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The VaNTH Bioengineering Curriculum Project

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***Abstract* – The NSF-sponsored VaNTH Engineering Research Center in Bioengineering Educational Technologies is developing a website, www.vanth.org/curriculum, to provide a forum for ideas about bioengineering curriculum. Two elements of that site are: 1) a listing of recommended core content, as opposed to core courses, for biomedical engineering undergraduate programs, and 2) recommendations for creation of curricula in terms of both content and pedagogy. This presentation addresses these two area. Our recommendations are intended to allow programs to meet a set of standard criteria that will allow industry, in particular, to understand what a biomedical engineer is, while allowing universities to meet local constraints and take advantage of their own strengths. Feedback from a broad cross-section of the bioengineering community is now needed to achieve agreement on core elements of a biomedical engineering curriculum.**

***Keywords* – Curriculum, undergraduate education**

I. Introduction

One of the goals of the VaNTH (Vanderbilt-Northwestern-Texas-Harvard/MIT) Engineering Research Center in Bioengineering Educational Technologies is to define curricula in bioengineering. While we are working on all areas of bioengineering, we restrict our attention here to that segment of bioengineering that has medical implications. Biomedical engineering (BME) curricula at successful programs across the country appear quite diverse on the surface, and we do not believe that VaNTH can reverse this and identify a set of core courses that all undergraduate biomedical engineers should take. (There is no course presently required in all of the accredited biomedical engineering programs.) Instead, we have decided to focus on 1) defining core *content* (as opposed to *courses*) that could be covered in a variety of ways in different programs, and 2) providing recommendations about the process of designing a curriculum, based on experiences of the VaNTH universities and on learning science principles. If we can accomplish these aims, it will provide a great service to new programs and it will provide clarity for the bioengineering industry about a common knowledge base that can be expected of biomedical engineers. Our concept is that biomedical engineering programs can teach the core material either as blocks or as material integrated into many courses throughout the undergraduate curriculum. BME programs will generally then go beyond the core to teach selected areas that fit constraints and opportunities at each university. At present we are focusing on undergraduate education, with work toward graduate education planned.

II. Core Content

To date, ideas about core content have been reviewed within the VaNTH Center by faculty specializing in many content areas (domains) of biomedical engineering and/or in the "core competency" areas of communications, design and ethics. The charge we have accepted is to define the set of knowledge and skills that may be required of all biomedical engineers, no matter what branch of the field they may enter in the future. We also need to consider not only the needs for today's biomedical engineering graduates, but those of the future, so that the core content does not have to be revised yearly. To our knowledge, there has been no attempt to obtain agreement on core topics previously. Currently, the proposed parts of the core include topics in 1) signals and systems analysis, 2) instrumentation and electronics, 3) imaging, 4) chemical physics and thermodynamics, 5) materials, 6) mechanics, 7) fluid mechanics and transport, and 8) particular applications of mathematics, e.g. statistics and modeling. There is also general agreement, among academia and industry, that physiology is core knowledge for biomedical engineering. Further effort will be required to identify the equally important core concepts in other areas of biology. Finally, the core contains a set of "core competencies," sets of skills and abilities that are independent of bioengineering content.

Few current faculty have a knowledge base that is as broad as the biomedical engineer we are defining, so it appears that the biomedical engineer may be a distinct species. This has been a tacit assumption of programs that have been teaching undergraduate biomedical engineering for many years. We do not claim to be inventing the biomedical engineer, but simply making the definition more visible, and seeking agreement on it. Interestingly, from the list of core topics we have generated so far, it appears that one might be able to teach all of the core engineering content without ever specifically referring to biological systems, because none of the important topics are unique to biomedical engineering practice. However, the breadth of knowledge in this core allows the biomedical engineer to analyze more aspects of complex biomedical problems and synthesize more solutions than can be expected of other engineers. Further, the scales of forces, lengths, temperatures, chemical reactions, etc. that a biomedical engineer needs to be comfortable with may be

different from those dealt with by any other engineer, and this idea may need to be part of the specification of a biomedical engineer. Finally, while the individual topics may not be unique, anecdotal evidence from successful existing programs shows that teaching engineering topics in the context of biological systems, and teaching biology from an engineering point of view is beneficial. This approach often provides the most motivation for biomedical engineering students. In addition, until they become experts, we know that students often have difficulty applying concepts they have learned to new problems. Integrating engineering and biology early in the curriculum probably assists students by making their knowledge more relevant, thereby reducing the step size when they are required to transfer their existing knowledge to solve new problems.

III. Website

These ideas about core content and curriculum design are the main thrusts of a new, public part of the VaNTH web site: www.vanth.org/curriculum. The main audience is intended to be faculty engaged in developing, assessing, or modifying curriculum. The website is currently available, and is continually undergoing enhancements. The main elements of the web site will provide:

- Information on the state of the art of curricula in bioengineering nationally,
- Information on the bioengineering curricula of the VaNTH institutions as examples,
- Design principles and recommendations for the creation of new bioengineering curricula,
- A description of the integration of core competencies with bioengineering content,
- Web and text references and resources for curricular planners,
- A forum for feedback and discussion of bioengineering curricula.

Feedback from a broad community is now necessary to make our curricular recommendations valid, and we invite faculty and industry feedback on any portion of this work, particularly our attempt to define core concepts.

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