Abstract— A novel, community-based course was created through collaboration between the School of Engineering and the Physical Therapy program at the University of North Florida. This course offers a hands-on, interdisciplinary training experience for undergraduate engineering students through team-based design projects where engineering students are partnered with physical therapy students. Students learn the process of design, fabrication and testing of low-tech and high-tech rehabilitation technology for children with disabilities, and are exposed to a clinical experience under the guidance of licensed therapists. This course was taught in two consecutive years and pre-test/post-test data evaluating the impact of this interprofessional education experience on the students is presented using the Public Service Motivation Scale, Civic Actions Scale, Civic Attitudes Scale, and the Interprofessional Socialization and Valuing Scale.

Index Terms— Interdisciplinary Education, Rehabilitation Engineering, Adaptive Technology, Pediatric, Disabilities.

I. INTRODUCTION

Incorporating problems with real world applications in the academic curriculum remains one of the most pressing challenges in engineering education. Recent reports from engineering and health professional communities have emphasized the need for interdisciplinary, hands-on classroom experiences that expose students to multiple professional behaviors. The objective of such experience is to enhance the student’s learning and the potential for translating technologies to underserve populations [1, 2]. In addition, multiple studies have been carried out demonstrating that professional behaviors such as caring, compassion, civic engagement, social responsibility, and citizenship can be realized through experiential activities followed by guided reflection [3, 4]. Consequently, exposing students to experiential service-learning activities as part of the academic curriculum has the potential to provide deep changes in the student’s professional behavior. This could reaffirm or transform a student’s interest in the biomedical engineering field, either as a potential industry career or their desire to further their education in a graduate program.

Inspired by these reports, as well as a strong local community demand for pediatric adaptive technology, a new interprofessional, community-based service-learning (CBSL) elective in the engineering curriculum was created at UNF. This CBSL course aims to provide a novel hands-on, interdisciplinary training experience for undergraduate engineering students and graduate physical therapy students. In this course, students work in interdisciplinary teams to assess, design and fabricate customized technology for children with disabilities in the local community. Figure 1 presents an example of a finished adapted ride-on toy from this course. Such a device is used by physical therapist to engage children with disabilities in therapy activities that help their development.

The following manuscript introduces the multiple facets of this course and is organized as follows: Section II provides the course description. Section III describes the community-based organization and interprofessional affiliation with physical therapy. Section IV presents examples with technical details of the hands-on experience. Section V discusses the evaluation and impact of this course on the students, and finally, Section VI presents future work and conclusions.

II. COURSE DESCRIPTION

In this course engineering students are partnered with physical therapy students to collaboratively modify/adapt...
ride-on toy cars to fit the individual needs of children with mobility based impairments who are referred through community therapist working in area hospitals or the school district. In addition to the technical, hands-on design and fabrication aspect of the course, engineering students are also exposed to the clinical assessments carried out by physical therapy students under the supervision of licensed therapists. The ultimate aim for the sum of all these experiences is to prepare students for future bioengineering challenges and help them appreciate the roles and contributions from the different disciplines, especially those in the health care sector.

The course consists of lecture and laboratory sessions. Students attend lectures providing basic introductory information in neuroscience, child development, rehabilitation provision models such as International Classification of function (ICF) and Human Activity Assistive Technology (HAAT), developmental disabilities, and assistive technology principles including assessment, construction, and design. They form interdisciplinary teams, and under the guidance of clinical professionals and direct supervision of qualified licensed and expert faculty, students design, construct, and test appropriate assistive technology addressing the needs of identified children with developmental disabilities in the community. The products from each team are given to the families/children free of charge for their personal use. In addition, children who receive these 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.

![Image](image.png)

Fig. 2. Engineering and Physical Therapy Students carrying out patient assessment under the guidance of a licensed therapist. [11]

Students enrolled in the course are also exposed to a clinical observational period where they observe the assessment methods typically employed by therapists in the community. Figure 2 presents an image of the students carrying out such assessment. In addition to several standardized assessments, the therapist asks the child, parent or both, whichever is appropriate, to discuss their goals for independent function. After the session observation, the pediatric therapist facilitates a team discussion about the child’s disability, and using the ICF model of enablement, helps the students identify the child’s specific impairments, activity limitations and participation in life activities restrictions that could be addressed with assistive technology.

This clinical exposure helps the students understand the culture of child centered or family centered approach commonly used in pediatric rehabilitation settings, and help train the next generation of independent practitioners, biomedical/rehabilitation engineers, and researchers in basic thinking, communication, and teamwork, as well as teaching them respect for team diversity in problem solving. The end goal is to increase the appreciation of collaboration and understanding of the diverse roles and contributions from different disciplines. This is further reinforced through the laboratory activities where designing, and fabricating an assistive technology for their child client takes place. At the end of the semester each team presents and delivers their custom device to their child and provides instruction to the parent about the care, safety and maintenance of the device.

