Board 7: Work in Progress: A Collaborative, Principle-focused Curriculum Design Process for a BME Undergraduate Program

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Work-in-Progress: A collaborative, principle-focused curriculum design process for a BME undergraduate program

How biomedical engineering (BME) students learn to approach problem-solving is critical—they must consider ethical and societal implications; develop and implement systems of increasing complexity; and become global citizens, working in diverse groups and contexts [1-5]. As educators, we are tasked with designing a curriculum that ensures our students graduate with the knowledge, tools, and experiences needed to meet these desired outcomes. And as our field evolves and changes, so does our curriculum.

Revising a curriculum is a time-intensive, complex process. In our efforts to make the process as efficient as possible, we can find ourselves focused on student outcomes to the exclusion of the consideration of the people who will have to carry out that curriculum: faculty. If we want our faculty to experience shared ownership and responsibility over the curriculum and buy-in to the process of continual improvement for the sake of our students' learning, then we must be intentional in our approach to curriculum redesign [6-8].

In this work-in-progress, we describe a curriculum redesign process undertaken by our undergraduate BME program at the University of Virginia in collaboration with Center for Teaching Excellence. This process was rooted in five design principles [9-12] for both product (the curriculum itself) and process (how the curriculum redesign process was carried out):

1. **Equitable**, in experiences and outcomes for students and participation for stakeholders;
2. **Purposeful** and intentional curriculum design decisions;
3. **Transparent**, in goals and requirements to students and design process to stakeholders;
4. **Learner-Centered** in all curricular decisions; and
5. **Aligned** among goals for student learning, pathways, course objectives, teaching pedagogies, and assessment.

These principles are applicable across institutional contexts, and we hope that our process can inspire other BME departments when they undertake their own curriculum revisions.

Process Overview

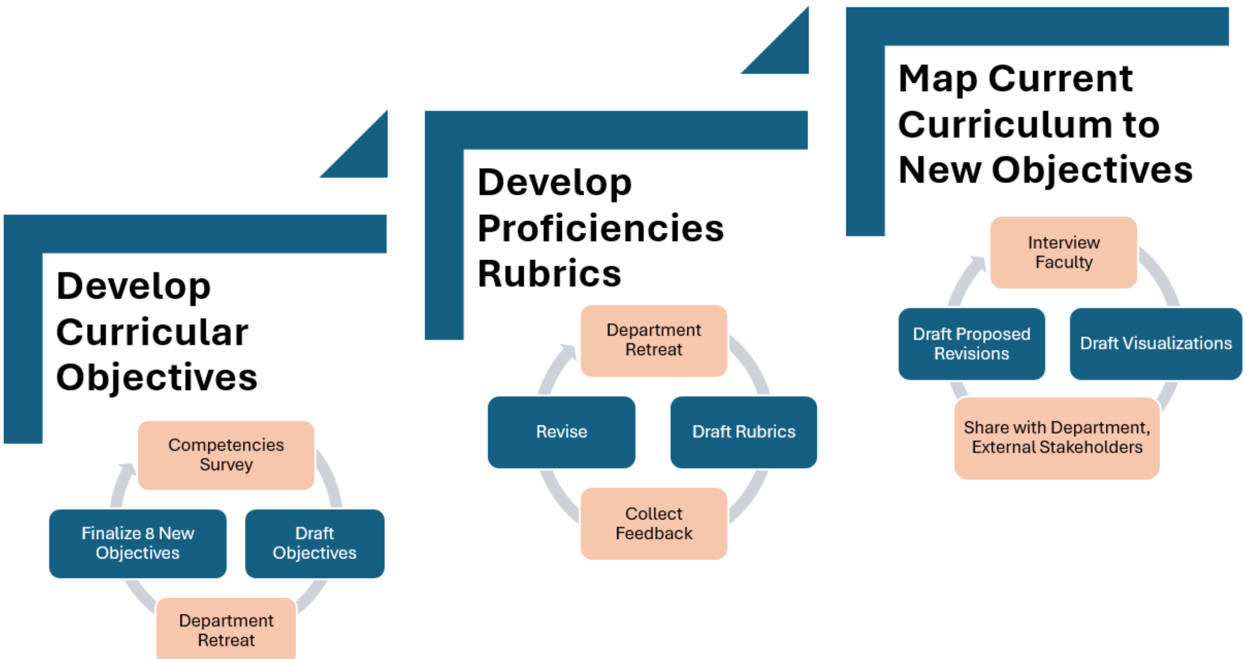
Our redesign is facilitated by our program's undergraduate program director and the Undergraduate Program Committee (UPC), which consists of five associate and full professors. Two of these faculty are also on the department's Diversity, Equity, and Inclusion committee, and all members teach, advise, and mentor undergraduate students. All faculty within the department, regardless of tenure status, number of courses taught, etc., have been participants in the process.

