Remotely Designed and Performed Biomaterials Lab

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“Did they design for it?” is the title for the final project of the sophomore Biomechanics and Biomaterials lab. The learning objectives include designing, executing, and analyzing an appropriate experiment to address a question with specific limitations of time and resources. The aim is to test a student-chosen, relevant variable on hydrogel-based consumer products. In the spring of 2020, this experience demonstrated that learning objectives of designing and executing appropriate experimentation were able to be performed in a remote setting.

The required sophomore-level course is a two-credit, writing intensive lab with one hour of lecture and three hours of lab per week. The course content starts with skeletal biomechanics, leads into mechanical and biological material properties, and ends with a final project focused on experimental design and hydrogels used in consumer products. For the last section, one of the learning objectives is designing an appropriate experiment to test two consumer products at three levels in triplicate. Commercial products that contain hydrogel materials and supplies for mixing solutions are provided and intentionally limited. Another limitation is time; teams of 2-3 are given one three-hour lab period to draft a procedure and mix solutions and a second three hour lab period for performing the experiment. Another learning objective is executing the designed experiment by being prepared and using the limited time wisely. The instructor provides feedback on a drafted procedure usually during the initial lab period but at least 48 hours prior to performing the experiment in order to anticipate pitfalls and elicit more details as needed. The last learning objective of correctly analyzing the results is assessed in a final presentation. The challenge in the spring of 2020 was to translate this to an off-campus experience.

The experimental design process changed from previous semesters because the challenges to implementing a procedure were different from the controlled lab environment. Previously the students had to work with resource and time limitations as well as plan a procedure without the ability for a “do over” if mistakes were made. In the remote version of the project, experimental design challenges evolved from focusing on perfect planning to identifying available tools to make measurements. During the design phase, students were encouraged to troubleshoot the procedure to ensure adequate resolution of the measurements. As the students were off campus, tools such as very precise volume measurements for solution mixing and scales for sample measurements were not available to everyone. In anticipation of mass not being measureable for everyone, early coaching was provided on how to utilize volume to perform an experiment that would be repeatable. During the implementation phase, time no longer was a limitation. In an effort to have the experience be as equitable as possible, the requirement that the tested material be composed of a hydrogel was expanded to any absorbent material. This change allowed many students to study easily accessible absorbable materials such as paper towels.

Feisel and Peterson listed 13 objectives typical to lab courses [1]. This approach to designing and performing a remote lab allowed for achievement of experimental design and implementation as well as selecting appropriate measurement tools. This experience also increased the creativity required by the students. It is not common for an underclassman student to be so resourceful and
have to find their own measurement tools or collect supplies from their environment for an experiment.

Approximately two-thirds of the students had access to an appropriate scale. The other third needed to utilize a different measurement technique compared to previous course offerings and techniques focused on earlier in the course. Methods employed involved measuring volume, either removed from the solution by the material or amount added to material before it showed signs of saturation. This was anticipated and preemptively addressed in the early coaching which did appear to help based on the draft procedures submitted by the students.

Unless student communication was poor, traditionally the drafted experiments have been easy for the instructor to envision as the equipment and supplies were provided. In this circumstance, a few students required back-and-forth with the instructor to ensure an acceptable experiment was designed. Concerns related to bathroom scale resolution and ranges of thermometers available were discussed. Ensuring appropriate measurement tools were being used was sometimes challenging as well. The communication style was similar compared to previous semesters, a Word document submitted into the online course management system. However, this semester did not facilitate personal one-on-one discussions to accelerate the process as was done during the initial lab time in previous course offerings.

A new challenge posed was the students’ choice to study gelatin due to the hydrogel-like characteristics. This was a likely result of having used it earlier in the semester and expanding the possibilities for which materials could be studied. Upon coaching by the instructor, the students realized studying this material would be very different. Gelatin needs to dissolve and solidify in order to absorb solutions, which resulted in students modifying the experiment and measuring time to dehydrate instead of amount absorbed.

By changing the format and allowing more planning and experimental time, a couple aspects of the experience changed as well. Students were able to change their perspective to a “time to dry” instead of “amount absorbed”. Creams and face masks which are purchased hydrated were now available for study. Also, emphasis has usually been placed on preparing a well thought-out procedure but in this situation the students were encouraged to troubleshoot in order to find limitations such as accurate measurement ranges and measurement resolution. These characteristics of our experimental design were usually taken for granted; in previous semesters, students were frequently surprised when the team was handed only one diaper to be subdivided for studying instead of nine individual diapers because our instruments could allow for smaller samples.

Once our course is back in the lab again, time and resource limitations will be reinstated while measurement tools become readily available again. However, in the future we will start the experimental design discussion earlier and not be so quick to give them the base procedure…if a third of the students can accomplish the objectives without a scale there is no need for it to be the default tool. Also, the focus will remain on hydrogels but redefining the allowed materials to include other skin contact materials such as creams will be explored.