International Journal for the Scholarship of Teaching and Learning

Volume 5 | Number 2 Article 19

7-2011

Assessing the Pedagogical Impact of the VaNTH Engineering Research Center on Faculty and Postdoctoral Professionals

Monica F. Cox
Purdue University - Main Campus, mfc@purdue.edu

James Cawthorne
Purdue University, jcawthor@purdue.edu

Nathan McNeill
University of Florida, nmcneill@ufl.edu

Osman Cekic
Canakkale Onsekiz Mart University, osmancekic@gmail.com

Matthew Frye
CTS Automotive Products, mrmattfrye@gmail.com

See next page for additional authors

Assessing the Pedagogical Impact of the VaNTH Engineering Research Center on Faculty and Postdoctoral Professionals

Abstract
From 1999 to 2007, the Vanderbilt-Northwestern-Texas-Harvard/MIT (VaNTH) Engineering Research Center focused on improving bioengineering education through the applications of learning science, learning technology, and assessment and evaluation within the domain of bioengineering. This paper discusses results from a survey to explore the impact of the VaNTH experience on participating faculty and postdoctoral professionals. The results note that respondents differed in their familiarity with and applications of dimensions of the "How People Learn" framework and in their operationalization of effective instruction after their participation in VaNTH. Implications for teaching and learning with the context of a Center model are discussed along with next steps for exploring the experiences of faculty and professionals engaged in the VaNTH ERC.

Keywords
Pedagogy, Faculty professional development, Engineering Research Center, "How People Learn"

Authors
Monica F. Cox, James Cawthorne, Nathan McNeill, Osman Cekic, Matthew Frye, and Melissa J. Stacer

Assessing the Pedagogical Impact of the VaNTH Engineering Research Center on Faculty and Postdoctoral Professionals

Monica Cox
Purdue University
West Lafayette, Indiana, USA
mfc@purdue.edu

James Cawthorne
Purdue University
West Lafayette, Indiana, USA
jcawthor@purdue.edu

Nathan McNeill
University of Florida
Gainesville, Florida, USA
nmcneill@ufl.edu

Osman Cekic
Canakkale Onsekiz Mart University
Canakkale, Turkey
osmancekic@gmail.com

Matthew Frye
CTS Automotive Products
Elkhart, Indiana, USA
mrmattfrye@gmail.com

Melissa Stacer University of Southern Indiana Evansville, Indiana, USA mjstacer@usi.edu

Abstract

From 1999 to 2007, the Vanderbilt-Northwestern-Texas-Harvard/MIT (VaNTH) Engineering Research Center focused on improving bioengineering education through the applications of learning science, learning technology, and assessment and evaluation within the domain of bioengineering. This paper discusses results from a survey to explore the impact of the VaNTH experience on participating faculty and postdoctoral professionals. The results note that respondents differed in their familiarity with and applications of dimensions of the "How People Learn" framework and in their operationalization of effective instruction after their participation in VaNTH. Implications for teaching and learning with the context of a Center model are discussed along with next steps for exploring the experiences of faculty and professionals engaged in the VaNTH ERC.

Keywords: pedagogy; faculty professional development; Engineering Research Center; "How People Learn"

Introduction

The White House, industry, and academia joined together in 1984 to request that the National Science Foundation create the Engineering Research Center (ERC) program.

With a focus on revitalizing industry, ERCs were multi-university, multi-disciplinary collaborative centers that were each created with $10 million in seed funding from the National Academies of Engineering (Boardman & Bozeman, 2007). Since their founding, ERCs have developed into places to nurture innovations and ideas, to produce better-educated individuals, and to promote collaborations among educational institutions, industry, and the government (Suh, 1986).

Previous studies have explored the impacts of ERCs upon a variety of stakeholders including faculty and students. In a report on the impact that seventeen ERCs had on institutional and cultural norms at participating universities, Ailes, Feller, and Coward (2001) identified several outcomes pertaining to the roles of ERC-affiliated faculty. They found that:

- Faculty participating in ERCs appreciated the interdisciplinary nature of the ERC structure and the resulting impact on their research even though the collaborative nature of the ERC structure was contrary to traditional, individualistic notions of promotion and tenure.
- The structure of ERCs allowed faculty to engage both graduate and undergraduate students from a variety of disciplines in the research process.
- In integrating industry, faculty sometimes faced the challenge of educating university research administrators programs about the nature of industry funding and contracts.
- Faculty engaged with industry partners were able to provide opportunities for students to connect theory and practice.

