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#FunTimesWithTheTA—A Series of Fun Supplementary Lessons for Introductory Level Biomedical Instrumentation Students (Work in Progress)

Mr. Orlando Sanguinette Hoilett, Purdue University

Orlando is a PhD student in Biomedical Engineering at Purdue University. Orlando graduated from Vanderbilt University in 2014 with a Bachelor of Engineering in Biomedical Engineering. His academic interests involve developing wearable sensors for mobile health platforms and developing engaging engineering design activities for undergraduate students. He has several years of experience with analog circuit design and embedded systems. His previous work includes developing an impedance analyzer for a microfluidic blood-brain barrier model. On the education side, he has developed a number of lab activities for first year and junior level Biomedical Engineering students. Aside from his academic pursuits, he is an avid electronics hobbyist and tinkerer. He spends most of his free time developing open source hardware for students, educators, and makers alike.

Mr. Asem Farooq Aboelzahab, Purdue University

Asem Aboelzahab is the Lab and Assessment Coordinator in the Weldon School of Biomedical Engineering at Purdue University. He has been at Purdue since 2014. He instructs/coordinates undergraduate labs including Bioinstrumentation, Biotransport, and Capstone Senior Design. He also serves as the school's ABET coordinator. Asem received his BS and MS degrees in Bioengineering from the University of Toledo in Toledo, Ohio.

Erica Amanda Layow, Purdue University

Erica Layow is an instructional developer at the Center for Instructional Excellence at Purdue University in West Lafayette, IN.

Dr. Jacqueline Callihan Linnes, Purdue University

Dr. Jacqueline Callihan Linnes is an assistant professor of Biomedical Engineering at Purdue University. She earned her Ph.D. in Bioengineering and certificate in Global Health from the University of Washington. She was a Fogarty engineering fellow in collaboration with Brigham and Women's Hospital and the Little Devices laboratory at MIT before moving to Boston University's Biomedical Engineering department where she received a NIH NRSA postdoctoral fellowship to work with Dr. Catherine Klapperich developing molecular diagnostics for point-of-care pathogen detection. Dr. Linnes's current research bridges innovations in basic science and translational diagnostic techniques in order to develop non-invasive, rapid detection technologies that efficiently diagnose and monitor diseases at the point of care. Her teaching focuses experiential learning and co-creation of devices and technologies via user-centered design.

Prof. Chi Hwan Lee, Purdue University

Chi Hwan Lee is an Assistant Professor at Purdue University, with appointments in Weldon School of Biomedical Engineering, School of Mechanical Engineering, and Center for Implantable Devices. His research focuses on flexible, stretchable, skin-wearable, and/or dissolvable electronics for a broad range of biomedical applications. Prior to joining at Purdue, he was a postdoctoral research associate in Department of Materials Science and Engineering at University of Illinois at Urbana-Champaign. He obtained a Ph.D. in Mechanical Engineering from Stanford University in 2013. He received dual B.S. degrees from Illinois Institute of Technology and Ajou University in 2007 with double majors in Mechanical Engineering and Industrial Engineering.

#FunTimesWithTheTA – A Series of Fun, Supplementary Lessons for Introductory Level Biomedical Instrumentation Students (Work-in-Progress)

Engineering is hallmarked by the process of assessing a need and implementing a design to meet the need[1]. Over the years, universities have adopted the capstone Senior Design project in order to provide students the opportunity to put their engineering skills to the test in real-world projects. However, educators agree that obtaining competency in engineering design requires hours of hands-on practice beyond the time and scope of a university course. As a result, we are pilot testing a series of supplementary active-learning experiences for an introductory instrumentation course in a Biomedical Engineering (BME) program. The active-learning experiences were implemented as a subsection of normally scheduled office hours with the Graduate Teaching Assistant (GTA). The experiences were offered to students on a voluntary basis with no added incentive other than they were fun and practical ways to learn. The aim of these experiences was to reinforce iterative techniques in circuit design, measurement, and analysis taught in the weekly lab activities. The intention was to provide a low-risk, low-stress opportunity for students to practice their circuit designing skills without fearing how their performance may affect their grade. Additionally, by incorporating the use of "hashtags" into the experiences, students can share their creativity through social media and engage in the growing "maker" community as a means of continuing their learning[2]. The following paper describes our pilot study. The immediate goal is to informally observe the students and gauge their general interest in the activities. Since the interest in the activities was positive, we are developing a more formal study to assess the effectiveness of the activities in improving student learning.

