Providing an Enriching Learning Experience for Underresourced Academic Programs Through MOOCIBL

Stanley Shie Ng, Biola University

Stanley Ng received his BS in Biomedical Engineering from University of California Irvine and MS in Biomedical Diagnostics from Arizona State University. He serves as faculty and director of engineering programs at Biola University. Currently, he is pursuing a Ph.D. in Engineering and STEM Education at North Dakota State University.

Ryan Striker P.E., North Dakota State University

Ryan Striker is a life-long learner. Ryan has over a decade of professional experience designing embedded electronic hardware for industrial, military, medical, and automotive applications. Ryan is currently pursuing a PhD in Electrical and Computer Engineering at North Dakota State University. He previously earned his MS in Systems Engineering from the University of Saint Thomas and his BS in Electrical Engineering from the University of Minnesota.

Mr. Enrique Alvarez Vazquez, North Dakota State University

Enrique is an experienced Systems Engineer with a demonstrated history of working in the electrical and electronic manufacturing field. Highly skilled in Embedded Devices, Software Engineering, and Electronics. He is a strong information technology professional with two MSc’s and working on a Doctor of Philosophy - PhD focused in Electrical Engineering from North Dakota State University.

Ellen M. Swartz, North Dakota State University

Ellen Swartz is currently pursuing a M.S. degree in Biomedical Engineering at North Dakota State University. Her research interests include STEM education, innovation-based learning, and agent-based modeling of complex adaptive systems. She previously received her B.S. degree from North Dakota State University in Electrical and Computer Engineering.

Ms. Lauren Singelmann, North Dakota State University

Lauren Singelmann is a Masters Student in Electrical and Computer Engineering at North Dakota State University. Her research interests are discovery-based-learning, educational data mining, and K-12 Outreach. She works for the NDSU College of Engineering as the K-12 Outreach Coordinator where she plans and organizes outreach activities and camps for students in the Fargo-Moorhead area.

Mary Pearson, North Dakota State University

Mary is a Ph.D. candidate in biomedical engineering with research focused in the area of bioelectromagnetics, specifically designing electronics that can be used as medical devices. She obtained her B.S. and M.S. degrees at NDSU in electrical and computer engineering. Mary is also interested in STEM education research.

Mrs. Grace Sangalang Ng, Biola University

Grace Sangalang Ng is a researcher, pursuing her Ph.D. in Educational Studies at Biola University. Her research interests include the integration between the psychological and sociological aspects of honor and shame as it relates to educational psychology.
Providing an Enriching Learning Experience for Under-resourced Academic Programs Through MOOCIBL

Introduction

Cardiovascular Engineering is a multidisciplinary field of study that requires interdisciplinary collaboration [1]. This kind of course can provide students with an immersive opportunity that prepares them for graduate studies or industry jobs. However, the cost to start and maintain a robust cardiovascular engineering course can be challenging, especially for smaller universities. The added costs to staffing, research spaces, and enrollment challenges are barriers to starting a rich course for aspiring students.

One way to creatively support a Cardiovascular Engineering course at smaller, under-resourced programs is establishing collaborative relationships with other institutions. With the sudden rise of remote learning tools and the increased proficiencies in remote delivery, the bridge to develop multi-institutional collaboration has never been more accessible. While it is more common to see multiple institutions collaborate on research, collaborative education can benefit all participating institutions. The diversity of teaching and research experience can provide greater depth and offer broader expertise as a resource to students [2] [3]. With larger research institutions often having more laboratory equipment available for student use, students benefit from the combined resources of both institutions and collaboration between unique student cultures and perspectives [4].

