2006-2482: BIOMECHANICS AS A TOOL FOR TEACHING MINORITY STUDENTS

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Biomechanics as a tool for teaching minority students

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Abstract

In the Upward Bound Math and Science (UBMS) summer college preparatory program at the University of Texas at San Antonio, low-income, first generation and students with disabilities that are college bound students are exposed to the fields of math, science, engineering, and technology. In the Summer 2005 program, students were challenged with the task of designing and performing an experiment having to measure a biomechanical movement. As two large groups, they learned about the mechanics of upper arm movement, designed experiments, watched as their experiments were performed, and then in smaller groups (3 or 4 students), they analyzed different portions of the experiment, wrote final reports, and gave final presentations.

Introduction

UBMS is a college preparatory program, which prepares and encourages low-income, first generation college bound students and students with disabilities to pursue higher education in fields of math, science, engineering, and technology. UBMS students participate in a six-week Summer Academic Enrichment program. In the summer of 2005, the students participated in a class that introduced them to experimental design, data collection, and data collection tools, and analysis.

Upward Bound Math and Science (UBMS)

The Upward Bound Math and Science (UBMS) program at the University of Texas at San Antonio is one of the TRIO Programs - outreach-based programs dedicated to helping low-income and first-generation college bound, secondary students to improve their grades and enroll and graduate from an institute of higher education. The program at UTSA is one of over 124 Upward Bound Math & Science programs serving students throughout the country. TRIO is supported by a federal grant for four years. UBMS at UTSA concentrates on strengthening math and science skills in its students. Students are also taught computer technology, English, foreign languages and study skills as part of the program. The UBMS program paid for their tuition, books, rooms at an on-campus dormitory and board. In addition to the academic work, enrichment and cultural sessions took place in 2005. This year a research component was added to the program. The students participated in a 40 hour program to help them start thinking about what engineers and scientists do.

The majority of the 45 current UTSA UMBS students are low income, primarily Hispanic and first generation university students, of which half of them are from outreach sites including Eagle Pass, Del Rio, and Uvalde as well as a San Antonio High School. The students enrolled in the program have the potential for success in post secondary education but have a need for program services not available at their local high school. Of the first graduating cohort (2003), at least 80% went on to college, which is very high when compared to historical averages for low income, first generation students.

Didactics

The course was called Measurement of Human Movement. Following is the syllabus that was distributed:

Course Description

This course provides students with direction toward research in the academic environment. It will consist of lecture, once a week; two field trips to an on-going research lab; lab instruction; hands-on use of test equipment and computer-based data acquisition systems; data collection; analysis; and presentation of findings. We will focus on measuring human movement. The students will be examined on the theory of the research objectives and will demonstrate proficiency in experimentation, data collection and analysis of findings.

Course Materials (all provided in lab)

- Computer systems
- Accelerometers.
- Acquisition Software
- Presentation software

Assignments

- Learn Basic Computer Input
- Study Body movements
- Interface Accelerometers (with TA help)
- Acquire data from accelerometers attached to arms in movement

Methods of Assessment

- One hour exam on methods and theory (as lectured) near end of course
- Individual evaluation of student participation
- Evaluation of group presentations

Expectations

- Students will learn the thrust of technical research
- Students will establish a practical interest in applying math & science to human problems
- Students will increase a desire to continue studies in math & science

The course schedule, as shown in Table 1, was followed successfully. The students met four times per week for five weeks. The classes were two 90-minute sessions each day. The theoretical lectures discussed the process of acquiring data through transducer-based instruments and the fundamental aspects of time series data. Lectures on biomechanics focused on movement of the arm and how motion capture can pinpoint issues with body movement. Both Dr. Roberson and Dr Hudson have graduate level training in biological systems and engineering. Along with the theoretical lectures presented by Dr. Hudson and Dr. Roberson, UTSA students demonstrated lab equipment, software and projects.

The lectures included a presentation by students who had just graduated with electrical engineering degrees. They had developed, as their senior design project, an embedded processor-based device for counting the number of repetitions made when the device is connected to the wrist of an individual exercising with a dumbbell. These were young people who had come from circumstances similar to those experienced by the TRIO students. The students received them well.

Table 1.
Course Calendar
(note: G1 is Group 1 (15 students), G2 is Group 2 (15 students))

Day	Topics & Assignments
Mon, June 13	Lecture on electronic measurement G1&G2 Assignment to two groups and 3-person subgroups in R1 – Dr. Hudson
Tues, June 14	EE Lab intro G1 EB 3.04.64 - Computer lab research G2 in R2
Wed, June 15	EE Lab intro G2 EB 3.04.64 - Computer lab researchG1 in R2
Thurs, June 16	Library work G1&G2 meet at R1
Mon, June 20	Lecture on electronic measurement G1&G2 – Dr. Hudson – R1
Tues, June 21	EE Lab hookup and data input G1 EB 3.04.64 - Presentation skills Computer lab G2 in R2
Wed, June 22	EE Lab hookup and data input G2 EB 3.04.64 Presentation skills Computer lab G1 in R2
Thurs, June 23	Presentation of two week progress by group leaders in R1
Mon, June 27	Lecture on human movement – Dr. Hudson R1
Tues, June 28	Visit to GAIT lab at VA G1 EE Lab hookup and data input G2 EB 3.04.64
Wed, June 29	EE Lab measure movement G2 EB 3.04.64 Computer lab researchG1 in R2
Tues, July 5	Lecture on human movement- Dr. Dawn Roberson
Wed, July 6	EE Lab measure movement G1 EB 3.04.64 Computer lab researchG2 in R2
Thurs, July 7	EE Lab measure movement G2 EB 3.04.64 - Computer lab researchG1 in R2
Mon, July 11	Lecture on data analysis and presentation – Dr. Hudson
Tues, July 12	Visit to GAIT lab at VA G1 EE Lab work G2 EB 3.04.64
Wed, July 13	EE Lab measure movement G1 EB 3.04.64 Computer lab research G2 in R2
Thurs, July 14	Visit to GAIT lab at VA G2 EE Lab work G1 EB 3.04.64
Mon, July 18	Lecture on bombs in Iraq – Dr. Clutter in R1
Wed, July 20	Presentations by All in R1
Thur, July 21	Course Final