Figure 1 provides an overview of completed phases of our current redesign process and demonstrates the shared labor among the UPC and the department faculty. Each phase included mini-cycles of information gathering, drafting, collecting feedback, and revising. These "mini-cycles" are central to the success of the entire curricular redesign process, as they increase transparency and the collective contribution of faculty to the redesign.

To illustrate the power of this approach to curriculum redesign and to demonstrate incorporation of the five design values, we describe in greater detail two of these phases with their corresponding mini-cycles: 1) developing curricular objectives and 2) mapping the current curriculum to the new objectives. IRB approval was not required for work completed in this paper.

Figure 1

Current Curriculum Redesign Process with Mini-Cycles of Faculty Engagement



Curricular Objective Development

The process began by developing a collective understanding of what students should learn (Principle 4). Surveys were sent to alumni and employers (Principles 1 & 3), asking them to choose from a list the competencies they deemed important and at what level of learning (introductory, more practice, deep understanding). Survey results were used by the UPC to formulate 13 draft curricular objectives (Principle 2; see Appendix Table 1). Then, through a survey, faculty mapped their individual course learning objectives to the 13 draft curricular objectives and indicated level of learning (Principles 1 & 3). The resulting mapping data indicated that the program's core courses covered each of the 13 draft curricular objectives at some level (Principle 5). Next, through a department retreat, faculty articulated how they would know a student had learned a particular objective at each level of learning (Principles 1, 3, & 4). These discussions revealed interesting overlaps and redundancies in the draft objectives, prompting the UPC to revise the 13 objectives into 8 (Principle 2; see Appendix Table 2). These new curricular objectives were then shared with faculty and voted on (Principles 1, 2, 3, & 4).

During this minicycle of gathering, drafting, feedback, and revision, faculty were heavily involved at each stage. For example, 90% of faculty completed the objective matching survey, and at the retreat mentioned above, ~80% of the department faculty participated, including 21 tenure-track faculty (12 full, 5 associate, and 4 assistant) and 3 teaching-track faculty.

Curriculum Mapping

During this minicycle, faculty collectively worked to understand how the current curriculum reflects the new curricular learning objectives. To calibrate the mapping of course objectives and evidence of student learning to the curricular objectives, the UPC conducted one-on-one interviews with each undergraduate course instructor (Principles 1, 3, & 4). These faculty were asked to choose two or three curricular objectives most central to their course and apply its associated proficiency rubric to their course. These proficiency rubrics list criteria and qualifiers for each criterion for student learning the different levels of learning and were developed with iterative feedback from the faculty. An example can be found in Appendix Table 3. Based on these interviews, the UPC developed a curriculum map and visualizations (Principles 4 & 5; two examples are shown in Appendix Figures 1 & 2) showing where the current curriculum covers each learning objective, at what level of learning, and in what courses and student years. At a second retreat, faculty reviewed these visualizations in a gallery walk and discussed their observations (Principles 1, 2, 3, 4, & 5). Faculty then shared ways the UPC could use the mapping data to make proposals for changes in the curriculum: How could gaps or deficiencies be addressed? What other data are needed before making changes? (Principles 1, 2, 3, 4, & 5).

Again, faculty were highly engaged at each step: 100% of faculty teaching an undergraduate course were interviewed, and at the second department retreat, ~70% of faculty participated, including 18 tenure-track faculty (10 full, 4 associate, and 4 assistant), 2 teaching-track faculty, and 1 lecturer. At the conclusion of this retreat, attendees were asked to complete an exit survey. Responses showed clear appreciation for our approach, as well as an acknowledgement that we as a department have work to do together on the curriculum to better reflect our new objectives.

Future Work and Conclusion

While they are central and essential to our redesign process, faculty are not our only stakeholders. In our future work, the new curricular objectives and proficiency rubrics, along with curriculum mapping data, will be shared with a focus group of current undergraduate students, as well as external stakeholders (including alumni, employers, and the program's external advisory board), for observations and input. Once input has been received and any final adjustments to the objectives and rubrics have been made, the UPC will develop proposals for curriculum changes. These changes may include changes in sequencing, course offerings, or individual course changes. The UPC plans to use the objective rubrics to track student learning over time to ensure the curriculum continues to meet the program goals and values.

Clearly defined curricular objectives and concrete data visualizations may be precursors to the wholescale curricular *product* of this redesign. Small successes like continued faculty investment and diverse faculty participation may be key indicators of progress in a complex, protracted, collaborative *process*. By prioritizing equitable participation and partnering with institutional support, we utilize the very strategies for success that we encourage for our students.