To foster such collaboration, MOOCIBL (Massively Open Online Course for Innovation-Based Learning) was used as the central learning management system for a multi-institutional Cardiovascular Engineering course across four universities around the United States [5]. The course introduces students to a non-traditional Innovation-Based Learning environment. In this learning model, students define and track their learning goals by creating tokens representing their completed learning tasks. Tokens are self-defined learning objective “crumbs” that go through an anonymous peer-review process, where students experience giving and receiving peer feedback [6] [7]. Students move their tokens through a modified Webb’s Depth of Knowledge sequence that shows greater depth of learning while progressing towards innovation [8]. In the Cardiovascular course, depth of knowledge assesses four levels of learning (DOK-1 Describe, DOK-2 Connect, DOK-3 Apply, and DOK-4 Innovate) while progressing towards innovation impact levels based on expert review (Impacts Self/Group, Impacts College/Community Outreach, Impacts Academia - Limited, Impacts Academia - Extensive, and Impacts Society) [9].

The opportunity to collaborate on an innovative project while tracking student learning provides a win-win situation for both students and instructors. Without MOOCIBL, learning responsibilities fall back on individual institutions causing divergence from collaborative learning.
The essential goal of this paper is to examine the unique classroom experience of a particular set of students from a small, liberal arts institution without an engineering program. Qualitative interviews were conducted and thematically analyzed.

Sample

A convenience sample was used for the qualitative study. The students of a Cardiovascular Engineering course at a private liberal arts university were invited to participate in semi-structured interviews [10]. After course instruction ended, the course instructor sent an invitation to all the students in the course, and three out of the total of five students participated in the interviews (n = 3). Although a few students participated, the response rate was 60%, two male and one female student. The students responded to the invitation by scheduling a date and time to meet with the interviewer through Zoom. The interviewer sent each participant an informed consent form and the verbatim instructions to read through the documents before the interview. Before participating in the interview, each participant emailed their informed consent.

Methods

An exploratory qualitative study was conducted to learn more about student experiences using MOOCIBL and their experience in the remote course. Inductive thematic analysis was used to categorize the data into codes, which then emerged into themes to understand student’s experiences [11, p. 75]. Since the study is concerned with how MOOCIBL affects student learning, especially under-resourced programs, listening to students’ perceptions and experiences in the course is an integral piece of the study.

Using semi-structured interviews, questions in Appendix A were used as the basis for the interviews, and clarifying questions were asked when needed. 30–45-minute interviews were conducted and transcribed [12]. Using thematic analysis, an inductive process was used to code the transcripts—nodes were created, organized into categories, and then into themes.

Results

The main themes that emerged from the data were:

- Student Learning through MOOCIBL
- Access to Various Resources through Collaboration with Other Institutions
- Expanding Network and Connections Through the Course
- Challenges of the Course
- Suggestions for Improving the Course
Student Learning through MOOCIBL

The participants saw the value of MOOCIBL as a platform to help keep track of their learning progress. To track learning progress, students had to submit tokens for their learning through MOOCIBL, which included short videos explaining key concepts of the course. All participants found it helpful to reference the videos throughout the semester. In many cases, MOOCIBL pushed students to do more than memorize information. Students had to learn how to concisely explain fundamental concepts to others and apply them in their innovative projects. For example, Participant A said:

“I think having the tokens was actually really helpful for me. Because I'm the type of person who, when you want to be able to really explain it to someone, or you really have to work through something, that's when you understand it the best.”

In this way, explaining the concepts to others helped the students learn as they appreciated the token system on MOOCIBL.

Also, Participant B said:

“That kind of also bled into my other courses, where it kind of shifted my gears from just trying to remember the concepts being taught to trying to think of ways to apply the concepts, which obviously, is really helpful as an engineer, because, you know, if you're taking your math classes, or your physics classes, they can kind of be a little mundane, and, you know, kind of boring at times. But if you're constantly thinking, well, how can I apply this information to something that's exciting? That, you know, makes the class more enjoyable.”

As students learned more about the various Depths of Knowledge, they could use MOOCIBL to integrate and apply the concepts that they had been learning both in this course and other courses in an innovative way.

