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STUDENT LEARNING OF BIOMECHANICS TOPICS BY EMBEDDING "QUANTIFIED SELF" MOTIVATED PROBLEM BASED LEARNING MODULES IN BIOMEDICAL ENGINEERING COURSES

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INTRODUCTION

Traditional undergraduate courses in engineering have followed the deductive pedagogy of proposing a concept, explaining the principles and demonstrating the theoretical framework of the concept [1]. The student is expected to memorize the material or work many examples and their mastery is then evaluated during an exam. This teaching method lacks important student learning opportunities, such as; the reason why these concepts or mathematics are important, what is their real-world relevance and how this will impact the students' future career in engineering. Project Based Learning (PBL) is an alternative method that is an inductive pedagogy, which is more student-centered [2]. These techniques begin with a real-world problem or observation that is introduced to the students and can lead to deeper student learning when properly implemented [3].

The "Biomechanics" sub discipline of Biomedical Engineering (BME) is taught in various forms in most undergraduate programs. The BME curricula at Lawrence Technological University requires that students take semester long courses covering "Statics", "Biomechanics" with "Biomechanics Lab", and "Tissue Mechanics". There are also opportunities to develop interest and experience with biomechanical applications in non-technical or elective courses, such as the freshman-level "Introduction to Biomedical Engineering" or senior-level "Engineering Applications in Orthopedics" courses.

"Quantified Self" (QS) is a trend in the consumer electronics and digital health industries that have introduced many devices with new sensors and data logging systems to allow individuals to understand their personal health and wellness through quantification and tracking a variety of physiologically relevant parameters. The QS theme can be related to a variety of topics in many engineering and science disciplines (Figure 1). Besides companies' excitement over QS devices, it is increasingly common to find students that own these devices, such as the Fitbit activity trackers, Withings smart scales, or Apple smart watch. Many popular QS devices are based on biomechanics concepts using kinematics (e.g. Microsoft Kinect and Nintendo Wii Remote) or the kinetics (e.g. Wii Balance Board). Other examples like the electromyography based Myo Gesture and pressure based Nike in-shoe sensors do not have wide customer base yet.

Figure 1: Representation of the broad diversity of topics that can be related to Quantified Self devices.

The goal of this project was to develop and implement learning modules and associated resources that use the QS theme to motivate biomechanics topics in a range of BME courses. By spreading the modules into a variety of courses at the freshman, sophomore, junior and senior levels, the students may be repeatedly exposed to QS devices with an increasing levels of difficulty and expectations throughout their degree program. This not only promotes a deeper understanding of the fundamental biomechanics concepts but also allows the students to develop experience and confidence in working with these types of devices.

METHODS

In this project, we developed and implemented QS theme based PBL modules to teach biomechanics topics in four BME courses following a similar pedagogical technique from modules developed for other topics in a range of disciplines [5]. The PBL modules were organized as a combination of short Active Collaborative Learning (ACL) activities that were completed in class and partner/group based design project homework assignments. The modules combined several open-ended tasks that build sequentially, following previously completed work and the topics that were covered in class. Student learning outcomes during a pilot implementation of the modules were measured with direct (formal design report and/or group presentations) and indirect (student survey) assessments. The instructors also maintained close observation of student groups in class and during office hours to reflect and improve the implementation of the module.

RESULTS

Detailed assignments and instructor guides for the biomechanics modules were developed and implemented for at least one pilot test prior to being shared with other BME faculty through teaching workshops and a website [6]. Generally, these modules required 1-3 partial class periods to introduce the theme, develop understanding of the QS devices, and conclude with a final project wrap-up with the groups. The modules were scheduled to coincide with the appropriate technical concepts that were covered in the course.

