Collaborative Biomedical Engineering / Physical Therapy Clinical Data Collection Learning Module

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ABSTRACT

The Biomedical Engineering undergraduate program at Wayne State University has developed an effective collaborative partnership with the Physical Therapy department, which involves a cross disciplinary learning module providing BME students opportunities to work with PT researchers developing innovative measurement devices, but a has also been developed.

This learning module involves third year BME students working with first year graduate PT students to observe, process and assess gait lab data of patients presenting different gait dysfunctions. The data is then processed by the biomedical engineering students and then returned to the physical therapy students for assessment. Students then meet together to discuss their work and to understand the perspectives of the other group of students.

The model used and feedback from the first iteration are described along with plans for continued implementation.

Introduction

In the development of effective medical diagnosis and treatment of gait dysfunction, there is great need for collaboration between the engineers developing the hardware and software used to measure gait and the physical therapists who are actively using gait analysis equipment. This paper describes an ongoing collaborative effort between the undergraduate biomedical engineering program and the physical therapy program at Wayne State University. It will document the past two years of development of a classroom learning module and describe some of the most significant takeaways from these experiences as well as our next steps for this semester and going forward.

Description of programs

The Wayne State biomedical engineering program is a newly developed undergraduate program which is building on a long history of biomedical research and graduate education. It is a unique program in that it places a strong emphasis on the importance of holistically integrating the student's engineering education into the development of medical related design projects through a sequence of eight design labs. Each semester of their 4 years, the undergraduate students are enrolled in a design lab. The content of the design labs differs from semester to semester, but the

intent is always to challenge the students to think about users and their needs and to develop skills which will best enable them to bridge the technical information they have been learning to the real world problems they find when they step outside of the classroom. In order to help students succeed as problem solvers and innovators, there is a strong emphasis in this program on the critical use of design thinking. This emphasis on the cultivation of design thinking requires students to not only be well versed in their own fields of study, but to also be exposed to those who will be using their innovative ideas, requiring them to leave the classroom and enter the clinical arena to observe, participate and eventually influence the clinicians and patients who interact there.

Description of courses

The two courses involved in our current collaboration are quite different from one another, but they pair well for this collaborative learning exercise. To begin with, they are both part of a "lock step" curriculum, where the courses are taken in a specific sequence meant to build each student's knowledge and skill. Therefore, each time the learning module is offered, all of the students are at a similar point in their academic careers and have had comparable educational experiences and exhibit similar technical skills, making it easier to provide experiences and tasks which all of the students are equipped to engage in. Secondly, the two courses described below both relate to the study of information collected in clinical settings.

The BME course, ***Biomedical Design Lab IV***, is a part of the design lab sequence described above, and it is scheduled during the second semester of the third year of the program. By this time, the students have had a wide range of fundamental engineering and natural science courses and are beginning to apply these ideas to real life applications. The primary focus of this semester for the BME students is developing observation and ethnography skills for the assessment of user needs and the use of these skills for collecting and disseminating clinical information to a wide range of audiences. The skills they develop in this course will be directly applied to the development of their senior capstone projects, and will hopefully serve them in whatever field within biomedical engineering they choose to pursuit. Clinical observations play a very important role in this skill development, and the learning module describes here is one of several which are implemented throughout this semester.

The Physical therapy course, ***Kinesiology and Biomechanics,*** is a first year, second semester course which focuses on normal movement and biomechanics as applied to the human body. At the core of the Doctor of Physical Therapy program is the need for the student's to understand not only the control of human movement but also the biomechanics of human movement. Within this course, the Physical Therapy students study human movement and interpret deviations. This prepares the students not only to understand the biomechanics behind human movement but also provides them with an opportunity to see how neurological and musculoskeletal disorders impact human movement.

Facilities and Equipment

The Human movement laboratory is a state of the art facility housed within the PT department. It contains equipment that has the capability to record and analyze an extensive range of human movements in 3D such as human walking, upper limb reach, grasp and hand function. The lab is used by a number of PT researchers for their clinical research in human biomechanics.

