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Using Quantified Self as a Learning Tool to Engage Students in Entrepreneurially Minded Learning and Engineering Design

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Abstract

A learning module was developed to engage students in entrepreneurially minded learning (EML) and engineering design through an activity related to the Quantified Self (QS). This social movement, which involves the measurement of parameters within one's own daily life, was used as the basis for investigating new concepts for devices to aid individuals with disabilities. The learning module was implemented in a sophomore level course in biomedical engineering at Western New England University. Results from assessment using pre- and post-module surveys showed increased student-reported knowledge/ability regarding a variety of EML concepts, including opportunity recognition and communicating solutions in terms of societal benefits. Additionally, while the present activity used QS to investigate a biomedical-related problem, the module could be tailored to fit the needs of a variety of engineering disciplines so as to engage other students in EML.

Introduction

Recently, there has been significant interest within the engineering education community to produce engineers with an entrepreneurial mindset.[1-3] Students with this mindset are often highly sought in industry due to the unique skillsets they possess, including effective communication, customer awareness, persistence through failure, and innovation.[2] However, these skills have not often been directly addressed in engineering curricula, thus new activities are needed to engage students in entrepreneurially minded learning (EML).

This work describes a newly developed learning module that engages students in EML and engineering design through an activity based on the Quantified Self (QS). Based in part on the rise of commercially available personal tracking devices, QS is a social movement in which users measure various parameters within their own daily life and use this information to build habits for better lifestyles.[4,5] Examples include devices to monitor movement, sleep duration, heart rate, and other daily activities.[1] Tracking with QS devices is rapidly gaining popularity, with 21% of survey respondents saying that they use some kind of technology to track health data.[6] Consequently, this field has seen a flurry of entrepreneurial activity and makes an excellent case study to learn about various aspects of entrepreneurship. Additionally, a main theme of QS involves the use of data to drive decision making, thus it provides an interesting framework for developing design concepts for open-ended problems.

Activity Details

The learning module was implemented within BME 201 – Foundations of Biomedical Engineering at Western New England University. This sophomore level course, which is the first course that BME students take in their major, involves modules on anatomy, bioethics, careers within BME, and conservation-based problem solving. In previous iterations of the course, a design project was implemented that allowed students to propose solutions to problems identified during a tour of a clinical care facility. While this project was a useful exercise to engage students in engineering design, they often had no quantitative basis for their design proposal. Instead, they often relied on intuition and preferences as opposed to being data-driven. In the present course offering, the design project was restructured to (1) utilize the data-driven QS methodology and (2) focus on the development of concepts for devices to aid individuals with disabilities.

The activity was implemented over a period of approximately a week and a half, including work involving 4 class periods (see Table 1). First, students were introduced to a set of measurable parameters from their daily life regarding their physical activity (e.g., number of trips to the bathroom, flights of stairs encountered, etc.). The students then monitored and recorded these parameters (called activities of daily living, or ADLs) using a worksheet over the course of a 24-hour period. In the next class period, the students formed groups and analyzed their results according to the challenges that these would provide for a patient with a specific disability (e.g., Parkinson's disease). Using a worksheet, the students then brainstormed ideas for new assistive technologies to mitigate these challenges. After selecting the best option among their generated concepts using a concept selection matrix, the students created a final design concept. On the final day of the project, the designs were presented by the students to the class in the form of elevator pitches. The goal of these presentations was to convince the instructor (serving as the venture capitalist) to invest in their design concept.

Table 1. QS Activity Schedule

Day	Location	Tasks
1	Class	Introductory lecture, group formation, review worksheets
2	Outside	Quantified Self
3	Class	Analysis, concept brainstorming
4	Class	Concept selection, final concept
5	Class	Presentations, wrap-up

The new learning module was implemented for the first time in Fall 2014. The course consisted of 35 students, including 22 males and 13 females. All students in the course were biomedical engineering majors, with the majority in their second year of study.

