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Using an Open Course Pack to Support Interdisciplinary Learning in Sustainable Energy Engineering

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Abstract

For interdisciplinary engineering programs, it can be difficult to find textbooks that meet the needs of the course – open educational resources (OER) are well suited to bridge this interdisciplinarity challenge. As there was no suitable textbook identified for the course SEE 310: Integrated Energy Solutions in the Sustainable Energy Engineering program at Simon Fraser University, we developed an OER course pack, entirely Creative Commons licensed, that introduces students to energy systems modelling techniques and different types of models. To gain feedback on the effectiveness of the course pack we surveyed the students in SEE 310 and invited them to participate in a focus group to discuss the course pack and how it could be improved. We received positive feedback including that, in almost all cases, they would prefer it over a traditional textbook. Through building the OER course pack, we discovered plenty of commitment to OER development and well-maintained OER repositories, but that material for higher level interdisciplinary undergraduate engineering courses is still difficult to find. Given the suitability and positive feedback from developing OER for SEE 310, we feel that OER are well suited to answer the complexity and interdisciplinarity of sustainable energy engineering.

1 Introduction

To meet the challenges of the climate crisis engineering students need increasingly integrated educational programs that will prepare them to face complex problems that transcend traditional disciplines (Lattuca et al. 2011). An issue arises when seeking textbooks to match such blended course material; often none exist. Open Educational Resources (OER) are well suited to bridge this complexity and interdisciplinarity challenge. OER often fit more varied learning styles as they don't have to be a consistent format and can incorporate videos, simple explanations, cutting edge research articles, and other elements to construct a versatile learning experience. OER are more accessible because, once they are created, they can be used for free. Depending on the licensing, they may also be remixed and reused for other courses. This accessibility makes them adaptable to the rapid technological changes and the growing complexity of sustainable engineering. As more resources are developed and shared, the accessibility of material, and the ease of adapting this material for new and different courses can accelerate.

One example of an interdisciplinary course where OER has been successfully deployed in Sustainable Energy Engineering is SEE 310: Integrated Energy Solutions at Simon Fraser University. SEE 310 introduces students to the modelling, simulation, and optimization of energy systems. As no suitable textbook was identified, we developed an open course pack to meet the needs of the course. The course pack is entirely under Creative Commons licenses and covers energy systems modelling techniques and model structures. We combined existing open-source resources into a course pack and, in the process, discovered that few resources existed for a course like SEE 310 and had to develop additional resources.

We have received positive feedback from both the SEE 310 students and an open energy modelling community on the course pack. Early in the process we put out a request for open learning materials to the online community OpenMod¹, energy modellers committed to open models, data, and resources. While some made suggestions and shared their own course materials, many more responded with excitement at eventually having access to the course pack. We found that others were seeking out similar resources, and since developing the open course pack a collection of open learning materials is being maintained on the OpenMod website², the core of which came from our request for information. In a survey and focus group we sought out student feedback on the course pack. Overwhelmingly, the students indicated they would prefer an OER to a traditional textbook due to the accessibility and format. There was also general agreement that it improved their understanding of the course concepts, and that the students would like to see it expanded to include more styles of learning material, such as reading quizzes. Given this positive feedback, we feel that OER are well suited to answer the complexity and interdisciplinarity of sustainable energy engineering.

2 Background

A report by the Canadian Digital Learning Research Association defines OER as “resources useful for teaching and learning (text, media, and other assets) that are freely accessible and openly-licensed (such as a Creative Commons license), where there is legal permission for creation, use, and reuse of educational content” (Johnson 2019). In this 2019 study, they also classify OER as being in an “exploratory and experimental stage.” This suggests that, while there is plenty of interest in OER, the development of these learning materials is still ramping up. Because they are free for students, OER have shown to reduce course withdrawal rates, and increase completion and enrollment rates for classes that adopt OER and can improve end-of-course grades (Hilton et al. 2016; Colvard, Watson, and Park 2018).

¹ <https://forum.openmod.org/>

² https://wiki.openmod-initiative.org/wiki/Learning_materials

Student performance in classes with OER are found to be the same or better than those with traditional for-cost textbooks (Hilton 2020; 2016; Delgado, Delgado, and Hilton 2019; Fialkowski et al. 2020). Additionally, both student and teacher perceptions of OER are found to be positive (Delimont et al. 2016; Jhangiani and Jhangiani 2017).