Description of clinical gait analysis collaboration

Year one of the interdisciplinary collaboration

Since 2013, we have been developing collaboration between the biomedical department and the physical therapy department. In the first year, undergraduate BME students visited the Human movement laboratory. While there, they instrumented one of their fellow students from the class and data was collected both for his normal gait and for a feigned limp gait. During this visit, the students learned how the data acquisition equipment worked and gained hands on experience of the many technical difficulties faced by technicians and clinicians when collecting gait data. The students then learned to use the raw data to simulate the kinematics of the walking using musculoskeletal modeling software (OpenSim) and to develop appropriate joint kinematics curves. The students then used case studies to learn about clinical gait analysis and write up an assessment of the data collected on their "subject." This opportunity allowed the students to experience gait data acquisition and to wrestle through some of the difficult issues related with these types of measurements. It also allowed them to build relationships with the PT faculty, which in several cases, led to student research opportunities. What this opportunity did not provide however, was an opportunity for the students to work directly with PT practitioners to learn directly from them how gait lab data can be used in patient assessment.

Year two of the interdisciplinary collaboration

In 2014, the second year that we attempted this collaboration, we included several new features which have greatly added to the student experience. First, we invited test subjects with true gait abnormalities to participate in the gait measurements and second, we included students from the graduate PT biomechanics course in the observations and assessment of the data.

The intension of involving both BME and PT students together in the clinical gait lab was to help each group of students get a better understanding of the backgrounds, professional interests and technical language of the other group.

Two patients were invited to participate in the data collection over the course of two days. These subjects each came for one afternoon and were instrumented and measured for two different groups of students. To accommodate all of the students in the tight quarters of the gait lab, each of the classes broke up into four sections, with two sets of data collection each day. During these sessions, before beginning the data collection, the BME students (5 per group) and the PT students (~8 per group) met for the first time and were directed to get to know one another and to discuss the upcoming data collection and assessment. The BME students in particular were

instructed to learn from the PT students what type of information they expected they would need from the data collected in order to make meaningful assessment of the subject's gait. This introductory time was designed to build rapport between the groups of students, and also prepare the BME students in particular for the specific types of data that they needed to be recording in order to effectively document the data collection process.

Along with the two instructors, the prosthetic engineer who worked with the subjects and an additional PT instructor with expertise in gait analysis were all involved with preparing the clinical gait data collection Once the subject was ready and the equipment was properly set up, the students were invited into the lab and were introduced to the subject, and the other participants. Explanation of the equipment and the data collection / processing were provided by Dr. Galen, and additional instruction into the physiology of the gait changes were provided by the PT instructor.

Data was then collected from the subject walking along the lab arena, first for their natural prosthetic gait, and then with modifications to their prosthetic which altered the gait. Throughout the testing, physiology commentary was provided. Although this commentary was specifically given to the PT students, the BME students were also encouraged to record the knowledge in order to inform the development of their gait lab reports. After completing the data collection, the students discussed once more what types of data would be most important for the PT students to have in order to perform a full assessment on the patient's gait.

After completing the lab, raw data, measured as marker location in global coordinates, was provided to BME students, who were responsible for taking this data an presenting it to the PT students in the form of joint angle curves. The original intent had been for the students to use the same musculoskeletal modeling software used in the previous year to perform the inverse kinematic calculations necessary to develop the joint kinematics, however due to changes with the marker locations used, the students were not able to use their model accurately, and the proprietary software, C-motion was used to perform the inverse joint kinematics.

Once the BME students had collated the data, they synthesized a report describing the details of the data collection and processing. This document also reported the specific information requested by the PT students. Once complete, the reports were passed along to the PT groups for assessment of the gait data.

Using the report prepared by the BME students, the Physical Therapy students studied the human movement as described by joint angles relative to normative data and interpreted any deviations that were observed while performing clinical reasoning exercises as to the possible causation behind the deviations. They then

At the end of this learning module, the students met one more time to discuss their experiences and share what they had learned in their field of study from the data. This provided an opportunity for all of the students to learn from each other about what made sense in their reports and what needed improvement, it helped them to understand that technical jargon can vary

substantially from one field to another and that interdisciplinary communication of ideas, while very rewarding, can require additional effort.

Year three of the interdisciplinary collaboration

Currently, in 2015, our third year of this collaboration is underway, and we have already completed the observations of the gait data measurements, and the BME students are now working on processing the data so it is possible for them to provide effective joint kinematic data for the PT students. As was done in 2014, the BME and PT students will meet again at the end of the semester to discuss their results and learn from students in the counterpart discipline.

