

Educational Outreach Using Learning-Theory-Informed Modules

Alene H. Harris, Ph.D., Stacy Klein, Ph.D.

Department of Teaching and Learning, Vanderbilt University / Department of
Biomedical Engineering, Vanderbilt University

Introduction

For the past four years bioengineering and learning science faculties of Vanderbilt University, Northwestern University, the University of Texas at Austin, and Harvard/MIT Health Sciences Technology have collaborated in the NSF-sponsored VaNTH Engineering Research Center for Bioengineering Education and Technology. Two of the Education Program goals are (1) to provide training in basic HPL philosophy and methodology to K-12 science teachers and to VaNTH institution graduate and undergraduate students for the development of bioengineering-related modules and (2) to raise awareness of bioengineering in general, particularly to K-12 students.¹ Thus, a key thrust of this ERC is the development and dissemination of bioengineering-based secondary school materials and teaching strategies that incorporate current “How People Learn” (HPL) learning theory as set forth in the National Research Council’s *How People Learn: Brain, Mind, Experience, and School*.² This theory involves the integration of lesson elements that are *knowledge-centered, learner-centered, assessment-centered, and community-centered*.

Learning Modules Design

Through the cooperative efforts of bioengineering and education professors, secondary teachers, and bioengineering undergraduate and graduate students, and education graduate students (facilitated through the sponsorship of Student Leadership Councils, Research Experience for Teachers programs and Partnerships in Education and Research programs), VaNTH outreach efforts now include a variety of bioengineering-influenced, inquiry-based modules for grades 5-12 classrooms. Each of these modules is designed using the Legacy Cycle, a challenged-base approach that takes students through six explicit phases of inquiry: (1) a *challenge* that provides enough background knowledge to enable them to engage in (2) the *generation of ideas* to determine what they know and need to know, (3) *multiple perspectives* of information from other sources, (4) opportunities to *research and revise* their initial thoughts, (5) opportunities to “*test your mettle*” and formatively self-assess conceptual understanding, and (6) go public activities that provide a solution to the original challenge.³ These six incorporate the four “centerednesses” identified above, as they provide opportunities for students to engage with appropriate and well-organized content (knowledge-centered), to relate this content to their own prior knowledge and experiences (student-centered), to check their own understanding/comprehension of their conceptualizations (assessment-centered), and to collaborate with one another in solving problems (community-centered).

Summary of Outreach Efforts

Over the past three years, the outreach programs of VaNTH have involved over 270 teachers and reached almost 2400 students; Table 1 below shows outreach growth through the past three academic years¹. Participants within the four institutions of VaNTH have leveraged NSF funding and resources in several ways to achieve these results. Some pursued and received a supplemental Research Experience for Teachers (RET) grant. Others pursued and received supplemental Partnerships in Education and Research (PER) grants. Still others developed materials and modules without additional external funding. As each ERC site had a Student Leadership Council (SLC) composed both of VaNTH-supported graduate students (bioengineering, learning science, and technology) and volunteer bioengineering undergraduate students, each site had a resource of “student power” that it could engage in developing and disseminating modules. These students participated in a variety of ways: they researched information, developed materials, assisted teachers with lab activities, taught lessons, collected data, assessed student learning and teacher satisfaction, and revised materials.

Year	2000-01	2001-02	2002-03	TOTAL
# Teachers	0	144	127	271
# Students	108	535	1748	2391

Table 1. Secondary Teacher and Student Involvement Resulting from VaNTH Outreach.

Outreach programs developed through the RET and PER programs typically followed a six-step path from initial development to the recruitment of multiple teachers (see Figure 1). Secondary science teachers have indicated that two things within this process influence them to adopt these modules for their own classrooms: (1) the modules are based on current National Science Standards and (2) the modules have received testing, review, and revision and have demonstrated a proven track record of student academic achievement. The remainder of this paper provides a brief description of the outreach efforts at each of the four institutions.

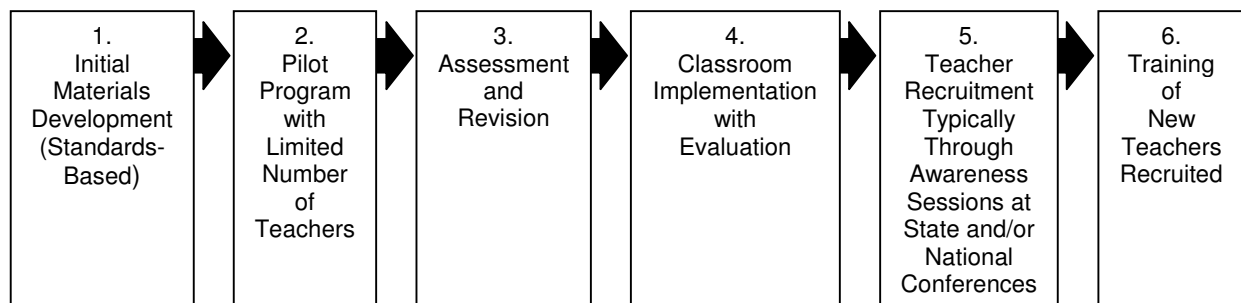


Figure 1. Steps in Module Development and Outreach.

