OPENCHEME: OPEN EDUCATIONAL RESOURCES FOR MATERIAL AND ENERGY BALANCES

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Abstract – A survey of student opinions around open educational resources, with a focus on open textbooks, was undertaken in a second year material and energy balances course. Roughly one third of the class of 200 students participated in a voluntary online survey. One sixth of students reported having no easy access to a textbook. Students believed that free online resources and a low-cost online textbook would significantly improve their learning. Students were generally in favour, although not as strongly, of contributing to these free online resources. When asked which resources would be most valuable to improve their learning, students most often called for sample problems and solutions as well as videos of problem solutions or concept explanations. A search was then undertaken to find open educational resources that could be used to meet student requests. This search was successful in finding a variety of appropriate resources that could be adopted and built upon to meet student requests as well as finding a gap in terms of sample problems and solutions for students to practice applying their knowledge.

Keywords: Open Educational Resources; OER; Material and Energy Balances; Chemical Engineering; Student Perceptions

1. INTRODUCTION

There is increasing interest in many disciplines to create open educational resources (OER) [1]. Articles with “Open Educational Resources” as a topic have increased at an average rate of 20% per year over the past 15 years according to the Web of Science Database [2]. This trend parallels a move toward open access manuscripts for research funded by federal agencies in Canada and the United States [3,4]. There is also a push in the British

Columbia Post-secondary education system to create OER through the BC Open Textbook project [5]. OER are generally licensed under schemes such as creative commons or GNU licenses which provide permission for these works to be copied, modified and distributed under certain conditions without the need to contact the original author. OER can include a wide variety of resources such as textbooks, lecture content, classroom activities and assessments.

Within the context of Chemical Engineering, material and energy balances is a course that is common and fundamental to many chemical engineering programs around the world. Textbooks for this course date back over 50 years with similar concepts and organization to those being published today [6,7]. There are a variety of OER currently available for material and energy balances which include instructional videos [8], course notes [9,10] and conceptual tests [11]. These resources present an opportunity to improve student learning using openly available comprehensive course materials.

A material and energy balances course (course code: CHBE 241) is offered to second year students at the University of British Columbia (UBC). CHBE 241 has an enrollment of 193 students with 128 students (66%) majoring in Chemical and Biological Engineering and 65 students (34%) majoring in Integrated Engineering. In order to understand student views of current course resources and OER, student opinions were solicited in an online survey and focus group sessions.

This paper will evaluate student requests for learning materials in the classroom and seeks to determine if currently available material and energy balances OER can meet this demand.

Figure 1: Student responses indicating textbooks to which they easily have access.

2. STUDENT SURVEY

2.1. Methods

Students' opinions were solicited on their access to course resources through a survey on the online learning management system. The survey was run in the last third of the course to ensure students had adequate course experience to comment on resources that would be beneficial to their learning. The survey was optional and students were encouraged to participate through class and email announcements. The survey length was kept short, to five questions, to encourage student participation. The academic experience survey run by the Alma Mater Society (student's society) in 2016 showed that 75% of students reported going "without a textbook or other course resource due to cost" and that 37% of students do this frequently or often [12]. Based on this report, questions in the survey in this study focused on use of an open textbook. The questions developed were as follows:

1. Which of the following textbooks do you easily have access to (select all that apply)
2. Rate your feeling about the following statement "It would significantly improve my learning if educational resources were available for free online"

3. Rate your feeling about the following statement "I would be willing to contribute to online resources, perhaps as an assignment in the course"
4. What resources would be the most valuable to create to aid in your learning in this course?
5. Rate your feeling about the following statement "It would be a significant benefit if an online textbook was available for low cost printing"

Question 1 had response options for a variety of common course textbooks for material and energy balances. These responses included: the textbook currently used in the course, Felder (2016) [6]; the previous edition of that same textbook, Felder (2005) [13]; the course textbook used in the previous year's course, Murphy (2005) [14]; as well as options for "other" and "none". Questions 2, 3 and 5, were evaluated using a five point Likert scale with responses ranging from strongly agree to strongly disagree. Question 4 was open-ended and was evaluated using thematic analysis [15]. Thematic analysis was performed by coding responses [16]. This was done by first going through all responses and identifying unique themes such that each response was coded to at least one theme. These unique themes were then consolidated to major themes and responses were re-coded using these major themes. The major themes used for coding can be found in Table 1.