While the term ‘open’ generally means that something is available to use at no cost, there are different levels of openness as explained with the four ‘R’s of openness: Reuse, Redistribute, Revise, and Remix (Hilton et al. 2010). Reuse is considered the lowest level of openness, that others can freely use the material without modification. Redistribute is the next level, meaning that others can share the OER freely. The third level, revise, means that it can be modified and adapted from its original form. Finally, remix, the highest level of openness, requires that two or more OER can be mixed to create a new resource. Generally, once your resource is licensed for a higher level of openness the previous levels are also adopted. The Creative Commons³ provides options to openly license your work congruent with the four ‘R’s. All material newly developed for the course pack is under a CC BY-4.0 license, meaning that it can be freely shared and adapted as long as attribution is given.

Though in this case created for a specific course, the intention of any OER is that it can be shared and will be useful to other educators and self-learners. Understanding and following the Creative Commons licensing (or equivalent) is a vital step to developing OER, and when the OER is completed the licensing must be clear and obvious throughout. This ensures that others know how it can or cannot be used. With OER developed for specific courses, steps should be taken when sharing beyond the class to make sure it works in a broader context. Especially when the open resource is a full course, such as with MIT’s OpenCourseWare Initiative (MIT OpenCourseWare 2001), best practices include making the source files for material available in order to make them easily reusable. Steps must be taken to ensure that when converting to an open format the material from the course can stand on its own and doesn’t have key elements missing or broken links (DeVries 2013). To reduce barriers to the adoption and use of OER, ultimately there should be an institutional commitment to OER and a paradigm shift to openness (Peñaloza 2015; Jhangiani et al. 2016). This includes raising awareness, expertise and support from librarians, and sufficient time and funding to incorporate and create OER as well as research the impact of OER adoption.

3 Methods: Developing an OER for SEE 310

The purpose of developing the OER project was to support student learning in the Simon Fraser University course SEE 310: Integrated Energy Solutions. This course introduces students to modelling, simulation, and optimization of energy systems. The course pack contains an Introduction, Optimization Models, Building Energy Models, and Energy-Economy Models section. Each section is a combination of material written by the professor of the course, Dr. Taco Niet, and openly licensed educational material from various sources. The course pack compliments SEE 310 lectures to support student learning to comprehend fully the main features and strengths and weaknesses of each type of modelling. A focal point of the course, and course pack, is to be able to identify what model type would be most appropriate for a given situation. As SEE 310 covers a variety of energy systems modelling techniques and model structures, there were no existing OER or textbook identified that brought together all the course topics into a well-structured course pack. Although this project sought to combine existing open-source materials and resources into a course pack, a lack of existing OER required we develop a significant amount of the course pack from scratch.

³ <https://creativecommons.org/about/cclicenses/>

By exploring a number of different OER repositories and with assistance from librarians and researchers in the field we collected resources on energy modelling to combine into the course pack. A challenge and benefit to this process is that these resources are of many types and formats, such as research papers, practice questions, model documentation, and more, all openly licensed. The outcome is that the students have a variety of styles of educational resources to support their learning, providing a different experience from a traditional textbook. Most of the resources are not adapted into the course pack as they are useful as a stand-alone piece. In these cases, the course pack provides a link to the original webpage with an attribution included in the section. In the few cases where material is adapted into the course pack it is done with minimal changes and attributed immediately following the adapted material.

The course pack follows all topics covered in the course, namely explaining the different model types and their importance, structure, and appropriate uses. One expectation held at the beginning was that there would be more existing resources available to be compiled into the course pack. Finding resources that covered the material in a suitable way for SEE 310 proved to be challenging. Much of the existing resources, both open and not open licensed, is aimed at a graduate level course and was not targeted at undergraduate students. The resources that were at an undergraduate level and open licensed tended to focus on only a specific topic at a level more in depth than it is taught in SEE 310. The result of these challenges was that much of the course pack ended up being newly written for SEE 310 by the course instructor, Dr. Taco Niet. Given that the course pack incorporates longer and more technical readings in with those developed by Dr. Niet, these links can be considered supplementary readings that provide a broader context to the shorter readings available directly in the course pack. This ensures that the readings are an appropriate length for the students and avoids information overload, while still providing a well-rounded and comprehensive exploration of the course topics for a variety of learning styles.

