Gait Module for Freshman-Level Introductory Course in Biomedical Engineering

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Introduction

In an effort to improve educational methodologies in biomedical engineering, the Vanderbilt-Northwestern-Texas-Harvard/MIT Engineering Research Center (VaNTH ERC) is conducting research in challenge-based methods of teaching. We have recently partnered with the VaNTH ERC to test the challenge-based approach in an urban university setting. The rationale for using a challenged-based instructional method is based on the learning science theory presented by Bransford et al.[1] on "How People Learn" (HPL). HPL theory states that learners achieve greater understanding when they are taught in learner-centered, assessment-centered, community-centered, as well as knowledge-centered environments. When all of these environments are used in the instructional scheme, the learner is more engaged and motivated.[1] The challenge-based instructional module is delivered within the framework of the STAR-legacy cycle,[2] an action/reflection learning cycle. Challenge-based teaching is complementary to problem-based teaching; however, in challenge-based teaching the students have not been educated on all of the required skills/knowledge to complete the challenge at the time of assignment. The challenge involves leading the students to understand what skills and knowledge they must master and integrate to complete the challenge.

We have developed a challenge-based instructional module on gait motions and elementary biomechanics for our first-year engineering course co-listed in biomedical and mechanical engineering to target skills in manipulating, graphing, and interpreting empirical, time-varying data. Our motivation for this module is that freshmen often arrive without adequate experience in simple graphing techniques and unfamiliarity with basic data representations. In addition, the students have a wide variety of educational backgrounds in mathematics, where some students are enrolled in third semester Calculus and some in College Algebra.

Gait Module

The learning objectives for this module are to (1) practice problem solving techniques, (2) realize the value of team work and creativity, (3) implement graphing techniques, and (4) use data analysis and statistics to solve engineering problems (open-ended problems). The overall challenge requires the students to show how gait is described and captured in numerical and graphical ways that apply to engineered products. Specifically, the students use available gait measurements such as stride intervals to suggest useful descriptions of walking for

improvements and developments of two products: a simulator/tester for knee prostheses and a "smart" running shoe with computer-adjusted cushioning.

The STAR-legacy cycle is used to structure the module and consists of the following phases: challenge, generate ideas, multiple perspectives, research and revise, test your mettle, and go public. First, the "challenge" is presented early in the semester before the students have covered needed topics such as descriptive statistics, spreadsheets, and graphing tools. The challenge statement is as follows:

> "Congratulations! Submitting your resume and application to many companies has led to finalist interviews at two companies. One company, Mechanical Joint Testers, Inc., will be adding new features to their knee simulator. The second company, Memphis Shoe Tech, plans to bring out a walking version of a computer-adjusted exercise shoe. Can you impress your interviewers and suggest product improvements or developments for the Knee Simulator and Computerized Walking Shoe based on available gait measurements?"

The students "generate ideas" in brainstorming sessions in teams of 3-4 students. Next, the students are presented with traditional lectures and reading on basic gait terminology, biomechanics, and measurement devices for the "multiple perspectives" and "research and revise" phases. For the "test your mettle" phase, the students are given gait data sets (stride intervals available via www.physionet.org/physiobank/database/gaitdb) to calculate descriptive statistics (mean, variance) and perform different graphing techniques (line graphs, histograms) as they gain the required skills through traditional instruction as the semester progresses. Students are also allowed and encouraged to research and use other public gait measurements and databases. At the end of the semester for the "go public" phase, the students submit written reports and oral presentations that are required to contain graphs, descriptive statistics, and discussions of how the gait data and analyses are relevant to the knee simulator and smart running shoe for product improvement and/or development.

Assessment and Evaluation

Our assessments consist of pre- and post-test knowledge based questions (KBQs), peer evaluations of oral presentations, self-critiques and a module survey. The KBQs evaluate students' understanding of data analysis concepts (estimation, outliers) and using spreadsheets. Comparison of student performance on the data analysis concepts in pre- and post-tests did not show improvement; however, the feedback from the remaining assessments show that the students are gaining problem solving skills. It is important to note that participation in the post-test fell by approximately 40% compared to the pre-test. This drop in class participation at the end of the semester is typical for our freshmen-level, introductory engineering courses at The University of Memphis.

For instance, in the peer evaluations of the oral presentations, the majority of the students were rated as good or outstanding (Figure 1). In the written report, the students were asked to reflect on the problem solving skills used in the module. All responses indicated that the students were gaining an appreciation for the open-endedness of engineering problems as compared to

problems solved in traditional courses such as Calculus or Physics. However, the majority of students also stated that they found the assignment frustrating due to the open-endedness. The survey results (Table 1) indicate that the majority of the student responses agree that the module clarified fundamental concepts in data analysis and problem solving.

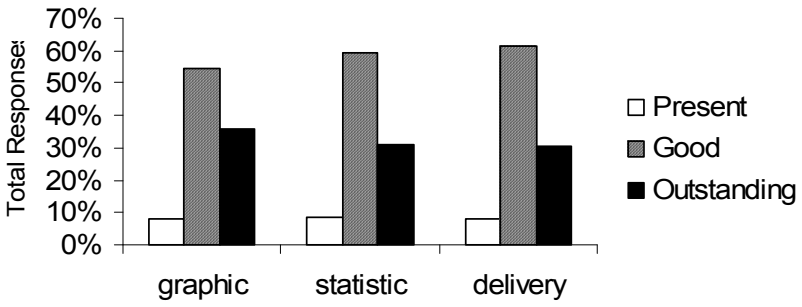

Figure 1. Total number of responses in each category from the peer assessments completed during the gait module presentations. More than 50% of the presentations were evaluated as 'Good' and approximately 30% were 'Outstanding' in each category.

Table 1. Percent Responses for Gait Module Survey

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I found the Gait Challenge interesting.	19	16	22	41	3
2. The gait data provided on WebCT helped me understand how walking can be quantified.	3	19	13	63	3
3. The experts' perspectives (websites provided on WebCT about gait terminology) did not provide me with any new insights.	9	38	31	19	3
4. After the Gait Challenge I feel confident I can analyze stride interval data.	13	16	26	35	10
5. On my own I could work through the assignments related to the Gait Challenge.	23	26	10	32	10
6. I think working on the Gait Challenge helped me clarify fundamental ideas we covered this semester.	19	26	16	39	0
7. Compared to other assignments, the challenge format is very different.	6	3	0	52	39
8. I find the challenge to be a worthwhile addition to the other assignments.	19	23	26	29	3

Summary

In our first and second offering of this instructional module on gait, the formative feedback indicates that the students are gaining an appreciation for the open-endedness of engineering problems. We feel we can alleviate the students' frustrations by adding a session where students meet in small groups to share preliminary results. In this way, we can demonstrate that many different, but equally valid, conclusions can be obtained. By incorporating the gait challenge

into our first-year course, we feel that we are giving the students an application of their acquired data analysis skills that is more highly motivating than a canned exercise.

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