Work in Progress: 3-D Curriculum - An Innovative Structure to Model the Co-curricular Experience in Biomedical Engineering

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(Work in Progress) 3D Undergraduate Experience: An innovative structure to foster the co-curricular activities in engineering

The era of producing graduates that perform reliably from a one-size-fits-all flowchart called curriculum is over. The sharp increase in co-curricular activities has been calling for a new framework. The 3D framework we developed has the capacity to create the eco-culture necessary for educational innovation. The book "A Whole New Engineer: The coming Revolution in Engineering Education [1]" inspired us to create this cultural transformation. In the final report of a three-year study of engineering education led by Leah Jamieson and Jack Lohman [2], one of the seven recommendations was: Expand collaborations and partnerships between engineering programs and a) other disciplinary programs germane to the education of engineers as well as b) other parts of the educational system that support the pre-professional, professional and continuing education of engineers. The 3D framework addressed these recommendations.

This is a process that aligns the attributes of graduates with their post-graduate plans in a way that is customized for each student in the program. In the first dimension, the *academic foundation*, core courses required of all students have been converted into course bricks that include professional and ethical development activities. A course brick is a course structure with ABET student outcomes embedded in it. In the second dimension, the *community creation*, students pursue a diverse set of opportunities unique to their personal interests and goals such as clinical, research, and entrepreneurial experiences to be realized in partnership with other academic divisions including the medical school, business school, college of veterinary medicine, college of design, or college of arts and sciences. In the third dimension, *professional development*, students assimilate a rich set of professional skills. The pedagogical theory behind the 3D Undergraduate Experience is competency-based learning (CBL). CBL is especially effective in interdisciplinary fields such as Biomedical Engineering as its primary strategy is autonomous learning [3]. In the 3D framework, this theory is applied not just to the academic foundation, but to the entire educational process while addressing the assessment challenges that plague CBL.

Figure 1 and Tables 1-2 outline the 3D Undergraduate Experience. To graduate, students complete the 1st dimension (Figure 1). To receive a Certificate in Leadership and Professional Development, students complete the 2nd and 3rd dimensions. Most students are already deeply committed to activities described in these dimensions, but pursue these activities in a self-directed and unstructured manner. 3D framework gives direction to motivated students and encourages reticent students to broaden their field of knowledge.

Assessment: The academic foundation is currently assessed through our rigorous accreditation process. The Certificate for Leadership and Professional Development program will be assessed through its program objectives given below.

- Pursue opportunities for innovation and entrepreneurship
- Lead the way to address problems related to local and global healthcare
- Continue education in BME or another field in one of their top three academic choices
- Advance in professional positions that align with their career goals

1st Dimension -- *Academic foundation:* The academic foundation is illustrated in Figure 1, but may be replaced by the established BME curriculum at any institution. Students complete fundamental courses (white blocks) in Calculus, Chemistry, Physics and English before beginning lab-based fundamental engineering courses in design, material science, mechanics, electronics and computer programming taught from the perspective of biomedical engineering (gold). As juniors (orange), students continue design and study human physiology using engineering analysis. Students choose gateway electives that prepare them for senior level specialization electives (green). The specialization areas are in alignment with BME faculty research to encourage synergy between research and teaching. The curriculum culminates in a two-semester clinical immersion senior design sequence. The classes are held in design studio format with two of them are on site at hospitals. Senior design course responds to the economic and technological changes promptly. Increased emphasis on medical economics and using a software package to manage design controls are the latest actions.

