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Engineering, Physical Therapy and the Community: A Service Learning Course

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Abstract

The School of Engineering and the Physical Therapy program at the University of North Florida developed a novel, community-based course where undergraduate engineering students are partnered with physical therapy students. In this course students participate in hands-on, team-based design projects focused on low-tech and high-tech rehabilitation technology for children with disabilities. The impact of this interprofessional education experience on the students has been evaluated using the Public Service Motivation Scale for three years and its impact on the students is presented.

Index Terms

Interdisciplinary Education; Rehabilitation Engineering; Community Based; Pediatric; Public Service

I. INTRODUCTION

In recent years the engineering profession has looked at service learning as a model to educate new generations of engineers. Under such a model students are exposed to real world problems where they apply engineering skills to generate practical solutions and gain new knowledge. As students work on problems they generate new knowledge in isolated pockets which are tied together through self-reflection activities ultimately yielding a comprehensive view of their profession [(1)]. Furthermore, to help students gain the professional and interpersonal skills needed for future success in their profession, an increased exposure to societal context and interdisciplinary teamwork is necessary [(2)]

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The School of Engineering in partnership with the Doctoral Program of Physical Therapy at UNF incorporated such service learning activities as part of their academic curriculum with the ultimate goal of enhancing professional behaviors such as caring, compassion, civic engagement, social responsibility, and citizenship of the students. This has been carried out by following recommendations from engineering and health professional communities that emphasized the need for interdisciplinary, hands-on classroom experiences that expose students to multiple professional behaviors [3, 4]. Based on these recommendations, a new interprofessional, community-based service-learning (CBSL) course elective in the engineering curriculum was created. This CBSL course was shaped by the University's collaboration with the local physical therapy community and a strong need for pediatric adaptive technology [5, 6]. Because of this collaborative effort the aims of the course were centered on translating highly needed technologies to underserved local populations of children and families in the community. This had the unintentional effect of strong media coverage [7].

This CBSL course was designed to engage undergraduate engineering students -in their junior and senior years- and doctoral physical therapy students. In the course, students work in interdisciplinary teams to assess, design and fabricate customized technology for children with disabilities in the local community. Figure 1 presents two examples of adapted toys generated as part of this course. Such devices are employed to engage children with disabilities in therapeutic activities that aid their development.

The following manuscript presents this course and data collected from students during a period of three years. The manuscript is organized as follows: Section II provides a brief overview of the course and community engagement. Section III describes the technology developed in the course. Section IV introduces the Public Service Motivation Scale (PSM) and how it was employed to collect student data. Section V discusses the results collected from the students, and finally, Section VI presents future work and conclusions.

II. COURSE AND COMMUNITY INTERFACE

Pre-test and post-test data was first collected from students enrolled in this CBSL course during fall 2015. A detailed description of the course and the data collected for that year was previously reported elsewhere [8]. The course description is summarized as follows:

- Engineering students are partnered with physical therapy students to collaboratively address the needs of identified children with developmental disabilities in the community. These children are referred through community therapists working in area hospitals or the school district.
- Engineering students observe clinical assessments carried out by physical therapy students under the supervision of licensed therapists.
- Engineering students attend lecture and laboratory sessions providing basic introductory bioengineering and physical therapy information.
- The products from each team are given to families/children free of charge for their personal use, and children who receive adapted-toys are followed as part of

a research effort to understand the impact that such technology has on their sensory-motor function and quality of life [9, 10].

Students enrolled in the course are also exposed to a clinical observation period where they witness the assessment methods typically employed by therapists. Figure 2 presents images of the engineering and physical therapy students undergoing such activities. During these sessions the therapist interacts with the child, the parent (or both) and discusses their goals for independent function. A subsequent meeting with the students provides them with an insight on the relationship between the child's impairments, participation in life activities and the goal for this technology.

III. ADAPTIVE TECHNOLOGY

The technology developed in the course consists of a mobility assistive device (Ride-on toy) and an interactive small toy (see Figure 1B). Although these devices are customized to each individual user, it is noted that common features are repeatedly found in them, in particular for the ride-on adaptations. These adaptations are grouped in two: proportional control through a joystick and line follower technology. Figure 3 displays examples of these two types of ride-on technologies. The following section presents two projects developed as part of the course to elucidate these technologies.

A. Proportional Control through a Joystick

The ride-on presented in Figure 4A was adapted for a four year old child with cerebral palsy. The assessment carried out by students and therapist indicated that to increase participation in life activities the ride-on needed to operate well in an outdoor environment, specifically on grass and gravel. Therefore, a Kid Trax Ram Dually 12-Volt Battery Powered Ride-on was selected due to its size and power. This unmodified truck operates using a foot pedal to provide power to two rear motors, a steering wheel connected to the front axle to turn the front wheels, and a shift handle to select forward or reverse direction.

