CAUCE Program Awards Entry

Credit Programming over 48 hours

Supplementary Learning Resources in first year Biology

Abstract

First year Biology instructors at Memorial University of Newfoundland (Memorial) identified a need for additional learning support for first year students taking Introductory Biology courses. The average failure rate of first semester large enrolment Science courses (Biology, Chemistry, Physics, and Mathematics) was almost 18% (Memorial Registrar's Office data 2010-2015). To address this need, the biology department collaborated with the Centre for Innovation in Teaching and Learning to develop five self-paced, online tutorials that focused on troublesome concepts in biology. The project was funded under the university's Teaching and Learning Framework 2016-2017 competition. The tutorials were provided to students during the fall 2017 semester.

The self-paced tutorials presented content from the course in an alternate format, than lecturing. Each tutorial included content pages, quizzes, animated video, interactive activities, and badges. The project team collaborated on the design. Tutorials were pilot tested before being implemented in the fall semester of 2017. The effectiveness of the tutorials were measured using a pre- and post-test approach to assess gains in student learning. Student engagement was measured using the Classroom Survey of Student Engagement (CLASSE). Preliminary analysis of the data indicate that there was a significant gain in learning over the previous year ($p<0.05$).

Project Description

Memorial University of Newfoundland (Memorial)'s Biology department identified a need for additional learning support for first year students taking Introductory Biology courses. The delivery mode of large introductory courses is based on lecturing which may create knowledge gaps contributing to the reported decrease of students in Science, Technology, Engineering and Mathematics (STEM). The decrease in the number of students in STEM has alarmed educators (National Research Council, 2003; 2013), prompting a call for efforts to increase STEM majors in universities. The introductory STEM courses usually promote memorization without focus on meta-cognition imperative to critical thinking and scientific skills (Handelsman et al., 2004; Hurd, 1997; Williams et al., 2004). Memorial's average failure rate for the first semester large enrolment Science courses (Biology, Chemistry, Physics, and Mathematics) was almost 18% (Memorial Registrar's Office data 2010-2015). The biology department engaged the Centre for

Innovation in Teaching and Learning to develop open, self-paced, online tutorials that focus on specific concepts in biology.

Large class sizes, such as first year Biology with ~900 registrants annually, with detail-oriented, content-heavy loads can result in low success rates and attrition. Active learning methods which encourage student engagement in course material can be effective in large classes (Rissanen, 2018) and in introductory science classes (Freeman et al., 2007 & 2014; Wieman, 2007). Active learning includes collaborative learning among students, preparing and attending classes, and any kind of interaction with the course material inside and outside of the classroom (Larose et al., 1998; Svanum & Bigatti, 2009; Handelsman et al., 2005). Active learning has been shown to increase grades on average by 6%, and to decrease failing rates in STEM disciplines. (Freeman et al., 2014). According to several instructors teaching first year Introductory courses at Memorial, the attendance drops after the first few weeks by at least 30%, and keeps decreasing toward the end of the course when approximately 50% of students miss classes regularly (Rissanen, 2016). High level of absenteeism might have an effect on the course failure rate that is currently at 15.4% in Biology 1001 (Registrar's Office data 2010-2015). We aimed to increase student success in these courses by providing them with foundational and supplementary material in the areas where there is a known gap as a result of students' insufficient background from high school or other first year courses.

A team consisting of four biologists, a graduate student, an instructional designer and media developers collaborated on the design, development and evaluation of these first year Biology online tutorials in 2016-2017. Tutorial topics were identified by analyzing previous years' tests, student feedback, and pedagogical research in biology. The top five topics identified as common misconceptions or troublesome concepts within the course were selected. Standard instructional systems design (ISD) processes were employed; including scoping, design, development, pilot testing and revisions, implementation and seeking of feedback from target audience. Tutorials included learning materials, quizzes, reflective questions and badges (gamification) to facilitate deep learning of the topics.