The lab instructor who assisted Dr. Hudson demonstrated how to interface accelerometers to lab computers. Students learned wiring and soldering and how to attach the devices to leads that connected to a National Instruments input port. They also learned how to use the most fundamental aspect of Labview ™ and input acceleration data into a file that they then displayed. They were taught the relationship of force to mass and acceleration, measuring the mass of a dumbbell and reading out the acceleration from the computer inputs to calculate the related force. In addition to the motion data collected in the biomechanics laboratory, the students also performed some direct measurements on themselves – comparing arm lengths of group members, and extending their lessons from the biomechanics laboratory to their own group members.

A Final exam was administered to the class of 30 students at the end of the class. As expected the Juniors and Seniors in the class did well. The class average was about 75%. Table 2 is a copy of their Final exam.

Table 2. Course Final Exam

Answer 10 of the 11 questions for 100%

True/False

1. Arms move by all the muscles in the upper arm contracting at the same time. _______
2. The motion we observe in arms can be captured into the computer using light. _______.
3. A transducer converts mechanical or chemical energy into voltage. _______

Fill in the Blank

4. The measure from peak to peak in an oscillating signal is the signal's ______________________.
5. Over ________ thousand samples per second are necessary to be collected when making a CD (compact disk recording).
6. Acceleration and Mass can be used in the equation ____________ to calculate the Force produced by a moving arm.
7. Capturing motion of a human body in _______ dimensions helps us know how the body moves when walking or lifting weights.
8. Acceleration can be used to count the number of _________________ in weight lifting.

Multiple Choice

9. The topic that plays the biggest part in motion capture is a) geometry b) chemistry c) digital logic. ________________
10. An accelerometer emits voltage, but, before it can be input into a computer, the signal must be a) changed to resistance b) amplified c) reduced. _____________
11. In order to prove a biologically-based hypothesis, a scientist must a) get a PhD b) buy expensive hardware and software c) observe and measure phenomena related to the hypothesis. __________

Experimental Testing

These students designed the data collection, and visited the Gait Analysis and Innovative Technologies Lab to collect the biomechanical data. The students observed clinicians attaching six reflective devices to the experimental subject. In one data protocol, the subject lifted a ten pound weight with both right and left arms ten times. For this experimental protocol, the subject had 6 reflective markers attached and one to the weight being lifted. The subject then performed ten pushups. The students noticed no visual change in the form or velocity of the pushups. The subject repeated this process again with the same result. The students modified the protocol to increase the number of pushups to twenty, and then they noticed a change lifting the weights.
In the second protocol, a subject lifted two different masses, each with a different arm, in order to test position, velocity and fatigue. The students calculated the velocity of the subjects forearm and estimated fatigue by comparing the earlier and later lift repetitions. The position location for each of the reflective markers (x, y, and z) was then exported to a file format that the students could use for analysis. The lab utilizes VICON software and hardware for motion analysis.

Figure. Experimental subject performing first experimental protocol. Notice the reflective markers on his arms and wrists.

Final Reports and Presentations

The students analyzed the experimental data using LabVIEW. In their analysis, the students looked at the velocity and acceleration of the arm and weights, and compared the differences over time. Each student group wrote a formal report on their research question. Each group included graphs of various arm measurements from their group members – their analysis included results based on gender and overall size. The students showed a very good understanding of what was presented, and were very comfortable performing web searches for applicable images and references. Their reports have a large number of images, most located on the internet, that generally apply to this topic. The vast majority of their images are referenced as required by Dr. Hudson. The report structure was not provided, but they tend to follow a diary approach – "We did this, and then we did that" – interspersing technical descriptions along the way. The average length of their group written reports was eight to ten pages.

Each group also gave a short presentation using PowerPoint. The emphasis of these presentations was not the results, but the method of data collection. It was discovered that the students had very high skill at researching on the web and most all had matching skill at creating computer presentations and organizing reports. Most of the reports were very well done, showing the close attention the students paid in their times in the research classes. Their analysis of their own body segments, compared by gender and size, was quite insightful.

Generalized Lessons for other training programs

This program can easily be generalized to other, similar programs. The facilities required are fairly generic – a basic electrical engineering laboratory that utilizes LabVIEW, and some sort of system that quantifies motion. While we were able to use a state of the art system, that is not required. Many universities have a kinesiology department which studies motion, or some sort of tools used by athletics to improve performance. For those without either of these available, there are computer programs that can quantify images collected on regular video cameras that should be sufficient for this training.

For the academic portion, the lesson plan is generic enough to be applied anywhere, and can be expanded or contracted to adapt to the needs and experience of the students. Anyone who can comfortably teach an introduction to the electrical engineering lab should be able to teach the LabVIEW portion, and a bioengineer or a physical therapist with research interests can teach the biology and biomechanics. The accelerometers would not have to be used, but any data-gathering device that has electronic output could be utilized, and the data gathered can be correlated to a type of physiological data.

Summary

This course was given during the second year of this federally funded four year program, and the faculty plan to give this course during the remaining two years. While it is too early to see the long term results for these students, many indicated that they liked working with the tools of our trade, and really enjoyed seeing something practical that resulted from their learning. Questionnaires for previous students who are in college will include questions on majors, and results from these inquiries will be included in future papers.