### III. INTERPROFESSIONAL AFFILIATIONS

#### A. Community Based

It is well documented by the pediatric medical and research community that children with impaired ability to play independently often experience a negative impact on their overall development leading to depression, social isolation, and lower quality of life [5-7]. It is therefore essential for healthy development that children with disabilities be able to reach a comparable level of independence as children without disabilities. This presents a daunting challenge for therapists working with severely and profoundly handicapped children. The complexity and variability of children’s illness and the lack of flexibility in the available assistive technology gives rise to high-priced personalized therapies. As a consequence, an unacceptable large population of young disabled children are alienated and restricted from access to this technology. This is particularly true for young children in the North Florida territory.

In response to this vastly unmet community need and recognizing the importance that this early mobility experience has on children with disabilities, a partnership between the School of Engineering and the Program of Physical Therapy at UNF was created. This partnership came to fruition through the previously described course and relationships with pediatric therapists in the community. Child participation criteria were established and a referral mechanism was created and these community therapists were invited to refer children that they considered ideal participants. All children that have participated are between the age of 6 months and 6 years of age with developmental disabilities that have impaired their mobility.

#### B. Physical Therapy

The described course is offered to engineering students in their junior/senior years, and also to graduate (2nd and 3rd year) physical therapy students. It is taught as two concurrent courses simultaneously using a common syllabus. This ensures that students complete team-based projects addressing
Problems faced by children with disabilities in the community, and also allows them to jointly attend lectures provided by guests who are experts in the areas of rehabilitation and engineering, and participate in clinical experiences where they observe typical and atypical child play activities as part of a clinical observation period. This clinical period takes place during the first weeks of the semester. During this time students schedule a convenient time with clinical co-advisors to participate in this supervised clinical observation period at the University and at the participating therapist’s location.

IV. ADAPTIVE RIDE-ON TOYS

Most of the children in need of this adaptive technology suffer from motor impairments caused by underlying medical conditions, secondary side effects resulting from their impairment, and other co-mitigating conditions. The uniqueness of their disability is classified according to their symptoms, e.g., spasticity, ataxia, athetosis, or hypotonia. These translate into poor head control, mobility with rolling, crawling and walking, difficulty grasping, tremor-like motions, unsteady balance, poor hand manipulation skills, movement delays of the entire body and speech, and muscle tone fluctuations causing locking joints.

![Fig. 3. Mechanical and electrical adaptations of a ride-on toy for a four-year-old child with spastic quadriplegia and cerebral palsy.](image)

This broad range of conditions requires mechanical adaptations to ride-on toys that augment the child’s postural control and allow clinicians to address many International Classification of Functioning (ICF) levels while the child focuses on a play activity. Adaptations consist of trunk and limb support that, in combination with steering and activation, engage the child in dynamic postural control during the operation of the device and allow therapist to address the targeted ICF body functions. Additionally, mechanical adaptations help mitigate undesired abduction, adduction and excessive forward or backward motions. Common, safe, and off-the-shelf materials are used to keep these adaptations economically viable. Mechanical adaptations are encased with soft materials that carry the weight of the child, eliminating loading asymmetries and preventing sores, ulcers, and wounds. Figure 3 displays mechanical and electrical adaptations as part of an adapted ride-on toy completed in this course.

Adaptations to the steering and activation systems are also important and typically done simultaneously. Circular, bar handles, and/or other mechanisms that target upper extremities are selected along with power switching devices for activation. A broad array of power switches are commercially available and employed as part of common assistive technologies. These switches employ pushing, pulling, squeezing, bending, blowing, voice, and any other type of available movement such as blinking or twitching to activate. Often they are combined with sensory feedback (tactile/vibration, sound/music, or visual/illumination) to enhance rehabilitation effects by activating sensory pathways. Each individual child is fitted with button, grasp, leaf, plate (horizontal or vertical), vibrating platform, and/or treadmill power switching. The selection of the appropriate power switch is addressed during the assessment session by looking at the most repeatable activation method (hands, head, mouth, feet), the device that will be controlled, location and positioning of the switch (for least possible fatigue for the user), and type of electrical connection.

The electrical interface is accomplished through a phono plug adapter that connects control units, timers, and/or power adaptors for driving electrical loads, such as motors. It is noted that using this simple phono connection provides great flexibility for swapping switches and adds value to the lending library, as toys can easily be reconfigure for different disabilities.