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Appendix

Table 1:

Initial Draft Curricular Learning Objectives

1. Define and apply foundations of physical and life sciences
2. Define and apply mathematical, computational, and engineering foundations.
3. Integrate physical and life science, mathematical, computational, and engineering principles toward BME-specific applications.
4. Define and perform the engineering design process
5. Define and perform fundamental steps in the research process
6. Analyze, visualize, and interpret data
7. Measure and perturb biological and biomedical systems
8. Develop strategies to continuously acquire contemporary concepts and skills
9. Function on a team where members together provide leadership, create a collaborative & inclusive environment, and effect goals, tasks, and objectives
10. Communicate science and engineering concepts and results to a variety of audiences
11. Recognize ethical principles in biomedical applications
12. Identify relevant aspects of the governmental regulatory process
13. Demonstrate awareness of inclusivity, equity, and empathy in research and design

Table 2

Revised Draft Curricular Learning Objectives

1. Apply physical and life science, mathematical, computational, and engineering foundations and integrate them toward BME-specific applications.
2. Define and perform the engineering design process within the biomedical engineering discipline.
3. Define and perform fundamental steps in the research process.
4. Make measurements on and interpret data from biological and biomedical systems.
5. Develop strategies to continuously acquire contemporary concepts and skills.
6. Function on a team where members together provide leadership, create a collaborative and inclusive environment, and effect goals, tasks, and objectives.
7. Communicate science and engineering concepts and results to a variety of audiences.
8. Demonstrate an awareness and application of ethics, inclusivity, equity, and empathy in biomedical research and design.

Table 3

Proficiency Rubric for Objective 6: Function on a team where members together provide leadership, create a collaborative and inclusive environment, and effect goals, tasks, and objectives.

Criteria	Exposed	Familiar	Depth
Team dynamics	Identify and list key factors to consider in team formulation; Identify and list common team remediation tactics; Identify and list the characteristics of a good team player	Develop a team remediation plan; Develop a peer evaluation process	Apply team remediation tactics and reflect on the outcomes; perform a peer evaluation process and reflect on outcomes
Team mechanics	Describe the various roles and expectations required for effective team outcomes.	Determine team roles and develop a set of expectations	Perform a post-hoc analysis of project outcomes and reflect on the impact of each team member toward those outcomes
Inclusion & valuing diverse perspectives	Describe the value of having diverse lived experiences represented on a team	Identify the value of each team members' perspectives and strengths	Evaluate the synergy produced when diverse teams work together positively

Figure 1

Curriculum Map showing how many courses are matched with each curricular learning objective at all levels of learning (introductory, more practiced, deep understanding).

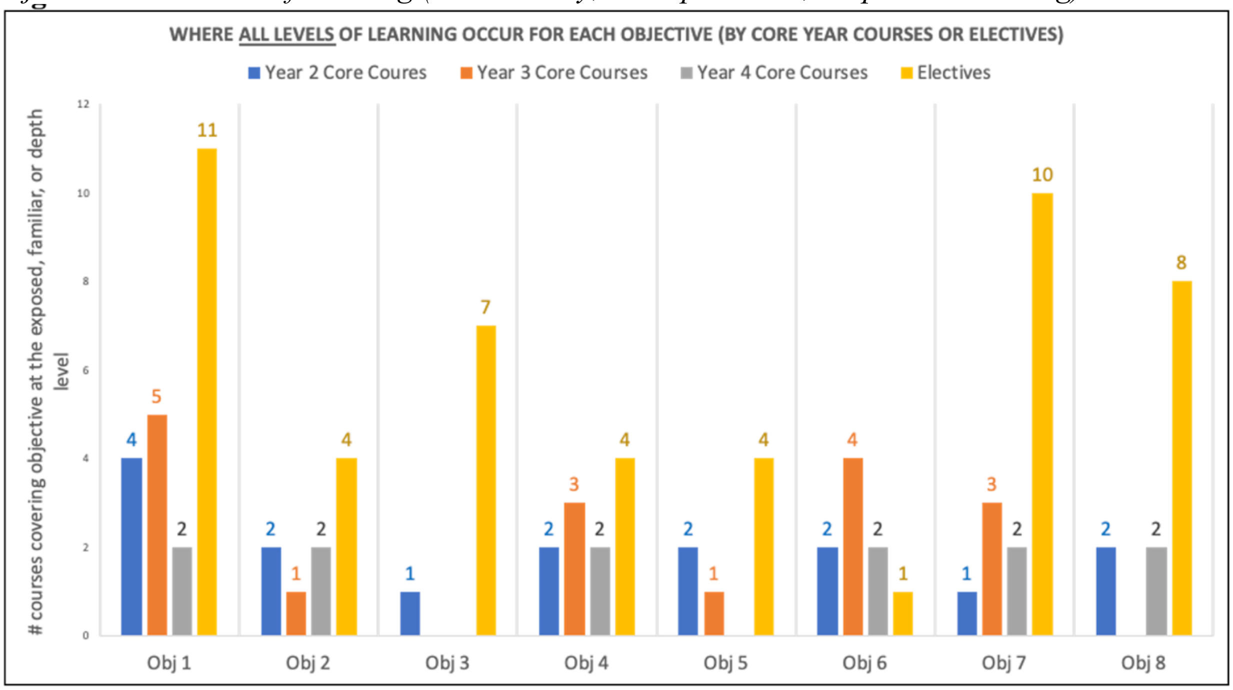

Figure 2

Curriculum Map showing how many courses are matched with each curricular learning objective at only the deep understanding level of learning.