Participant C also was able to apply the things they learned in the course during an internship interview as they said:

“I was on a phone call with someone talking to them about a possible internship opportunity. And they're like, ‘What’s an innovation that you're passionate about?’ And I was able to talk about what I worked on in this class. And it wasn't just some random idea that I had and have to think up on the spot. ‘Oh, what invention should I make?’ It was something that I was already actually working on. And I was able to talk about how I was getting professional peer-review on that. And that's just super rewarding to be able to have that.”
The students felt that their learning was more meaningful and rewarding as they could take what they had learned in the course and apply it beyond the classroom. In this way, they felt more excited about the content of their courses as they enjoyed what they were learning and saw how they were able to contribute beyond the classroom to have a societal impact. As Participant C said:

“I think it definitely gave me a sort of benchmark to see that I am capable of doing great things, which I think is super important for anyone in whatever field they're trying to pursue. If all you hear is criticism, and you don't have the opportunity to do something and achieve and be praised for it, you're just still going to be scared of that initial, ‘Oh, I'm gonna fail, so I might as well not do it.’ I think what this class taught me was, yes, you are going to fail, but just because you fail right off the bat doesn't mean that you're bad and you can't do anything. It's actually that you don't know things yet, or you're not good at this yet. And so I think it gave me this ability to see that, ‘Oh, wow, if I really put in the work, and I'm willing to get things wrong, and I have a good team around me and I seek out, you know, professional help, because all the professors have experience in engineering, or whatever it is that we were looking at.’ And I think it just helped me see that I am able to achieve things if I work with the right people. And I have the right mindset as I seek out the right resources.”

In addition, the students discussed their desires for future learning in various subjects such as having further interests in biomedical engineering, cardiovascular engineering, innovation-type engineering, and human factors engineering. Through their interaction with the course content and others through MOOCIBL, the students were exposed to a variety of topics that encouraged their desire to learn more about different subjects.

Access to Various Resources through Collaboration with Other Institutions

In addition to keeping track of student learning through MOOCIBL, the participants discussed how they had access to various resources due to the cross-institutional connections they had through the course. On MOOCIBL, students had access to the textbook and the syllabus, which the students found helpful. However, a participant also mentioned that MOOCIBL was not the initial place for them to find resources. Also, another participant noted that MOOCIBL was not the place where they collaborated with others. Still, it was a common platform used individually by the students, as they found other means like Microsoft Teams to collaborate with their groups.

The peer-review process through MOOCIBL was helpful for the students as other students could give them feedback before they submitted their tokens to the instructors. For example, Participant A said:

“On a larger scale, even doing the five token or the five pillar tokens and having the ability to have them peer-reviewed by a lot of different people who have different
experiences and would pick up on different things was also valuable and could be considered like other resources too, like the people in the other institutions.”

The participant found that having people from diverse backgrounds and varying perspectives can help with their learning as they receive feedback from multiple peers.

Also, Participant B said:

“It's kind of interesting, because you don't really do peer-review of homework assignments. You just kind of turn them in straight to the professor. And so if you do something wrong, you know, you're going to lose points right away. But having the peer review, in the MOOCIBL platform was another benefit because they could catch your mistakes before you submitted an assignment, which was nice.”

Students saw the benefit of the peer-review as other students could catch their mistakes before submitting tokens for instructor reviews, which provided multiple opportunities revise their personal learning.

The peer-review process also helped students engage with one another in the course as Participant C said:

“Yes, I'd say one of the big benefits is reviewing other students’ tokens. I think it can be hard in a traditional class. It can be hard to have lecture and then you have to go do your homework. And if you're not seeking out your classmates or creating study groups, then you're kind of left on your own and you’re stranded. But the way that the token review process through MOOCIBL works, we were forced to engage with other students and the way that they saw the material.”

Participant C saw the value of how the peer-review process helped students engage and connect with each other. Students had to review each other’s tokens and support one another in a way that may even be more interactive than the traditional classroom.