Figure 2: Student responses to Likert scale survey questions 2,3 and 5

Table 1: Thematic analysis results of responses to survey question 4 - “What resources would be the most valuable to create to aid in your learning in this course?”

Code	Frequency
Written sample problems and solutions	20
Video solutions to sample problems	14
Video explanations of concepts	13
Pedagogy changes	11
Textbook modifications	9
Sample exam questions	9
Online homework	3
Metacognition and solution strategies	3

2.2. Results and Discussion

The survey received responses from 63 students out of a class of 193, representing a 33% response rate. Results from the first survey question around textbook access can be found in Figure 1. 16% of students report that they do not have easy access to any textbook. Those students with access to textbooks are generally using the assigned course text, either the current [6] or previous edition [13]. As shown in Figure 2, many students report that their learning would be significantly improved if educational resources were available for free online, with 54% strongly agreeing and no students disagreeing with this statement. Integrating open resources in the course materials would likely have student support. Students are not as eager to contribute to online resources, with only 10% strongly agreeing and 16% disagreeing or strongly disagreeing. Should a student assignment focus on resource creation, the motivation should be made

particularly clear to students. Students were favourable to having an online textbook available for printing, with a majority of students indicating that this would be a significant benefit.

Student responses around what resources should be created to aid their learning in the course are summarized in Table 1. One notable theme was that students showed a strong desire for sample problems and solutions in either written (20 students) or video format (14 students). These were available in the textbook, but students generally reported the solutions were only numerical and not detailed enough to enhance their learning. Thirteen (13) Students responses contained requests for video explanations on course topics. Eleven (11) students also called for pedagogical changes, which focused on shifting course material delivery. Suggestions students gave included having more content delivered outside of class or flipping the classroom. Nine (9) students requested modifications to the textbook and requested having content freely available online. Three (3) students also requested having an online homework system to give them structured practice. Another three (3) students called for more emphasis on discussing solution strategies prior to solving questions.

3. SEARCH FOR OPEN RESOURCES

The author wanted to assess if currently available open resources could meet student demands. The UBC Library Open Educational Research Guide webpage [17] contains a variety of search tools and these were used to search for relevant available open resources. Searches were

performed for “Chemical Engineering” or “Material and Energy Balances” at the undergraduate level and search results were investigated to find content related to material and energy balance courses.

One large repository of content was found that listed almost all other materials found, this was the Computer Aids in Chemical Engineering (CACHÉ) website [18]. This resource contains content covering a large variety of chemical engineering fields, and notably a section on material and energy balances. This contains links to videos of problem solutions as well as concept explanation hosted on the LearnChemE website [8] and an open textbook hosted on the Wikibooks platform [9]. One resource that is lacking from our search is written problem solutions including those students may find on exams. To fill this gap, a repository for these types of questions could be set up, a model for which may be the Math Exam Resources wiki page at UBC [19]. Another resource that could be developed is WeBWorK, which are online, automatically graded questions used commonly as assignments in math and physics courses at many institutions [20]. WeBWorK is an open-source software developed in 1994 and has an open problem library system used to share problems between institutions and courses. It provides a robust and well-developed platform for problem creation and sharing, as well as an opportunity since there is not yet any chemical engineering content present.

4. CONCLUSION

Students have identified a variety of resources useful to their study including sample problems and solutions, video explanations of concepts and open textbooks. There are a variety of openly available video and textbook resources that can help meet these needs. A gap in terms of sample problems and solutions repository should be addressed in response to student feedback.

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