The course pack is a combination of different OER and openly licenced journal articles, all entirely Creative Commons licensed or equivalent. Due to this, it made sense to individually license each section and provide attributions with licenses for all linked material. The alternative would be to choose the most restrictive license from the collected resources for the entire course pack. However, we wanted any material created by Dr. Niet for SEE 310 and the course pack to be as open as possible, in this case CC BY-4.0. For more details on the course pack, we have made it available through the OER to SFU's open resources repository, Summit⁴, and on the OpenMod website⁵.

4 Methods: Evaluating Effectiveness

To assess the student response to the OER, and get feedback on possible future improvements, we conducted a survey and a focus discussion group with the students in the class after the course was completed. This took place during summer in 2020 under COVID-19 regulations and therefore the class, focus group, and survey were all completed online. The ability to gain statistically significant findings from student evaluation of the OER course pack is limited due to only six students being in the class, with all six students participating in both the survey and focus group. The survey was anonymous, and a small stipend was given for its completion.

The purpose of this survey was to evaluate the effectiveness and student perception of the OER for SEE 310. It was sent to and completed by all six students in the first instance of SEE 310. It comprised of ten questions and was the second section of a survey that included other aspects of the course for a total of twenty-five questions. The questions consist of six Likert scale style questions, two multiple choice

⁴ <http://summit.sfu.ca/item/20738>

⁵ https://wiki.openmod-initiative.org/wiki/Learning_materials

questions, and two open ended questions. A complete summary of the survey results is available as a google doc⁶. The average time spent to complete the survey was seven minutes and thirty-nine seconds for the entire survey, of which approximately half concerned the course pack. None of the questions were skipped by the students.

The focus group was an opportunity to gain more context to the survey responses. It included discussions on other aspects of the course, with thirty minutes used to discuss the course pack. The questions asked in the focus group were:

1. Did the course pack help you gain understanding of the class concepts and material?
2. Did the course pack help prepare you for the lectures, labs, assignments, and your project? How?
3. Is each section of the course pack an appropriate length?
4. What did you like about the course pack?
5. Did you have any problems or difficulties with the course pack?
6. Do you have any suggestions on how to improve the course pack for future years?

5 Results, Feedback, and Discussion

In this section we discuss our findings from developing an OER course pack. With feedback collected through the survey and focus group, and by reflecting on the experience of developing and using the OER course pack for SEE 310, we consider the benefits, challenges, and suitability of using OER for this interdisciplinary undergraduate program.

5.1 Availability of Open Material

While many OER exist and there are well maintained OER repositories (“OER Commons” 2007; “BCcampus” 2013), it is more difficult to find material for higher level, interdisciplinary courses. Many of the resources identified while developing the OER for SEE 310 were either at a level too high for undergraduate students (such as the growing number of journal articles with a Creative Commons license that do not provide the foundational knowledge needed for a course) or aimed at core introductory university courses (such as first year math, physics, English, and so on). Educators appeared to be very willing to openly license their course materials, such as slides and videos. However, when using course material, it will often be specific to that course and not always easy to reuse.

While much of the course pack was newly created due to a lack of existing OER for this field of study, a number of journal articles and other resources were used. Journal articles can provide interesting insights into the course material, especially as applied examples, but are often too advanced for an undergraduate level. When asked if the course pack was difficult to understand, the results were mixed, with two students agreeing and three selecting ‘neither agree nor disagree.’ It was commented that some of the material was overly technical. A natural solution to a lack of OER for upper-level engineering classes is to develop more OER, and to continue to fund projects such as this one. As more OER exist, finding the right resources will become less difficult.

5.2 Support for a Variety of Learning Styles

Another result of there being less material aimed at higher level, interdisciplinary courses is the need to be more creative and utilize more varied resources. Many of those who develop learning materials are willing to share their course resources, such as slides, videos, and exercises, and many journal articles are openly

⁶ <https://docs.google.com/document/d/1fH8VfqF4g5AD2sQluyp-Xo4TBJnmnlI3ms2z673um84/edit?usp=sharing>

licensed. Using these varied and often multimedia styles of resources together to build a course pack can contribute to a learning experience that is different than traditional textbooks provide.