The two-year project was funded by and closely followed the guidelines of Memorial's Teaching and Learning Framework. This project was one of the successful submissions, among the 37 applications, to receive funding in the 2016-2017 competition. The TLF funding competition was established to encourage the exploration of creative and innovative practices in teaching and learning on the St. John's campus.

The project is aligned with the overarching evolution of higher education, in which artificial intelligence systems are increasingly utilized in support of personalized learning and adaptive learning systems. Personalized and adaptive learning are defined as pedagogical approaches that focus on personalization of the learning experience. Each learner is unique, differing for example in skills, knowledge, adaptability, and learning styles. Therefore, personalized learning systems will be able to support the learner in the areas where they lack specific knowledge, skills and abilities (Graf, 2009). These systems will be able to automatically guide learners to

specific learning materials and tutorials based on quizzes, or other form of assessments. Thanks to this, they should be able to overcome the issues noted above which are prevalent in large classes (Graf, 2007). McDaniel et al. (2007) observed a significant increase in learning gain, measured by using conceptual learning inventories, with web-enhanced, interactive pedagogy in Introduction to Biology course compared to a standard instructor-centered pedagogy. In a similar study, Moravec et al. (2010) used online learn-before-lecture material in a large introductory biology class, and showed that students performed better in the content quizzes in the class that had in-class interactive teaching, and online learning resources. Therefore, by developing ways to support learners through the creation of additional learning resources, we can provide more effective.

The project enhances the flexibility of the teaching and learning environment with respect to program design, mode of delivery and scheduling, by providing self-paced, tutorials that focus on specific concepts in biology. Students may review these resources whenever and as often as they feel necessary to better master the concepts, with the content available via Internet. This makes the content applicable for the various learning styles and accommodation requirements found in students at Memorial. The remedial resources facilitate critical thinking and interaction among learners and educators.

The project, and associated evaluative study, aimed to determine if the tutorials were an effective means of providing foundational and supplementary assistance to students as well as gains in students' levels of engagement. Effectiveness of the tutorials was evaluated using a mixed-method, quasi-experimental design to compare the classroom research results. A conceptual understanding pre- and post-test approach was used to assess gains in student learning. Additionally, student engagement was measured using the Classroom Survey of Student Engagement (CLASSE). Preliminary analysis of the evaluative study data on these tutorials indicate that there was a significant gain in learning over the previous year ($p<0.05$). There was an increase in student engagement and overall feedback on the tutorials from students indicates that they were pleased with and found the tutorials to be of value. Results of the evaluative study will be published at a later date.

In a recent edition of the University gazette (https://gazette.mun.ca/teaching-and-learning/bridging-the-gaps/), the tutorials and project were featured as part of a special feature showcasing Memorial's innovation ecosystem, a pan-university effort focused on supporting the development and success of innovators across Newfoundland and Labrador. It provides some of the background on the project.

As seen from the description above, the tutorials, and this project, provide suitable university-level complexity to address specific learning gaps in the first year course. They provide valuable service to students in terms of representing content in an alternate, innovative approach. The content was designed to be presented in ingenious ways that presented abstract concepts in concrete terms.

The Tutorials

The five tutorials employ a constant design layout and include similar elements within each. Students may view the tutorials at any time during the semester and repeat activities as often as they wish. Each tutorial contains learning outcomes, content pages, quizzes to check understanding and badges designed as awards for completing content and quizzes. The content pages presented key terms, topic-specific content, animated videos with transcripts, interactive activities and reflection questions to encourage students to think more deeply about the topics. The quizzes may be completed numerous times; providing an opportunity to test understanding and identify areas where more study is required.

While the tutorials could be accessed in any order, it was expected that most students would access them as the topics were covered in the course. Students were encouraged to use the tutorials throughout the semester by the instructors, both of whom were members of the tutorial design team.

The tutorials may be viewed by logging into our learning management system here: https://online.mun.ca/d2l/loginh/?target=%2fd2l%2fhome%2f276781. The credentials for logging in are:

Username	Password
Bio-01	Biology01
Bio-02	Biology02
Bio-03	Biology03
Bio-04	Biology04

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