Development of a Remote Wearables Laboratory Course

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Delivering a remote, hands-on lab course in human biomechanics can be challenging. During the COVID-19 pandemic, we developed an inexpensive, customizable hardware kit along with fully open-source teaching resources to help educators deliver their biomechanics lab courses remotely. These resources allow educators to teach students how to conduct hypothesis-driven biomechanical experiments, without the need for students to have previous coding or electronics experience. Additionally, all of our resources are fully customizable, allowing educators to fit the requirements of their respective biomechanics courses.

Before developing our course resources, we defined multiple key principles. First, the whole system must be wearable. All measurement systems should be able to run battery powered and store data. Second, students should not require technical experience for taking the course. Setting up the hardware should work without soldering, and the number of wires and devices for a measurement system should be at a minimum. Students also should not require prior coding knowledge to set up software for the measurement systems and the data analysis. Third, all resources should be financially accessible. The hardware kit should be inexpensive (~cost of a textbook), all the software required should be open-source, and the instructional materials should be open-access. Lastly, the workload for educators to develop a similar course should be minimal. All hardware, software, and instructional materials should be customizable.

Our hardware kit consists of commercially available electronic components, specified online [1], with a microcontroller as its base (Fig. 1). A microcontroller functions as a small computer and can read, alter, and output signals from and to other devices in the system. To make the hardware kit wearable, a 9V battery can power the system and a data logger can store the data on a micro SD, eliminating the need for a computer connection. To make the system solderless and minimize the number of wires, all devices in the kit directly connect to the microcontroller with no more than three wires. Moreover, our hardware kit is ~$120 US and can be customized with any device that communicates digitally, analog, or via a specific one-wire-communication system called “qwiic”.

To support students without prior coding experience, we share our codes in open-access GitHub repositories [1]. To make all software open-source, we chose Arduino IDE (Integrated Development Environment), a commonly used programming platform for microcontrollers, to program our hardware, and Python, the fastest growing programming language in the world, for data analysis

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[2]. Educators can download, customize, and share all Arduino IDE and Python codes with GitHub. For lab manuals, we use open-access Google Docs to allow educators to copy and edit documents, and share them with collaborators and students [1]. To help students set up measurement systems and analyze data, we also created a YouTube channel with supplementary video tutorials [1]. To customize this library, educators can create their own YouTube library with videos from our channel and their own additional content. These resources allow educators to set up labs for students to conduct EMG, ECG, and kinematics experiments. For example, students can use the kit to conduct maximum voluntary contraction experiments (EMG), evaluate heart rate and exercise intensity (ECG), or classify activities through accelerations (kinematics).

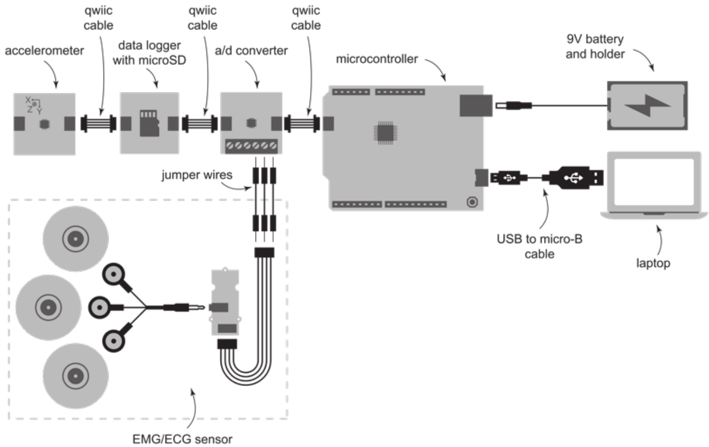

Fig. 1: Components of our hardware kit.

107 students took and evaluated the course in the first three consecutive semesters of offering the course. They provided feedback on their learning experience and engagement with the course materials. In particular, students perceived the video tutorials to be crucial for their success. Overall the mean satisfactory rating for the course was 83% (SD: 2%).

In conclusion, our freely available online resources can support universities to set up their own hands-on, customized wearables lab courses [1]. With these resources students learn how to build measurement systems, acquire and analyze real biomechanical data, trouble-shoot problems, and interpret results.

1. SFU BPK Wearables – Lab Overview. Available online: http://bit.ly/3popKqg_SFU_BPK_Wearables (accessed on 13 August 2021).
2. Srinath KR (2017) Python – The Fastest Growing Programming Language. IRJET 4:354-357.

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