The students highlighted in both the survey and focus group that these differences were something they enjoyed about the course pack, and that they would like to see even more varied learning styles in future iterations. They provided feedback that the course pack could be expanded to include more information on each section and include more graphics and examples. In the focus group, the students suggested adding more reading questions or short quizzes into the readings to test their knowledge. One section of the course pack included an interactive tutorial of a model, with step-by-step instructions to complete. During the focus group, some of the students agreed this was a favourite part of the course pack because it was interactive. They encouraged more of this style of learning material to be added in future updates of the course pack.

An advantage of a traditional textbook style of learning material, whether it is openly licensed or not, is that the information is organized, detailed, and builds on itself throughout the chapters and sections. This can be more difficult to achieve when remixing existing OER and is a trade-off of having the variety of styles and sources of information. This could be another reason some students responded to the survey that the course pack was difficult to understand. While this can also be improved with increased availability of material, it also highlights the need of OER to be sufficiently and consistently funded so that enough material can be newly created for the course, as required.

5.3 Accessibility and Adaptability

In the survey, five students indicated they “would rather have the course pack than a traditional textbook,” commenting that they liked the zero cost, accessibility, and different format compared to a traditional textbook. The most obvious benefit of OER is that the students no longer need to purchase a textbook, reducing barriers based on cost to education. One student did report they would be willing to pay \$50 to replace the course pack with a traditional textbook, though practically a textbook for the course at this price is highly unlikely, and the average cost of the textbooks originally considered for the course (none of which sufficiently covered the course topics) was CAD\$129.10.

Textbooks are also regularly updated, adding to the cost as the newest edition needs to be purchased. Sustainable Energy Engineering and programs like it will need to adapt quickly to provide their students with the most up to date information for the changing field of sustainable energy. For this, OER have an advantage. As long as OER are being developed and shared, they can be remixed and adapted as needed.

OER are also more adaptable to feedback and students’ needs. Though there were two students that indicated the course pack did not compliment what they were learning, one reported that they never used the course pack and two used it only once a month. The results suggest that those who used the course pack regularly, at least once every two weeks, strongly agreed that it complimented the course. While some mixed reviews are always expected with course materials, an added benefit of the OER are their adaptability to the needs of students and learning styles. Having the opportunity to collect and incorporate feedback from the students can help to improve the course pack and course with relatively minimal effort compared to a traditional textbook.

As this was the first occurrence of SEE 310, it is expected that the course will evolve over time and with the experiences of the students and instructor. Depending on if future funding is available to continue the project, the course pack could be further developed and refined based on student feedback and changes to the course. To better support student learning based on feedback, a possible update would be to include more graphics and examples. Another helpful learning tool suggested in the focus group of students using

the course pack was to include reading questions to improve understanding and highlight the most important points. In addition to reducing the barrier of cost of education for students, using the format of OER rather than a traditional textbook is also more congruent to adapting to both evolving subject matter and students' needs.

5.4 Online and Distance Learning

Though also increasingly true of textbooks that are not openly licensed, OER in particular are generally accessed online. Especially given that this course took place during COVID-19 restrictions and was moved to be 100% remote at the last minute, there are unique opportunities to examine student learning in a remote environment. To support equitable online learning, OER are crucial, as we are seeing now more than ever. COVID-19 has had a profound impact on education and laid bare issues of inequality. As eLearning is embraced and becomes more necessary, utilizing OER can help educational institutions be resilient to these changes by fostering “connectivity, learning outcomes, and financial concerns” (Craig 2020). In SEE 310, the OER course pack helped to facilitate more interactive learning for students at home by using different styles of learning and types of resources, including activities.

6 Conclusion

SEE 310 provided one example where no traditional textbook was identified that fit the subject matter covered in the course and developing an OER was the most suitable option. It combined information from different sources such as journal articles, activities, and newly created material that can now be reused, redistributed, revised, and remixed under a CC BY license. In the future we plan to update the course pack as the course develops and by incorporating student feedback. As new relevant OER become available they can easily be used for the course or integrated into the course pack.

Given the growing evidence of the effectiveness of OER, the positive feedback from the students of SEE 310, and an ever-evolving understanding for the need for accessibility and openness in higher education, we feel that further OER development in higher education is needed. As more OER and material become available, it will be easier to find relevant resources that can be remixed into course packs that fit even the most interdisciplinary courses. Because of the inherent adaptability and resiliency to change, OER are more well-suited to courses that cover integrative subject matter.

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