One of the major changes to the structure of the learning module was in the timing. Rather than scheduling it at the end of the semester as last year (to accommodate the PT course schedule), it has been moved earlier in the semester. This modified scheduling has allowed for a slightly expanded pace in order to to allow more time for the engineers to analyze the data, allowing them to provide more accurate, timely data to the PT students, which in turn affords them a greater opportunity to evaluate the data before the end of the semester. It also prevents the problem of the reports falling at the end of the semester when students were busiest.

Additionally for the BME students, more instruction has been given ahead of time relating to the processing requirements for the data collected. This additional instruction will equip the BME students to better handle the raw data that they are provided as a result of the clinical gait testing performed during this learning module.

Feedback from learning module

Student response to collaboration

After completing the learning module in the second year, the students from both classes completed an informal assessment. The intent of this survey was simply to aid in the improvement of our collaborative learning module. In this assessment the students were asked to include 5 significant things relating to this experience and 3 improvements which they would like to see. Some of the reoccurring themes associated with the survey results are included here.

Significant experiences:

- Opportunity to work collaboratively with students from a different discipline.
- Being able to collect data in a clinical setting, and work with actual raw data.
- Being able to collect data on actual patients (rather than themselves).
- Being able to see how their field of study is practically helping people.

Improvements:

- Students needed more time to complete data processing
- Needed more direct contact with the students from the other department to clarify questions during analysis.
- More instruction ahead of time concerning gait assessment.

The results of these surveys were recorded and are being used in the improvement of the learning module. It was clear from the responses provided that the students strongly valued both working in an interdisciplinary setting and in a clinical setting, with actual patients using state of the art equipment. They enjoyed the real world opportunity to help someone by providing a technical assessment of their gait.

It was also clear that they needed more specific instruction and direction as well as direct contact with someone from the other program in developing the data and the assessment. As described above, these concerns have been addressed in the third year of this collaborative effort.

Instructor estimation of collaborative learning module

The significance of this inter-professional laboratory is that it is jointly conducted as part of the undergraduate BME and the PT program is that it brings together both the Physical Therapy and Biomedical Engineering students to not just interact and study human movement, but communicate their knowledge and expertise in a language that the two professionals can understand.

The student's responses to the experience, along with our own experiences, have convinced us that this is a worthwhile collaboration. From an instructor perspective, students learned quite a bit from the hands on experience, and they gain a considerable amount from seeing clinical tests run on subjects over solely reading case studies or watching clinical videos.

By working first hand with students studying to be engineers or clinicians, the students were able to experience some of the issues related to cross disciplinary collaboration, especially when related to clinical settings. The students were able to recognize the differences in the language that is used to describe what occurred and how the focus of each group affected the information that was desired and how it was used.

Next steps

There are a number of improvements to this learning module which we intend to incorporate into our additional iterations of this collaborative effort which could have the potential to improve this experience for the students. First, the addition of a force plate to the gait lab would allow students to calculate ground reaction forces and perform inverse dynamics to determine joint kinetic values in addition to the kinematics currently developed. Second, it is very important that we continue building connections with multiple additional sources for subjects with gait deviation due to a wide range of ailments including subjects with orthotics, geriatric subjects or subjects who are recovering from a stroke. This may provide a wider range of subjects, and potentially allow for greater study of gait deviation for the students. Finally, the students would benefit even greater from this type of experience if it were expanded to include a service learning component. The gait subjects from both the 2014 and 2015 trials expressed interest in the data collection and were very interested in the results which the students developed. If the students were able to follow up with the patients and provide useful data to their physical therapists /

doctor etc., the work that they do for class may be able to play an important role in improving the medical care of these subjects.

Conclusion

This paper described collaboration between two distinct student populations, biomedical engineering students and physical therapy students, using clinical gait analysis as the forum for this partnership. Through an interdisciplinary learning module both sets of students were able to experientially learn terminology and skills related to the analysis and assessment of gait kinetics while gaining experience communicating technical information interdisciplinarily.

This collaboration allowed the students to leave the classroom and their comfort zone in order to gain experience in their respective fields while interacting with both patients and students from related fields. They were able to have a hands on experience of the types of interactions they may have once they finish school and begin practicing their chosen profession.