An Inquiry-Based Learning Undergraduate Laboratory Course During the COVID-19 Pandemic

Inquiry-based learning (IBL) has gained popularity as a tool for teaching science courses by allowing students to drive the learning process by asking questions. Its accelerating popularity is driven by technological advancements that allow IBL to be supported in the modern classroom.[1] In light of this, the Chemical and Biomolecular Engineering Department at Rice University adopted IBL in the undergraduate teaching laboratory courses for the 2019-2020 school year. The IBL model was implemented in the redesigned courses by giving the students a simple, non-prescriptive experimental objective. The students were provided with a short theoretical video and were given a quiz, as well as weekly access to the professor and teaching assistants, to help them develop the experiment. They were required to submit a laboratory proposal before they conducted the experiment, and once this was approved, they submitted a final lab report at the end of the term.

During Spring 2020, we already had all of the IBL course structure in place, which aided significantly in our shift to “virtual classrooms” after Rice University closed its campus in the wake of the COVID-19 pandemic. By redesigning both lab courses, we fortuitously gave ourselves built-in flexibility to immediately convert to a virtual format in the middle of the semester. We provided students with laboratory data so that they could continue the analysis at home. However, students were not able to conduct appropriate experimentation, which is one of the key learning objectives for the laboratory courses.

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As the rate of SARS-CoV-2 virus continued to rise in the summer across the nation, we decided to hold online laboratory sessions for the Fall 2020 semester to ensure the safety of everyone involved. In response to the need for the hands-on component, two take-home experiments were developed for the students. Over the summer, a graduate student teaching assistant 3D-printed and assembled enough 5-plate heat exchangers so that each group of students would receive two exchangers (12 total exchangers were printed and each exchanger took approximately 17 hours to print). The designs for the exchangers were acquired from www.thingiverse.com.[2] Two people in each group of 4 received a kit consisting of a heat exchanger, two peristaltic pumps, a thermocouple, and a plastic graduated cylinder. The 3D printer and all the kit components were purchased for ~$650 from a large online retailer. The objective of the experiment was to determine the overall heat transfer coefficient. The second experiment used blood glucose meters and Beano® to illustrate Michaelis-Menten enzyme kinetics in a sucrose inversion reaction. Each student received a 10 mL syringe and 100 glucose testing strips in their package. All of the items for the second experiment were purchased from a local retail grocery store.

The cost of the heat exchanger kits was about $75 each and the kinetics kits was about $30 each. The cost of the kits was funded by an internal Rice University grant, with no additional costs for the students. The kits were collected back from the students and can be reused. All of the learning objectives of the course could now be met by including these laboratory kits.

Overall, students were excited and grateful to receive these kits, and the quality of the data obtained from them was also acceptable for an undergraduate teaching laboratory. We believe that these kits were used to safely teach the students how to conduct experiments while upholding IBL principles. Since the kits are very affordable, they can be easily assembled with few resources, thus they are inclusive for students of different income levels and resources.

IBL experiences allow students to become proficient in research, design, production of scholarship, and creative works. Adopting the IBL model has helped satisfy the ABET, Inc., Student Outcomes 4 and 6 while being flexible and responsive to online instructional needs.

REFERENCES

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