Assessment

In order to assess the impact of the new learning module, a set of pre- and post-module surveys was developed and implemented. The surveys were approved by the Institutional Review Board (IRB) at Western New England University prior to their use. To maintain confidentiality, students were randomly assigned a 6-digit code that was used to pair responses on the pre- and post-module surveys. The surveys consisted of 5-choice Likert-scale questions that prompted students to rate their current level of knowledge/ability regarding: (a) opportunity recognition; (b) creating a preliminary model; (c) communicating solutions in terms of societal benefits; (d) examining technical feasibility, economic drivers, and societal and individual needs; and (e) the quantified self (QS) movement. The Likert-scale survey questions were analyzed using a one-tailed, paired t-test with a significance level of 0.05. The post-module survey also contained free response questions that allowed students to provide qualitative feedback on their overall development in the module and comment for improvements and modification. Of the 35 students in the course, 34 completed both the pre- and post-module surveys (N = 34).

Results

The results from the Likert-scale pre- and post-module surveys are displayed in Figure 1. The survey data shows that following completion of the module, students reported increased knowledge/ability in each of the target skills ($p=2.46\text{x}10^{-9}$, $8.49\text{x}10^{-14}$, $1.63\text{x}10^{-9}$, $1.86\text{x}10^{-10}$, $1.92\text{x}10^{-13}$, respectively).

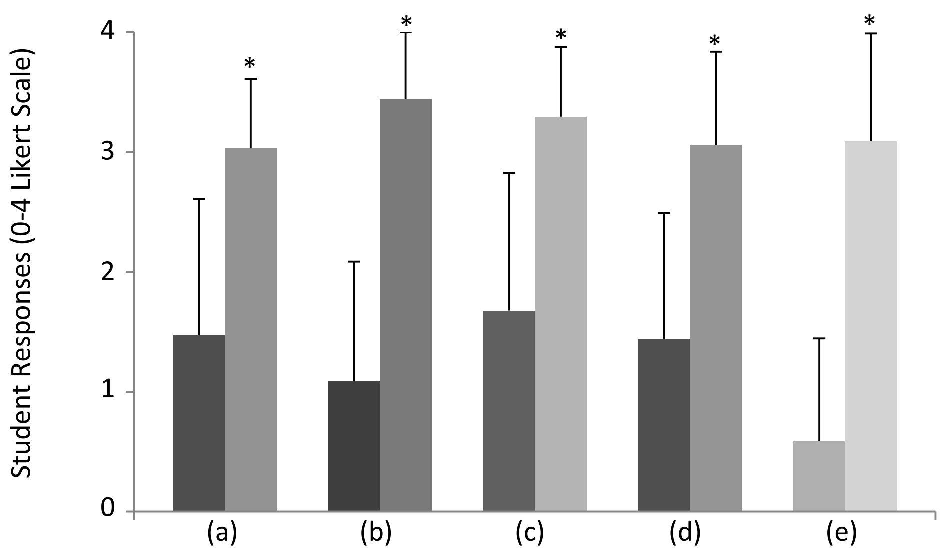

Figure 1. Results from student surveys (Likert scale 0-4) comparing responses on pre-module (left) and post-module (right) surveys concerning knowledge/ability regarding: (a) opportunity recognition; (b) creating a preliminary model; (c) communicating solutions in terms of societal benefits; (d) examining technical feasibility, economic drivers, and societal and individual needs; and (e) the quantified self (QS) movement. Each bar represents average student response plus standard deviation (N=34). The * indicates statistical significance (p<0.05).

The results from the qualitative free-response questions on the post-module surveys, including the question prompts and representative relevant student responses, are shown below.

Please comment on your overall development during this module (e.g., what you have learned, skills you have developed, etc.):

- Thinking more in terms of other people's needs
- This project reinforced working productively with a team as well as the engineering design process
- I had fun designing an innovative product that is able to help a patient with uncontrollable muscle tremors
- Definitely learned about the quantified self-involvement and developed more skills in recognizing a problem and coming up with a solution
- I improved my presentation and drawing skills
- I learned about the various stages of development of a product
- I learned the difficulty of someone w/ Parkinson's as well as how hard it must be to continue a normal life

Please comment on the things you liked about this module, if any, and why you liked them:

- Public speaking, business aspect
- I liked being able to brainstorm ideas and pick ones to further research and bring something to life from it
- It was nice to be able to work in a team and create a project that would improve someone's living
- I liked the idea of targeting a specific disease
- I enjoyed the freedom given to think of a creative solution for the problem
- Designing prototypes
- Working with a group being able to communicate ideas with feedback
- I liked making a new product

Please comment on portions of the module, if any, that could be improved or changed:

- Maybe focus on other symptoms of Parkinson's
- Improved: studying people with the disease
- More design restrictions
- I would prefer a longer period of time to work on it and maybe create a physical prototype of the design
- Next time I think every group should be given a different ADL to do because a majority of people did food or washing hands
- Give more variety in products, give every group a different disease
- Should have had a few different diseases allowing for more diversity in projects

Discussion

The results from the Likert-scale questions on the pre- and post-module surveys indicate the students were positively impacted by the module. Additionally, the results from free-response questions indicated that students enjoyed identifying a patient need and developing a preliminary solution using the product development process, particularly in a group problem-solving format. They also expressed that freedom for creativity was an important factor for them, as was using innovation to solve a real world problem with demonstrated clinical need. Another common response involved the specific learning that occurred regarding QS and Parkinson's disease, as well as skill development in public speaking.

Regarding things to improve for future implementations of the module, some students communicated that they would have liked to have worked on the project for a longer period of time, perhaps to the point of creating prototypes for their design concepts. While this may not be practical in the context of this particular course, it may be feasible in the courses of other instructors who adopt the module. This desire to continue working on the project beyond the originally planned scope also indicates that many students were engaged in EML. Other constructive comments from students that can be used to improve the module include adding more design restrictions, targeting other symptoms or diseases, and the general need for more diversity in the generated designs. As an example of the need for diversity, many designs centered on the same few ADLs, such as eating/drinking or washing of hands, even if the design concepts to address them were different. The diversity issue could be addressed by assigning each group a specific set of ADLs rather than allowing all groups to select from the complete list, which would likely have a tradeoff of reduced freedom of design for increased design diversity. Another option would be to give each group a different disease to address with their designs, thus maintaining the freedom of selecting target ADLs while increasing design diversity across the groups.

The design process that was used in this project is similar to the format used in the BME senior capstone project at Western New England University. Thus, the introduction to the concept generation and concept selection processes during this activity could prove valuable for these students in subsequent design efforts in their curriculum. Additionally, the module provided opportunity to discuss the process of gathering customer needs and the importance of data-driven design. For example, the instructor was able to highlight that while the design concepts generated in this activity were based on collected data, the population was based on students in a college course rather than patients with Parkinson's disease, and thus it may not be particularly valid. Likewise, the QS survey data afforded the opportunity to discuss the importance of measurements such as mean and standard deviation, which were discussed in the course just before the start of this activity.

It should be noted that this module uses the spirit of QS to engage students in EML; in other words, the focus of the module is not so much on the devices that enable QS, but rather on the philosophy of QS that can drive innovation and decision-making. Specifically, students quantified aspects of their daily life using a simple pencil and paper tracking system, which provided a basis for their subsequent design work. Some time was also set aside during the module to introduce students to QS devices that are commercially available, mostly to provide background information and provide context for the activity itself. For example, health trackers (e.g., heart rate), sleep monitors, and motion sensors were introduced during the lecture for the module. Additionally, a discussion was held regarding the need for new QS tools to replace the pencil and paper-based tracking system employed during the activity, again highlighting opportunities for developing novel tracking devices.

Due to the success of the new learning module, which was implemented for the first time in Fall 2014, it is expected that subsequent course offerings will include the QS-based design project. Additionally, the target disease may be changed to investigate design concepts to aid persons with disabilities other than Parkinson's disease, including, as mentioned above, the possibility that each group targets a different disease or condition. Additionally, while the present activity used QS to investigate a biomedical-related problem, the module could be tailored to fit the needs of a variety of engineering disciplines so as to engage other students in EML. For example, in an electrical engineering course, the QS survey data could be used to develop new electronic-based QS device concepts for monitoring the target ADLs. Similar modifications can be envisioned for mechanical and civil engineering courses for which QS-themed exercises are desired.

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