Switching Modalities: Implications of Online Education in Biomedical Engineering

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Introduction
The notion of providing higher education at a distance is growing at a rapid pace with advances in online and digital technologies. Currently, nearly 30% of all postsecondary students take at least one course at a distance, while public higher education institutions serve two-thirds of all distance learners [1]. The growing student population and the need for more skilled workforce, together, are changing the landscape of online education in engineering disciplines. The overarching purpose of this work is to review and demonstrate the implications of online education in biomedical engineering. Specifically, this work will present strategies, quality assessment, and lessons from designing and implementing the first fully online course in the Department of Biomedical Engineering (BME) at the University of Arizona.

Background
After three years of offering an on-campus version of an introductory, dual-level (graduate and undergraduate) course in biomedical informatics within the engineering curriculum, the course was transitioned to a fully online format in Fall 2019 to better serve the broader student population in BME and those in other engineering disciplines. The course surveys all subdisciplines of the field from bioinformatics, tissue/imaging informatics, medical informatics, and public health informatics, with more emphasis on medical informatics. This introductory biomedical informatics course was selected for an online format because of interest from students in several disciplines (e.g., engineering, statistics, health sciences). Furthermore, the course topics and content were more suitable and ready for virtual learning than other courses in the department as well as availability of instructional resources to support this initiative.

The course involves a 10-week project, along with weekly engagement and reflection activities that are designed to promote critical thinking and collaboration. Students were required to participate in a moderated discussion forum at least twice every week.

- *Discussion Forum:* Each student was required to initiate a new topic of discussion (*initiation* thread) related to the overall theme of the week as well as engage in a discussion with posts from one or more peers (*engagement* thread). Both initiation and engagement threads were meant to allow for weekly reflection among students and low-stakes assessment by course facilitators. Measures such as number of posts initiated, number of engagements with (i.e., replies to) peer posts, and number of posts read were automatically collected as a part of the forum management. Quality of posts and breadth and depth of topics discussed were monitored and assessed by the course facilitator.
- *Course Project:* Students worked in virtual teams of two in a mentored semester-long project with multiple design iterations. The project activity was divided into six stages: pre-proposal, proposal, two design review stages, final review stage, and project release. Each student pursued the pre-proposal stage independently to identify areas of interest and potential project ideas. Based on input from the pre-proposal stage, students were paired to form a project team. Each team then developed a project proposal with input from the course facilitator. Each team also created an online collaborative space (Google Drive folder or GitHub® repository) to initiate, maintain, and complete the project.

Quality Assurance: To assess the overall course quality and generate meaningful results to the engineering education community, the Online Learning Consortium's (OLC's) five pillars of online education will be used as a conceptual framework: learning effectiveness, access, scale, student satisfaction, and faculty satisfaction [2]. Additionally, the Quality Matters (QM) rubric [3] was used for continuous improvement purposes. An independent quality assurance team performed a Course Design Inventory, which is grounded in frameworks such as Universal Design for Learning (UDL) and the three modes of interaction based on the work of Moore [4] and Anderson [5]. This CDI provided recommendations based on best practices for student learning, primarily based around QM standards, ensuring elements that make navigation easier and providing multi-modal learning opportunities, among other aspects. Such quality assessment across six criteria, as shown in Table 1, is critical for understanding gaps and opportunities in online engineering education as more institutions adopt and/or expand their online program [6].

Table 1. Online Course Design Inventory*

Criteria 1: Course Overview and Information	
1.1	Course includes *Welcome* and *Getting Started* content on homepage
1.2	An orientation or overview is provided for the course overall, as well as in each module. Learners know how to navigate the course and what assignments are due
1.3	Learners have an opportunity to get to know the instructor
1.4	Expectations for timely and regular feedback from the instructor are clearly stated, including contact information
Criteria 2: Objectives and Alignment	
2.1	Course outcomes are clearly defined and measurable
2.2	Module outcomes are clearly defined, measurable, and aligned to course level objectives
2.3	Instructional materials are aligned to and support the learning outcomes
2.4	Assessments are aligned to and support the learning outcomes
Criteria 3: Assessment	
3.1	Course grading policy is clearly stated
3.2	Grading criteria is provided and tied to the grading policy
3.3	Course provides learners with opportunities for self-review and to track their progress
Criteria 4: Engagement and Modes of Interaction	
4.1	Learner to Content Engagement
4.2	Learner to Learner Engagement
4.3	Learner to Instructor Engagement
Criteria 5: Design and Accessibility	
5.1	The course is easy to navigate with a logical and consistent layout
5.2	The course design promotes readability and reduces cognitive load
5.3	Technology tools in the course are accessible
5.4	Links to technology accessibility policies are provided
5.5	Text is formatted with styles, fonts, and emphasis that enhance readability
5.6	Images are accessible
5.7	Text is accessible
5.8	Videos are captioned or have a transcript
5.9	Hyperlinks are descriptive
Criteria 6: Copyright	
6.1	Course and materials follow Copyright and Fair Use laws.

*The Course Design Inventory is a derivative of the Open SUNY Course Quality Review Rubric from Online Learning Consortium used under: CC By 4.0. This Course Design Inventory is licensed under CC By 4.0 by the University of Arizona, Office of Digital Learning.

Each sub-criteria (Table 1) was scored using the following rubric:

- 3 – There is clear evidence that the criteria is met and appropriate for the course.
- 2 – There is some evidence that the criteria is met, but needs to be presented more clearly and/or further developed.
- 1 – There is no evidence that the criteria is met.
- N/A – Criteria does not apply to the course.

Results

The course included a total of 42 students from five majors (biomedical engineering, clinical translational sciences, electrical and computer engineering, information sciences, and systems engineering). The discussion forum resulted in a total of 557 initiation threads and 674 engagement threads over the period of the entire course, providing a rich source of data to better understand students' learning process and misconceptions. An average of 40 posts per week were initiated by students, commensurate with enrollment. In terms of engagement with other peers, students directly engaged (i.e., replied to posts) with an average of 16 posts and implicitly engaged (i.e., read other posts) with an average of 145 posts.

The independent quality assurance and improvement process showed that there was some evidence that all criteria were met, but identified areas of moderate improvement in terms of design and accessibility (criterion 5) and course objectives and alignment (criterion 2 in Table 1). More specific results from this process and associated evidence are actionable and tailored to the instructional team, rather than a general audience. The overall process and methods, however, are of interest to general engineering education community.

Conclusion

We have presented preliminary results of developing and offering a fully-online course in biomedical engineering, with a focus on online engagement. We believe this work will serve as a steppingstone for designing, implementing, and assessing online courses in BME and other engineering disciplines, and identifying key opportunities for online engineering education, including low stakes assessments and virtual projects. It is also noteworthy that, at the time of this writing, the pandemic as a result of the 2019 Novel Coronavirus Disease (COVID-19) forced the majority of higher education institutions in the United States to temporarily move all courses and learning activities to online modalities. This transformative change, while transient, is likely to spur more conversations around online education in BME, for which a focus on universal design for learning and quality improvement, as described in this work, will be increasingly important.

References:

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