V. STUDENT EVALUATION AND RESULTS

Students participating in the course were evaluated via anonymous paper surveys before and after the interprofessional CBSL course experience. A total of 13 Doctoral Physical Therapy (DPT) students and 25 engineering students enrolled for fall 2015 course. All assessments surveys administered to them are valid and reliable tools widely used for assessing civic engagement, public service motivation, and attitude and behavior towards working in cross discipline teams. Civic engagement was measured using the Civic Attitudes Scale and the Civic Action Scale. The Civic Attitudes Scale [8] was designed to assess participants’ cognitive thinking regarding civic responsibility and the Civic Action Scale [9] was designed to assess participants’ future behavioral intentions regarding civic duties or actions. The students’ public service motivation was measured using the Public Service Motivation Scale [10]. This scale assesses four public service dimensions: 1) attraction to public policy making, 2) commitment to public interest, 3) self-sacrifice, and 4) compassion. The students’ attitude and behavior towards working in cross discipline teams were measured using the ISVS-Interprofessional Socialization and Valuing Scale. This scale is designed to measure the degree to which individuals have the affinity to work together in interprofessional groups. The instrument is comprised of three sub scales: 1) self-perceived ability to work with others, 2) value in working with others, and 3) comfort in working with others.
Table 1. Pre-course survey data analyzed using a repeated measures t-test.

<table>
<thead>
<tr>
<th>Pre-Course Survey Data</th>
<th>Civic Attitudes</th>
<th>Civic Action</th>
<th>PS – Overall</th>
<th>PS – Public Policy</th>
<th>PS – Public Interest</th>
<th>PS – Compassion</th>
<th>PS – Self-Sacrifice</th>
<th>Social Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPT</td>
<td>Mean (SD)</td>
<td>4.69 (.32)</td>
<td>4.59 (.32)</td>
<td>3.73 (.37)</td>
<td>3.13 (.62)</td>
<td>4.02 (.51)</td>
<td>3.60 (.49)</td>
<td>3.91 (.45)</td>
</tr>
<tr>
<td>Engineering</td>
<td>Mean (SD)</td>
<td>4.54 (.40)</td>
<td>4.19 (.53)</td>
<td>3.33 (.47)</td>
<td>2.36 (.80)</td>
<td>3.50 (.77)</td>
<td>3.26 (.49)</td>
<td>3.67 (.66)</td>
</tr>
<tr>
<td>Total</td>
<td>Mean (SD)</td>
<td>4.59 (.38)</td>
<td>4.32 (.51)</td>
<td>3.47 (.47)</td>
<td>2.62 (.82)</td>
<td>3.68 (.73)</td>
<td>3.38 (.51)</td>
<td>3.75 (.60)</td>
</tr>
</tbody>
</table>

Table 2. Post-course survey data analyzed using a repeated measures t-test.

<table>
<thead>
<tr>
<th>Pre-Course Survey Data</th>
<th>Civic Attitudes</th>
<th>Civic Action</th>
<th>PS – Overall</th>
<th>PS – Public Policy</th>
<th>PS – Public Interest</th>
<th>PS – Compassion</th>
<th>PS – Self-Sacrifice</th>
<th>Social Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPT</td>
<td>Mean (SD)</td>
<td>4.43 (1.05)</td>
<td>4.68 (.27)</td>
<td>3.86 (.36)</td>
<td>3.18 (.74)</td>
<td>4.10 (.43)</td>
<td>3.82 (.44)</td>
<td>3.99 (.45)</td>
</tr>
<tr>
<td>Engineering</td>
<td>Mean (SD)</td>
<td>4.42 (.57)</td>
<td>4.18 (.75)</td>
<td>3.56 (.46)</td>
<td>2.64 (.74)</td>
<td>3.67 (.81)</td>
<td>3.50 (.44)</td>
<td>3.89 (.57)</td>
</tr>
<tr>
<td>Total</td>
<td>Mean (SD)</td>
<td>4.42 (.77)</td>
<td>4.37 (.66)</td>
<td>3.67 (.43)</td>
<td>2.84 (.77)</td>
<td>3.83 (.72)</td>
<td>3.62 (.46)</td>
<td>3.93 (.52)</td>
</tr>
</tbody>
</table>

The survey data was analyzed using a repeated measures t-test on all participant responses for pre-course survey and post course survey to determine if there was significant change in the students’ pre and post experience ratings. Table 1 and 2 present the pre & post data results for civic attitude, civic action, public service (PS) and social value. These results revealed a statistically significant difference from pre to post course experience (p=.002, p=.026, p=.004) in civic action, public interest, and teamwork abilities with all three being greater on course completion. No other statistically significant measures were found on the other subscales.

VI. FUTURE WORK AND CONCLUSION

The work presented in this paper has shown that a highly interdisciplinary course where engineering students interact with colleagues from healthcare professions has the potential to provide an experience for both clinical and non-clinical disciplines that could serve as a bridge between college and the workplace by solving a “real world” problem too complex for a single discipline or profession.

Future plans to enhance this interprofessional experience involve incorporating students from other professional fields such as business and/or education.

ACKNOWLEDGMENT

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REFERENCES