Other available resources students had through collaborating with other institutions included access to academic software. Students worked in research groups with one another and used the software together. They also found access to journal articles and databases through connections with other students. The students also had more access to various opportunities outside of the classroom, such as competitions at other institutions and conferences in multiple regions from the other institutions.

Expanding Network and Connections Through Course

Since the students came from a small liberal arts college, they found the value in expanding their network through the connections they made with their professors and the other students in their
course. Students had access to multiple professors across several universities with various research interests and expertise in their fields. For example, Participant B said:

“And then having, three or four professors taking point and teaching the class, there were even more additional people that we could meet and get introduced to with guest speakers coming to the course.”

In this way, the students had access to multiple experts in different fields. If they had questions about a particular area, they could approach a specific instructor.

Having more connections with multiple instructors also helped students gain access to more research opportunities and have more options for feedback from differing perspectives. Participant A appreciated the instructor’s input as they said:

“And the feedback that we got throughout the semester about our presentations and the research that we had been doing was really valuable. Because people had so much experience, like the instructors and the people in the class, so they were able to give really good feedback and things that people hadn't thought about from a research point of view.”

The professors provided active feedback throughout the course, which helped students learn and grow in their research and professional development.

The students also appreciated the encouragement of the professors, even though there were various challenges in the course. Participant C said:

“And so to have, your instructor, and all the other instructors have that humility of saying, ‘Yeah, this is a little difficult to understand. And to sort of meet you there. I think that was really helpful instead of you look at your professors, you're like, ‘Oh wow, they have so many degrees, they have so much experience. I don't even have my bachelor's yet. What am I supposed to do?’ To hear them say, ‘No, this is hard. I had a hard time with this.’ But to also hear them say, ‘I know that you can do it.’ That was definitely a huge thing in pushing forward.”

The students appreciated the professors’ humility in showing them that it was ok not to understand everything, and that learning is a growth process.

**Challenges of the Course**

Since the course was different from any other previous course they had taken, the students faced challenges in acclimating to MOOCIBL and understanding the course expectations. Students had to create their unique, personalized learning objectives through MOOCIBL, and they found it
challenging as it was different from how learning happened in the past. For example, Participant A said:

“It definitely was an adjustment for me, just because it wasn't like any class that I had ever done before.”

Similarly, Participant C said:

“Yeah, so I would say specifically, with cardio, getting used to the whole MOOCIBL model. There are a handful of learning objectives that are established, but the rest, I have to go on and create myself. It's a lot different from, since kindergarten being told, ‘Here's this assignment, fill it out and turn it back into me.’ It's just a completely different experience to be put in the position of, you need to need to take the initiative to decide what you're going to learn.”

The instructional team presented five core pillar concepts of cardiovascular engineering, which served as a guiding framework for student-initiated and self-identified learning objectives to show their level of comprehension of a pillar concept. These learning objectives are created as tokens and are evaluated in their depth (based on Webb’s Depth of Knowledge) and internal or external impact factors (e.g., self, group, college, society conference, etc.) [7] [9]. Students had to take the initiative in their learning instead of having an instructor-defined assessment to show understanding, which made it challenging for students. It was different from how they are traditionally taught in school.

Participant B discussed the confusion of how tokens worked:

“A challenge was that there was a little confusion at the beginning of what to do with the tokens. And I think that the instructional team didn't want to give too many examples or instructions on what to do, because then a lot of students would have just done that and not kind of broaden their scope. So, it was nice to have a little bit of confusion at the beginning, because it forced a lot of people to ask questions.”

Participant A also mentioned how they had difficulties getting their tokens reviewed through MOOCIBL as they said that it was challenging getting their tokens reviewed and would have liked to be able to communicate with the instructors directly.

Another challenge that Participant A mentioned was not having a unified view of the course as they perceived that there were unwritten and varying kinds of expectations. In this way, it was sometimes confusing for students to know if their submitted tokens aligned with the goals of the course. There were also some challenges with coordinating meetings and schedules with the students being in various time zones. The students also came from a wide range of backgrounds
as some were undergraduate students and others were graduate students, so there was a difference in knowledge levels.

