the following table, Table II, lists the time commitments for this.

TABLE II
RESOURCE REQUIREMENTS BREAKDOWN FOR ONE ACADEMIC TERM.

Resource	Requirement
Teaching Assistants	4 individuals – 120 hours/week
Community Partner Outreach and Solicitation	1 individual – 40 hours/week
Lecturers	3 individuals – 12 hours/week
TOTAL	172 hours/week

Our teaching assistants are involved not only for grading of assignments but also for advising teams with technical guidance. Lecturers are the key components for ensuring that students are taught the appropriate project management, professional development, engineering design and technical skills to successfully finish the assigned projects. Thus, sustainability is not a major concern of for our service-learning program.

CONCLUSIONS

Service-learning projects are effective tools to introduce students to engineering design. The versatility of such projects allows for practically any skill-level and age group to successfully complete an assigned project. Introducing these projects to high school and first-year engineering students is an ideal solution to achieve interest and spark interest in the engineering discipline. Albeit, limited technical experience, students are still able to benefit from invaluable hands-on real-world experience of design problems. The opportunity to see real engineering in action is also beneficial to help students decide on their future academic and career paths.

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