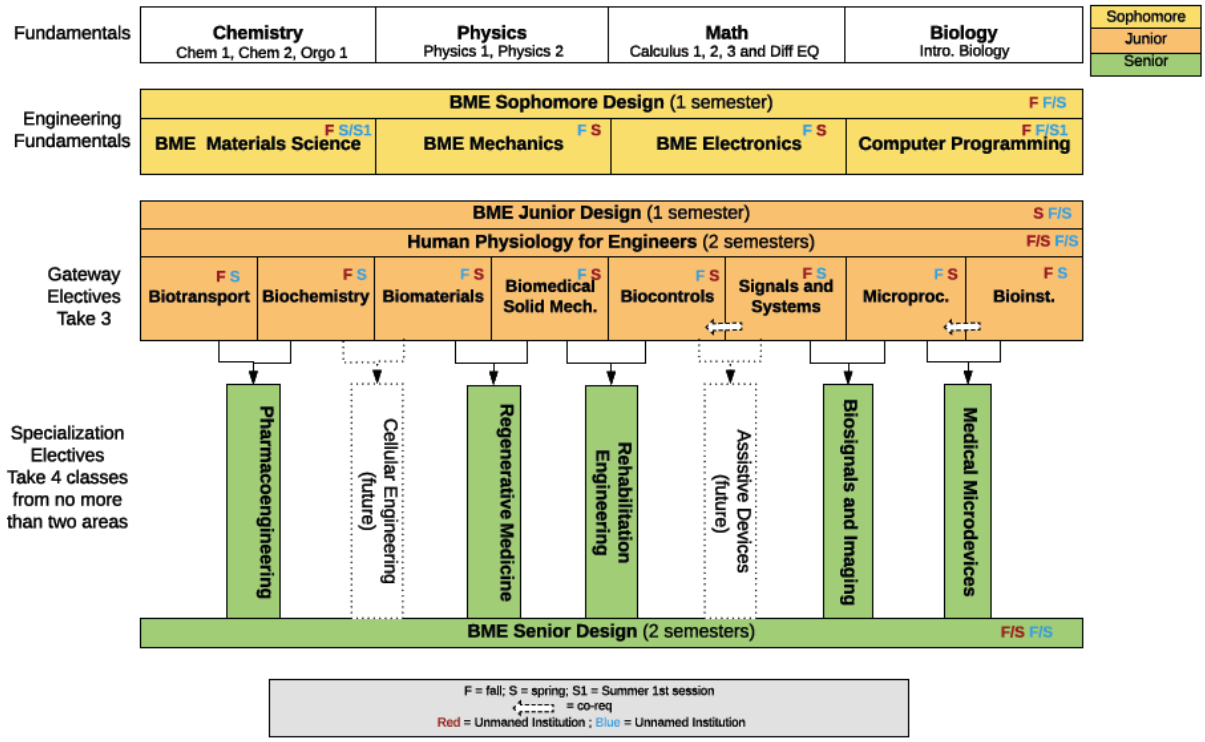

Figure 1: Academic Foundation: Three tier unified curriculum for the joint undergraduate biomedical engineering program between two institutions.

2nd Dimension –*Community Creation across institutional boundaries*: In the second dimension, students pursue activities to prepare themselves for careers in fields such as medicine, research, industry or entrepreneurship. At least one activity must be outside the College of Engineering in the medical school, veterinary school, business school, design school, or even another educational institution, encouraging students to cross institutional silos. Community creation contributes to program scalability. Example activities are shown in Table 1.

Table 1: Example activities for industry/entrepreneurial, clinical or research career goals.

Required related activity	*Examples*	*Organization (at least 2)*
Additional course	Entrepreneurial– Course in regulatory affairs	Business School
	Clinical – Course in pharmacokinetics	Veterinary School
Honors credit	Research – Academic based honors project in related course	Arts and Sciences
	Entrepreneurial – Medical economics based honors project in related course	Business School
Community involvement	Clinical – Attendance at grand rounds	School of Medicine
	Research – regular attendance at research seminars	Varies
Internship	Industry – industry internship	Company
	Clinical – Clinic volunteer or shadowing	Clinic
Capstone activity	Entrepreneurial –Certification as six sigma green belt	Industrial Expansion Solutions
	Research – Presentation at national research conference	Varies

3rd Dimension --*Professional development*: The first two dimensions serve as a platform for the third dimension, devoted to professional development, service, and leadership. Students must satisfy goals in each row of Table 2.

Table 2: Example activities for each professional development category

Category	*Examples*
Leadership Activity	Organize student activity or hold leadership position
Global Engagement	Study abroad or course in global engagement
Ethics Training	Complete ethics modules from NIH or NAE or participate in Rotary Club ethics initiative.
Community Participation	Helping Hands Participation or work with the Veteran's Bunker.
Mentoring and Outreach	Tutoring or activities that introduce younger students to study STEM fields
Communication Skills	Join Toastmasters or present research at a conference.

Conclusion: The leadership provided by students has been critical in developing the concepts behind the 3D Undergraduate Experience. This is a student driven process and they choose the skills relevant to their personal career goals with the guidance of their mentors.

References

[1] David E. Goldberg and Mark Sommerville with Catherine Whitney, "A Whole New Engineer: The Coming Revolution in Engineering Education," ThreeJoy Associates, Inc., 2014.

[2] L. Jamieson, J. Lohman, "Innovation with Impact: Creating a Culture for Scholarly and Systematic Innovation in Engineering Education," Washington DC, ASEE, 2012.

[3] M. Henri, M. Johnson and B. Nepal, “A review of competency based learning: Tools, Assessments, and Recommendations,” *JEE*, vol. 106, no. 4, pp. 607-638, 2017.