Suggestions for Improving the Course

The participants gave many suggestions for improving the course, such as having more examples of tokens to help them understand how the token system works. Since MOOCIBL is different from any other learning system the participants have previously used, they would have liked to see more examples of what tokens are. Students thought it would have been helpful to have examples of tokens, especially for the Depth of Knowledge 3 and 4 tokens. However, students also recognized that learning occurs with having models through self-discovery and exploratory means. This model of learning can be beneficial as it relates closely to industry demands [13]. The participants also suggested having the course content taught at the beginning of the course to have more time to work on their tokens. Another participant suggested having a reminder or messaging system with notifications to help students track what they needed to get done in MOOCIBL. To alleviate the stress at the end of the semester, a participant thought it would be helpful to have deadlines throughout the semester instead of only at the end of the semester.

Discussion

This study only provides a limited view for a broader application into engineering programs due to the small sample size. It can only provide insight into a specific program or course experience. While half the students showed an overall positive experience, further research needs to explore students' experiences in other courses and at other institutions of varying demographics; therefore, results cannot be generalizable. However, there is significant value in exploring these student’s experiences, as small institutional experiences can be easily overlooked. Future work also includes implementing MOOCIBL in other disciplines, grade levels, and other under-resourced venues.

The student interviews provided rich reflection and feedback using MOOCIBL for an under-resourced academic program. Due to high costs and resources, a Cardiovascular Engineering course would not be feasible to teach at a small, liberal arts college without a robust engineering program. However, MOOCIBL breaks down barriers in creating opportunities for students at this smaller school to take specialized courses and receive instruction from multiple experts in their field. In this way, students can connect with other universities, expand their networks, and gain access to various research opportunities [14] [15]. This collaborative model of multi-institutional support is seen in a community of practice, where individuals collaborate from multiple organizations and institutions to achieve a common goal or purpose [16].

Additional possible implications include the wider outreach opportunities in places like engineering education deserts, where a lack of industry and academic resources are not fertile or non-existent [17]. With minimal costs, implementing MOOCIBL platform can provide greater
accessibility for these regions across the United States and even around the world. With the increasing demand for remote learning technologies and resources, getting MOOCIBL to these areas is easier than ever. Also, during budget cuts, financial constraints, and declining enrollment in the traditional classroom, MOOCIBL can serve as a collaboration point between several universities to share expertise and resources. When resources are minimized and courses canceled due to low enrollment, students lose out on the opportunity to learn and innovate [18]. MOOCIBL is scaled to allow students from all backgrounds to join, with the added instructional benefit of tracking student learning.

Bibliography


Appendix A

Interview Questions

1. Please describe your experience learning and working with other institutions through the MOOCIBL platform?
   a. Can you provide an example?
   b. How was it working with other students from different institutions?

2. What are some ways the MOOCIBL platform connected you to additional resources through other institutions?
   a. Tell me more about the different resources and opportunities that you had through this course.

3. How does the MOOCIBL platform create or break down barriers in student learning?
   a. What kind of barriers can exist in student learning in a course like cardiovascular engineering?
   b. How did you overcome those barriers?

4. After taking this course and using the MOOCIBL platform, how has the overall experience inspired you to do better or differently about your future learning goals and outcomes?
   a. How has it affected your future learning?
   b. What are some things you are interested in learning more about after taking this course?

5. What are some ways the MOOCIBL platform can help under-resourced programs?
   a. What opportunities did MOOCIBL give you access to that you wouldn’t normally be able to use/access?

Evaluating MOOCIBL

6. What were some benefits and challenges of using MOOCIBL?
7. How could the use of the MOOCIBL platform in this course be improved?
   a. Please provide specific feedback and suggestions.

8. Is there anything else that you would like to comment about the MOOCIBL platform or the course in general?