The child assessment indicated limited hand mobility, with a preference for a therapeutic intervention on the left hand. Hence, a joystick position near the left hand was selected for directional control and actuation. This required the pedal, steering wheel, front axle, front wheels, and shift handle to be removed and replaced by a new mechanism. The new mechanism consisted of a joystick controlling the two rear motors independently. This allows for forward/reverse control as well as proportional control over the speed. In addition, by independently controlling each rear motor the ride-on could turn right or left. The front wheels were replaced by 10" casters (shown in Figure 4B) to allow this type of maneuvering without inducing wobbling.

The electronic set up for this type of control was centered on a Sabertooth 2×32 motor controller. The ride-on battery was connected to the motor controller (for power) and the joystick was attached to the S1 and S2 ports on the Sabertooth (for motor 1 and motor 2 control). In addition, the Sabertooth was set to ramp up, thereby slowing down the acceleration of the truck and avoiding sudden forces on the user who has weak postural control. The hardware was all housed in a waterproof plastic box placed in the back of the ride-on.

B. Line Follower Technology

The modified vehicle for this project was a SPORTrax Chevy Colorado Style 4WD Kid's Ride-On Car, seen in Figure 3B and 5A. This car was chosen for its centered seat, wide interior, and sleek design. Mechanical and electrical modifications to the car were made for a four-year-old child diagnosed with Cerebral Palsy (CP) and Cortical Vision Impairment (CVI).

The child's assessment indicated that directional control of the vehicle would not be appropriate due to the cortical visual impairment condition. Hence, line follower technology (where sensors in the vehicle detect a line on the floor to follow) was implemented. This was carried out by using an Arduino microcontroller to read an activation signal from a switch (operated by the child) and a sensor array for line following. The Arduino microcontroller then output a signal to a Sabertooth 2×32 motor controller to operate the motors.

The car was modified to run as a Rear-Wheel Drive vehicle with caster wheels on the front. A QTR Reflectance Sensor Array with eight sensors was selected to detect contrast underneath the front of the car. This sensor array was housed in a 3D printed box with an opening and mounted about 5 mm from the ground (see Figure 5B). This sensor array provides electrical input to the Arduino program to determine how off-center from the line the sensor array is. The Arduino then uses a simple control algorithm to process these signals and provides the Sabertooth with commands to maintain the ride-on position within the line. This all occurs with the push actuation of a button switch (5 inches in diameter, and large enough for a child with CVI) located in front of the user. Finally, the Sabertooth motor controller was also employed using a ramp up to avoid sudden forces on the children.

IV. STUDENT DATA MEASURES

The Public Service Motivation Scale (PSM) was selected as the measure to evaluate the impact that this course had on the students. This scale was developed by James L Perry in 1996 and has been widely employed by researchers across many disciplines. It is noted that although Perry defined public service motivation as "*an individual's predisposition to respond to motives grounded primarily or uniquely in public institutions*", this definition has been revised and modified by many authors and scholars [11]

In this manuscript Perry's definition and his PSM scale was employed. This scale not only measures Public Service Motivation but also four subscales: 1) attraction to public policy making, 2) commitment to public interest, 3) self-sacrifice, and 4) compassion. The data was collected from students enrolled in the course during the first and last day of classes via anonymous paper surveys. An IRB was approved exempt [IRB# 620530–1] for the collection of this data. Under this IRB procedures, the confidentiality of participants was maintained by using pseudonyms, and secure data storage for the master lists and identifiers.

V. RESULTS

The student demographics for engineering students enrolled in the course for all three years of collected data (2015, 2016, and 2017) are presented in Table 1. The total number of students analyzed for all three years is 82, with 69 males and 13 females.

The collected student data was analyzed using a repeated measures t-test to determine whether there was a statistically significant difference in the pre-course and post-course surveys, and thereby the impact that the course experiences is having on the students. Table 2 presents the results from this test for all students, Doctoral Physical Therapy (DPT) only students, engineering only students, female only students, and male only students. The total PSM as well as each one of the four subscales is presented for each of the test subject groups. The t-value was calculated using the general function t-test *procttest* in the SAS program and the t*-statistic was determined from the inverse T function on a TI-89 calculator with 95% confidence level.

Analysis of this data shows that the categories with statistically significant changes were the overall Public Service survey, the overall Public Interest section of the Public Service survey, the Compassion section of the Public Service survey for engineering students, and the Compassion section of the Public Service survey for male students. These are all highlighted in Table 2.

It is also noted that there was no statistically significant change in the overall Public Service of doctoral physical therapy students. A question can be raised whether the technical skills learned in the course were more impactful to these students than the Public Service. This lack of change could be attributed to the direct public service physical therapists are expected to conduct in their careers. It is then concluded from this data that the perception of Public Service Motivation changes for all students, in particular in respect to the overall commitment to public interest. It is also observed that male engineering students had a statistically significant change in the compassion subscale. No other statistically significant measures were found on the other subscales.

VI. FUTURE WORK AND CONCLUSION

The results presented in this work have shown that an interprofessional, community-based service-learning (CBSL) course has the potential to change the student's predisposition towards public service, public service interest and compassion. As the course will be taught over the next few years, new measures including for civic responsibility, and interprofessional socialization are recommended. Furthermore, due to the nature of their profession DPT students showed little to no change in their PSM results. This is understandable, however a new measure to characterize the impact that this course is having on them is necessary.

