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Enhancing Core Competency Learning in an Integrated Summer Research Experience for Bioengineers

The NSF-sponsored VaNTH (Vanderbilt-Northwestern-University of Texas at Austin-and the Harvard-MIT Division of Health Sciences and Technology) Engineering Research Center in Bioengineering is focused largely on research to improve bioengineering pedagogy. As part of that effort, VaNTH has been exploring ways to offer core competency instruction, in areas such as ethics and communication, in both for-credit courses and non-credit settings. One non-credit setting is the VaNTH summer Research Experience for Undergraduates (REU). VaNTH REU students focus on projects in significant bioengineering domains such as systems physiology, tissue engineering, biomedical optics, etc. Following the recommendations presented in The National Research Council report *How People Learn* (Bransford, Brown, and Cocking, 1999), VaNTH faculty strive to integrate meaningful instruction in ethics and communication into students' research activities. Assignments for a mini-course in ethics and communication include a range of writing experiences, coordinated with each student's research focus and also the ethics curriculum. Instruction involves feedback, reflection, and conversation tied to reading, writing, and oral presentation assignments.

A major project for each REU student in 2002 and 2003 was to write and revise a paper focusing on an ethical issue related to his or her research. Students began by looking at the Belmont Report (the foundation for the U.S. government's regulations governing research with human subjects) and the VaNTH ethics taxonomy (www.vanth.org/curriculum/taxonomies/Taxonomy_Dec15_all_levels.doc). Faculty from ethics, communication, and learning science facilitated weekly, multi-site teleconferenced discussions. In addition, small groups of faculty and students at each site met weekly to discuss their ideas. In essence, we used the case study approach recommended by many experts in ethics education. Students focused on real situations in which ethical questions can arise and to which the ethical principles covered in their readings and discussion could be applied. Each identified an ethical issue related to his or her research, such as bias in research studies, equity in resource allocation, or ownership of intellectual property, and wrote about it in a detailed 8-10 page paper. After receiving feedback from both ethics and communication experts, students prepared a final report and slide presentation.

At both the beginning and the end of the summer, students were asked to construct two concept maps to represent their thinking: one showing the "10-20 most important concepts in bioengineering ethics" and the relationships among them, and the other showing "10-20 most important concepts in technical communication" and the relationships among them. Given the limited time available for core competency instruction, we sought to measure students' changes in understanding but not in their actual ethical decision-making or writing. We also sought an assessment method that would be efficient to administer and would take little time away from the students' main research activity.

We looked at the total number of nodes and lines students included in their concept maps and

compared node labels included in student maps to those included in maps drawn by experts. Ethics concept maps drawn by students at the end of the summer had significantly more nodes and lines than those drawn at the beginning of the summer. Each ethics map was also inspected to see whether each of the key concepts identified by the ethics expert was present or absent; three of these were the three key principles identified in the Belmont Report.

Overall, students showed a significant increase in their inclusion of concepts that made up the top level of the expert's concept map. The change was statistically significant for all three Belmont code concepts (respect for persons, beneficence, and justice), as well as for integrity and for credit for work. There was no change for responsibility. As anticipated, the proportion of students mentioning right vs. wrong (a more simplistic ethics perspective) decreased, though not significantly, from the beginning to the end of the summer.

Communication concept maps were also scored to see whether they incorporated key concepts identified by an expert. In contrast to the findings for ethics maps, communication concept maps drawn by students at the end of the summer did not differ in number of nodes or lines from those drawn at the beginning of the summer. This may suggest that students began the summer with more knowledge about communication than ethics. However, students at the end of the summer mentioned significantly more key concepts than at the beginning. Two concepts, multifaceted nature of technical communication and audience, were mentioned significantly more frequently; three others – persona, tone, and technology--showed positive trends. There was no change for purpose.

These findings suggest that students can make meaningful, measurable strides in core competency mastery by participating in a community of practice, even in a non-credit setting. This implies that core competency instruction can be integrated more broadly into the regular engineering curriculum. For example, faculty members who supervise student researchers in independent study, or even in design competitions, can guide them toward documents like the Belmont Report and help them reflect on the ethical and communication dimensions of their projects.

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