Outreach Efforts at Four Sites

Working from a Research Experiences for Teachers (RET) supplemental grant, Vanderbilt professors in education and biomedical engineering mentored a group of six high school teachers in developing, implementing, refining, and validating seven bioengineering-related and HPL-based modules, each linked to national science standards. The modules (ECG, Swimming, Optics, Imaging, Balance, Hemodynamics, and Iron Cross⁴) involve a mix of physics, chemistry, math, design, bio-optics, biomechanics, imaging, and systems physiology; they vary from two to six weeks in implementation length.⁵ Thus far they have been implemented for two years in five Nashville schools, including public magnet, public standard, and private. SLC students provided classroom lab support. Six of the seven modules are completed and ready for wider distribution; one module is undergoing more refinement. University faculty and secondary teachers developed and presented awareness sessions on the modules at two national science teachers conferences (National Association for Research in Science Teaching, National Science Teachers Association). They then developed a modules dissemination workshop, and additional NSF funding provided a workshop this past summer to follow up this national exposure with the opportunity for teachers from several states to participate in module training. Also, teachers who served as control teachers in the testing of the modules in year one were mentored by the experimental teachers to use the modules in their own classrooms the following year. Future outreach goals include further national dissemination through awareness sessions at conferences, the training of teachers at workshops, and the training of trainers to allow concurrent workshops in a variety of sites.

Working from this RET grant, a Northwestern professor of learning science with a background in bioengineering began with a pilot study involving two teachers and expanded to with nineteen Chicago area teachers to involve them in all phases of an educational research project to improve the teaching of science, engineering, technology, and math. The project also provided SLC students with experience in science curriculum design and testing, as well as in the design of bioengineering-related lab equipment. The resulting *I, Bio* program is a systems physiology-based and National Science Standard's-based middle school science semester curriculum⁶ of multiple modules that includes teacher materials, in-class technology, and classroom student kits. The program has been disseminated through the addition of a University graduate level course for middle school science teachers. Future goals include completing a comprehensive empirical evaluation of student subject-matter learning by those teachers who have taught the materials, identifying sustainable means to fund future research related to student and teacher achievement with the curriculum and its professional development, and expanded dissemination within the Chicago-area schools.

Working from a Partnerships in Education and Research (PER) supplemental grant at Northwestern, a professor of bioengineering and a professor of education involved bioengineering students in the development of module for middle school student to design, build, and test an artificial limb⁷. Goals of the Artificial Limb module included encouraging middle school students to develop/increase interest in math, science, and engineering through real-work problems and increasing university students' understanding of teaching and learning. Two SLC graduate students funded by the PER took the lead in module development activities that actively involved over 20 undergraduate SLC students in a collaborative design process. The resulting

two-week module has been disseminated by university students into a Chicago Public School middle school science classroom each academic quarter – three classes per year. The site is in the process of developing a teacher manual so that the module can be implemented independently by teachers. Also, SLC student groups at other VaNTH institutions are working to incorporate this module into their own outreach activities. Moreover, a collaborative relationship established with the Chicago Museum of Science and Industry promises another source of outreach. Future goal include further module implementation throughout Chicago Public Schools, especially through collaboration with the Center for International Rehabilitation.

Working from a Partnerships in Education and Research (PER) supplemental grant at the University of Texas in Austin, two bioengineering professors and an education professor involved secondary teachers, preservice and inservice education students, SLC graduate students, and bioengineering undergraduates in collaborative design teams to develop three standards-based modules: the first on the biomechanics of jumping, the second on optics, and the third on ethics. An objective of this project is to establish close collaboration among teachers in the Austin Independent School District, preservice teachers at the University, and the VaNTH ERC⁸. The involvement of preservice teachers provides a venue for continued outreach as these students incorporate the modules into their field-based experiences as well as their own classrooms after they graduate and assume a teaching position in a school.⁹ Outreach activities have also included workshops with teachers in the San Antonio Independent School District, building on former collaborative efforts with these teachers. Future goals include building on previous work with inner city middle school teachers in New Jersey through a special institute.

Working without additional external funding in the Harvard/MIT Health Sciences Technology Program, an ERC-funded staff member responsible for overseeing SLC activities has facilitated the development of a variety of SLC student-developed modules. Led by a graduate student, the SLC has designed and implemented four HPL-based modules for high school students, in collaboration with the National Space Biological Research Institute. Entitled “Spacercize,” this collection of modules (referred to as a *mosaic*) has been shared in a summer project with teachers in the Cambridge area. Other student-developed modules for secondary students include an Egg Drop module that involves basic principles of physics and a Forensics DNA Fingerprinting module that deals with DNA, mitosis/meiosis, inheritance, and DNA Fingerprinting. Future goals include expanding the dissemination of the Spacercize modules and disseminating two or more modules developed by the Vanderbilt RET group.

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⁸ <http://www.edb.utexas/petrosino/per/>

⁹ <http://www.edb.utexas/petrosino/per/redesign.html>

Biographical Information

ALENE H. HARRIS is a Research Assistant Professor of Education at Peabody College of Vanderbilt University. She serves as the Director of Education Programs for the VaNTH ERC.

STACY S. KLEIN is a Research Assistant Professor of Biomedical Engineering at Vanderbilt University, She is also a physics and mathematics teacher at the University School of Nashville.