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Fig. 1.

Adapted toys with push buttons, A) Ride-on, B) Small Toy

Fig. 2.
Engineering and physical therapy students during a child assessment session.

Fig. 3.
A) Proportional Control and B) Line follower technology.

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Fig. 4.
A) Proportional Control Adapted Ride-On. B) Caster System.

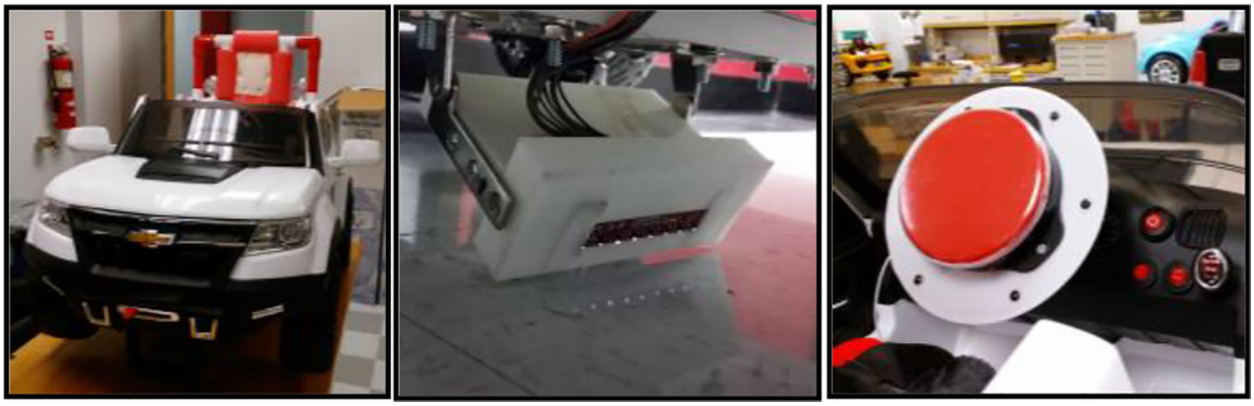

Fig. 5.
A) Line Follower, B) Sensor System, C) Actuation Push Button.

Table 1.

Engineering Student Metrics in Course.

Year	Students Total	Men / Women	Hispanic / African American / Asian / American Indian	Junior / Senior
2015	24	18/6	8/2/1/0	10/14
2016	26	20/6	2/1/0/0	4/22
2017	32	31/1	3/3/2/0	9/23

Table 2.

Repeated Measures t-test Results.

		t-value	t*-statistic	p-value	alpha	t-value > t*-statistic	P-Value > Alpha
TOTAL	PS Total	2.91	1.64559	0.0037	0.05	TRUE	TRUE
	PS Policy Making	0.36	1.65074	0.7206	0.05	FALSE	FALSE
	PS Public Interest	2.31	1.64837	0.0213	0.05	TRUE	TRUE
	PS Compassion	1.90	1.64707	0.0576	0.05	TRUE	FALSE
	PS Self-Sacrifice	1.25	1.64705	0.2108	0.05	FALSE	FALSE
DPT	PS Total	0.64	1.66039	0.5200	0.05	FALSE	FALSE
	PS Policy Making	0.98	1.71088	0.3372	0.05	FALSE	FALSE
	PS Public Interest	0.70	1.71088	0.4900	0.05	FALSE	FALSE
	PS Compassion	0.68	1.71088	0.5000	0.05	FALSE	FALSE
	PS Self-Sacrifice	0.24	1.71088	0.8140	0.05	FALSE	FALSE
Engineering	PS Total	1.69	1.65304	0.093	0.05	TRUE	FALSE
	PS Policy Making	0.57	1.67866	0.5744	0.05	FALSE	FALSE
	PS Public Interest	0.90	1.67866	0.3714	0.05	FALSE	FALSE
	PS Compassion	2.65	1.67866	0.0110	0.05	TRUE	TRUE
	PS Self-Sacrifice	0.90	1.67866	0.3748	0.05	FALSE	FALSE
Female	PS Total	1.41	1.66039	0.1626	0.05	FALSE	FALSE
	PS Policy Making	0.51	1.71088	0.6116	0.05	FALSE	FALSE
	PS Public Interest	0.39	1.71088	0.7033	0.05	FALSE	FALSE
	PS Compassion	1.24	1.71088	0.2278	0.05	FALSE	FALSE
	PS Self-Sacrifice	0.72	1.71088	0.4781	0.05	FALSE	FALSE
Male	PS Total	0.20	1.65304	0.8414	0.05	FALSE	FALSE
	PS Policy Making	1.56	1.67866	0.1251	0.05	FALSE	FALSE
	PS Public Interest	0	1.67866	1.0000	0.05	FALSE	FALSE
	PS Compassion	2.28	1.67866	0.0270	0.05	TRUE	TRUE
	PS Self-Sacrifice	0.53	1.67866	0.5954	0.05	FALSE	FALSE