Methods

Students were invited to the supplementary sessions by way of in-class announcements. #FunTimesWithTheTA was held in the last hour of office hours, which are usually two hours total, in order to give the students participating in the supplementary sessions a chance to attend both. We ensured that at least two GTAs were available during days we hosted #FunTimesWithTheTA, so that one GTA could host office hours and the other could lead the proposed activities. For the supplementary sessions, students worked in the same lab space as they would during the normally scheduled lab activities. The lab stations are equipped with a desktop computer, a variable power supply, a waveform generator, a digital multimeter, and an oscilloscope. The students had previously purchased small circuit kits for the course. These kits contained a handful of UA741CN operational amplifiers, resistors (1 Ohm to 10 MegaOhms), capacitors (1 nanoFarad to 1 microFarad), jumper wires, wire stripper/cutter, and a breadboard. The GTA also provided the students with a PN2907A transistor, a general-purpose infrared light-emitting diode, and a general-purpose photodiode. Schematics, Bill-of-Materials, instructional handouts and other materials can be found on the project's GitHub page[3].

For the first installment of #FunTimesWithTheTA, students built PulseSim, a Finger Photoplethysmograph Waveform Simulator (Figure 1)[4]. Finger photoplethysmography is a very common technique for detecting heartbeats and calculating heart rate[5]. The design goal of PulseSim was to simulate the finger photoplethysmogram signal using only analog components without any computer processing. By doing so, the students will gain in-depth experience using filters and operational amplifiers, which are used to auto-generate waveforms and transform them into other wave types. PulseSim was originally developed by the GTA as a hobby project and published on Instructables.com, a popular online platform for presenting "Do-It-Yourself" and "How-To" projects. Students were provided with a set of instructions on building the circuit. Before the students began building, a short description of the lesson was presented, providing the basis of the circuit design, functionality, learning outcomes, and real-world applications for the technique. The GTA highlighted the areas that were explicitly covered in the course to reinforce the course material, while also explaining the principles and operation of the design components that were not explicitly covered in lecture. The objective of the lesson is not only to reinforce the material taught in the regularly scheduled lecture and lab sessions of the course, but also to introduce the students to new components that are useful to them as budding circuit designers. After the introduction, the students began building the circuit.

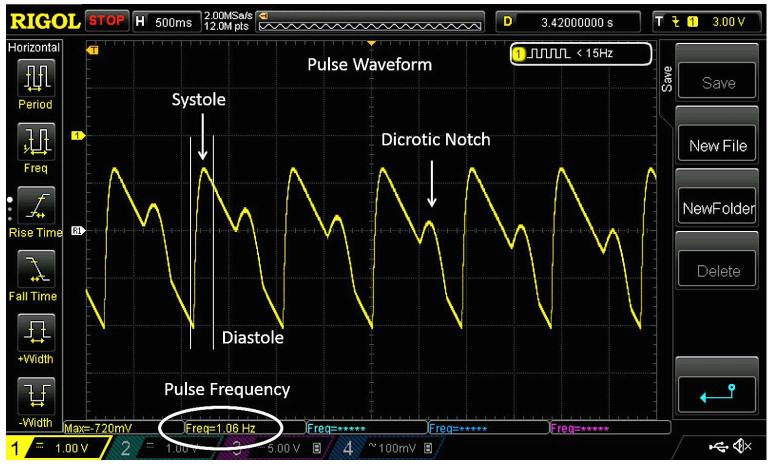

Figure 1: Output of PulseFit highlighting the cardiac phases.

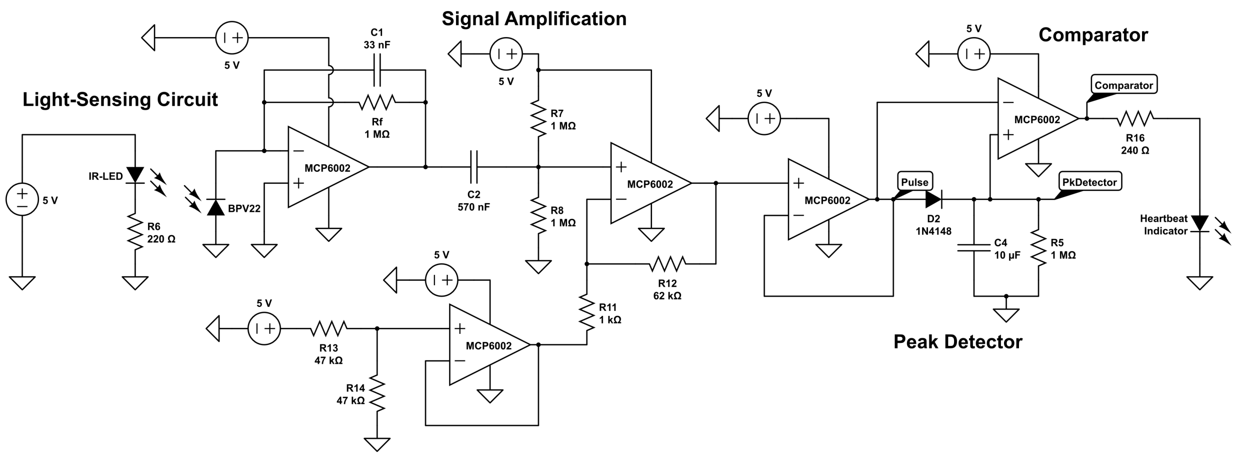

Figure 2. Circuit diagram of PulseFit consisting of a light sensing circuit that measures light passing through the finger. The signal is conditioned and sent through a peak detector to detect heartbeats.