Course: BME 1002 "Introduction to Biomedical Engineering"
Module: Product Concept Development based on the Nike+ Shoe Sensors

The project started with an introduction of the engineering design process. Then groups were formed to practice opportunity recognition through the "Painstorming" technique [7]. Finally, the groups were asked to develop a new application for the Nike+ Shoe Sensor system. They produced a device concept, a simple business model and evaluated the market potential. The assessment was concluded with a student produced elevator pitch video on economic and social benefits of their proposed application. Most students understood the importance of design in engineering and were able to communicate their product concept in terms of technical capability, customer value and economic viability. The sensors for this project were functional prototypes manufactured by Nike but are not currently commercially available.

Course: BME 3303 "Introduction to Biomechanics"
Module: Sensing Angular Kinematics of a Baseball Swing with Arduino

The scenario was a call for assistance from the university's baseball coach to help improve the team's batting performance. Students worked together during class to investigate baseball swing kinematics. Guided homework questions walked the students through the design process steps of; identifying customer needs, brainstorming, determining specifications, analyzing solutions. Next, students were introduced to open-source electronics like Arduino and sensor platforms (SEEED Grove) to use for the prototype development phase of the project. Next, the student teams developed a calibration method for the sensors and recorded the motions during a baseball bat swing. Finally, they developed a formal design report that refined their concept into a commercial product that could be marketed to the baseball coach and potential investors. Although most students had no prior experience with Arduino, they enjoyed the hands-on aspects of building a prototype. The hardware kits cost approximately $50/group, but can be reused in future course offerings.

Course: BME 4313 "Tissue Mechanics"
Module: Mimicking Muscle Optimization Strategies with Myo Gesture

In this course, students learn how to predict muscle contraction patterns using static optimization of various performance criteria. These same patterns can be directly measured with new QS sensors like the Myo Gesture armband. Students used the sensors to record forearm electromyography during everyday activities like using tools, typing, playing music or video games, sports, etc. They compared muscle contraction patterns between two different activies. Finally, they had to suggest ways that this information might be used for human-computer interface applications like active prosthetics control. The Myo Gesture devices cost approximately $200 per unit, and can be synced with a computer or mobile device running a variety of applications. The package includes a software development kit that allows access to raw EMG data.

Course: BME 5093 "Engineering Applications in Orthopedics"
Module: Surrogate Head Impact Measurement with Triax Headband

Impact biomechanics uses surrogate human devices like crash test dummies to assess injury risk and the effectiveness of safety systems to prevent injury. Students built their own surrogate head and neck to simulate the anthropometry and biofidelity of a human. Then they used the Triax headband sensors to quantify impacts for different scenarios and with various helmets. Hands on use with head impact sensors allowed the students to understand differences between linear acceleration and angular velocity and how those motions might lead to different injury patterns. The Triax SIM-G sensors cost approximately $200 per unit, but can be shared and/or reused for other projects.

DISCUSSION

Students were able to create product concepts, to collect and calibrate sensor data and relate this information to various biomechanical topics that were being studied in the BME courses. Although most students had no prior experience with the QS devices prior to the modules, they enjoyed the hands-on aspects of these PBL modules. Other positive reflections included the open-ended and real world aspect of these projects. On the other hand, some students expressed confusion during the projects, due to a lack of understanding of how the module was introduced and what was expected. These course modules were part of a larger project to implement Entrepreneurial Minded Learning into a variety of engineering courses so that students will be repeatedly exposed to this mindset with the ultimate goal of improving students' preparation and skills for their senior capstone projects and as professionals in the real-world.

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REFERENCES

[1] Froyd, JE et al., *Proc IEEE*, 100:1334-1357, 2012.
[2] Smith, KA et al., *J Eng Ed*, 94(1):87-101, 2005.
[3] Prince, M. *J Eng Ed*, 93(3):223-231, 2004.
[4] quantifiedself.com
[5] Meyer, EG and Nasir, M. ASEE Conf Proc, 2015.
[6] qs4eml.ltu.edu
[7] Weaver, J et. al. J Eng. Ent., 2(1): 10-27, 2010.