For the second installation of #FunTimesWithTheTA, students built PulseFit, an auto-calibrating optical heart rate monitor[6]. With PulseFit, students were introduced to photosensors, which are used very often in biophysiological measurements. The session began with a brief introduction of the circuit design (Figure 2) by the GTA followed by time for the students to ask questions. PulseFit uses photoplethysmography to detect changes in blood volume in the arteries at extremities such as the fingers. By detecting changes in blood volume, we can detect heartbeats. PulseFit utilizes a light sensing circuit, which is subsequently filtered, amplified, and sent through a peak detector, which detects the systolic phase as it occurs.

Students self-organized into groups in order to accomplish each task. The GTA was available to answer any questions the students had and to help them test the circuit once they were finished building. The GTA did not interfere with the students in building the circuit so as to facilitate student-driven informal learning.

Results and Discussion

Our preliminary assessment of this pilot study indicates that #FunTimesWithTheTA was successful due to the extremely high enthusiasm displayed by the students. The students were meticulous in trying to understand the details of the circuit by asking the GTA questions, pausing for a few minutes to think to themselves, and by asking the GTA follow-up questions to gain a deeper understanding about the circuit. About an hour was spent discussing the underlying principles behind PulseFit, four times longer than the GTA had intended. Furthermore, the students opted to have a third session to finish building PulseFit in order to achieve a functioning circuit. As a pilot test, the student enthusiasm is an important factor for us in considering whether or not we should develop the lessons further.

One of the key issues that we will address moving forward is low turnout. Of the 87 students enrolled in the course, eight students attended each session of #FunTimesWithTheTA. In speaking with the students however, the GTA noted that several students would have liked to participate, but the demands of their coursework prevented them from engaging in additional extracurricular activities. We will address the low turnout by offering more sessions throughout the semester. By offering more sessions, students will have more opportunity to fit the supplementary lessons into their schedules. Another point of mention is about 15-30 students normally attend office hours. If we compare the number of students that attended #FunTimesWithTheTA to the number of students that normally attend office hours instead of the total number of students in the class, the turnout for #FunTimesWithTheTA looks much better and makes us much more optimistic about student participation in future semesters.

We suspect that #FunTimesWithTheTA will have a degree of self-selection bias as only a fraction of the students enrolled in the course would choose to engage in additional academic activities in their free time. This poses a problem when evaluating how #FunTimesWithTheTA will affect student performance in later courses as one could argue that the more motivated students would outperform their peers, with or without the supplemental lessons. Though we agree with this notion to some extent, we can still evaluate key metrics such as autonomy and competency by following the Basic Psychological Needs Scale[7], [8]. One of the key tenets of #FunTimesWithTheTA is to provide a low-risk, low-stress environment for students to explore new topics within the subject matter to further their own interests. Assessing student autonomy allows us to evaluate whether or not we have met this goal. Additionally, the aim of the supplementary lessons is to reinforce the iterative circuit analysis techniques taught in the normally scheduled lab activities. By assessing competency, we can determine whether or not students gain a deeper understanding of the course material that will translate into the normally scheduled lab activities and also future courses.

Future Directions

We would like to further develop the model of #FunTimesWithTheTA by integrating the use of different sensors that students will find useful during Senior Design in the following academic year. The junior year instrumentation course is an introductory circuits course, and as such, it is difficult to incorporate the use of a bevy of sensors into the normal coursework. For the first two installations of #FunTimesWithTheTA, students followed a "guided design" approach. The students were provided the circuit diagrams and only needed to assemble the circuit as diagrammed. The guided design approach is sufficient for the students at this stage in their academic career as the introductory class is focused on allowing the students to gain experience building circuits on a breadboard and with using lab instruments. The next installations of #FunTimesWithTheTA will take a "less-guided" approach, giving students the opportunity to develop their own design implementations to solve problems. Furthermore, we would like to expand on our use of social media with #FunTimesWithTheTA. Social media has become a platform of self-expression and collaboration where academics, hobbyists, and lay-people alike share their inventions openly online[2]. We feel that students can benefit greatly from sharing their creativity and learning from the inventions of others.

The foundational strategy behind #FunTimesWithTheTA is to provide students with low-risk, low-stress opportunities to practice the subject material in fun and relevant ways as increasing student exposure to the subject material is a key component in engineering education. As such, #FunTimesWithTheTA can be easily adapted to fit other courses. We recommend that instructors investigate hands-on learning activities relevant to their course material that are both fun and lighthearted. Ensuring these qualities helps distill the core learning outcomes of the course from the labor intensiveness of the regular coursework.

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