Additional benefits of ERCs as reported by Ailes et al. (2001) include the development of new courses or course curricula, increased enrollment in newly developed or improved courses, and the creation of new degree programs within the academic units of ERC universities. Boardman and Bozeman (2007), writing about the impact of ERCs upon faculty, report that untenured faculty participating in ERCs were particularly susceptible to strain while learning to balance their responsibilities within ERCs with those of their academic units. Junior faculty engaged in the tenure process had to learn how to balance both ERC and departmental duties more strategically than senior faculty members.

In an effort to understand more about the individual experiences of faculty and postdoctoral researchers participating in ERCs, the current exploratory study was conducted with a sample of respondents from the Vanderbilt-Northwestern-Texas-Harvard/MIT (VaNTH) ERC for Bioengineering Educational Technologies, an ERC focused on the implementation of the educational principles of the "How People Learn" (HPL) framework (Bransford, Brown, & Cocking, 1999). The research question behind this study asked:

> What perceptions did respondents hold about the impact of participation in VaNTH on their professional development?

Respondents in this study completed a survey which questioned them about their professional development experiences before, during, and after their affiliation with the VaNTH ERC. The survey focused specifically on how respondents implemented elements of the HPL framework over time. Implications for professional development of faculty and postdoctoral professionals are described based upon the survey results.

Background

The VaNTH Engineering Research Center

The Vanderbilt-Northwestern-Texas-Harvard/MIT (VaNTH) ERC for Bioengineering Educational Technologies was created in 1999 to "unite educators and engineers, in

industry and academia, to develop curricula and technologies that will educate future generations of bioengineers" (VaNTH, 2010). With a primary focus on integration of the "How People Learn" (HPL) framework principles with undergraduate bioengineering curricula, this multi-million dollar ERC brought together expertise in learning science, learning technology, assessment and evaluation, and bioengineering. The VaNTH ERC differed from other ERCs in that it was the first and only ERC funded to explore bioengineering education in combination with advanced technologies, cognitive science, and assessment and evaluation.

During its eight-year existence, hundreds of faculty, postdoctoral researchers, undergraduate and graduate students representing the four primary institutions (Vanderbilt University, Northwestern University, the Texas at Austin, and Harvard University) as well as five additional institutions (the University of Wisconsin, Fisk University, the University of Texas-Pan American, the University of Memphis, and the University of Pittsburgh) engaged in a multitude of educational activities within the center (VaNTH ERC, 2008). Prior publications have explored the research impact of VaNTH (Cordray, Pion, Harris, & Norris, 2003), the development of VaNTH-inspired educational innovations (Roselli & Brophy, 2006), and the effects of VaNTH upon student populations (Martin, Rivale, & Diller, 2007). However, no research to date has reported the longitudinal impact of the VaNTH ERC upon faculty and postdoctoral respondents. For this reason the current paper presents self-reported outcomes from an exploratory study focusing on the professional development experiences of respondents before, during, and after their formal participation in the VaNTH ERC.

Implementation of HPL Framework Principles in the VaNTH ERC

VaNTH ERC researchers conducted several empirical studies to identify the pedagogical practices that would maximize the achievement of bioengineering students at VaNTH-affiliated universities (VaNTH ERC, 2008). The majority of these studies centered on the integration of the educational dimensions of the HPL framework. According to the HPL framework, an effective learning environment is simultaneously *knowledge-centered*, *learner-centered*, *assessment-centered*, and *community-centered* (Bransford et al., 1999). *Knowledge-centered* environments emphasize that students exhibit a deep understanding of course content as well as an ability to apply this knowledge; *learner-centered* environments build upon students' preconceptions, misconceptions, and ideas about course concepts; *assessment-centered* environments provide opportunities for both formative and summative opportunities so that students and faculty can learn from one another; and *community-centered* environments engage students with peers inside the classroom as well as members of the larger community outside of the classroom.

From its beginning, VaNTH focused primarily on the impact of HPL principles upon student learning and engagement, analyzing the HPL framework and its effectiveness among both undergraduate and graduate engineering populations. Subsequent studies have synthesized implementation methods and assessment tools in the hopes of confirming (both quantitatively and qualitatively) the positive benefits of implementing HPL framework principles in traditional bioengineering courses.

Research on the implementation of the HPL framework in bioengineering has been published extensively. Birol, McKenna, Smith, Giorgio, and Brophy (2002) tested and implemented several biomedical engineering modules that incorporated principles from the HPL framework and the Star Legacy Cycle, an educational model (also developed by VaNTH researchers) that allows students to engage in an interactive cycle of learning that represents the integration of HPL principles (Schwartz, Lin, et al., 1999). Research on effective implementation of principles of the HPL framework then extended to modules in tissue engineering, biomechanics of human movement, and Fourier spectrum

analysis (Greenberg, Smith, and Newman 2003; Barr, Pandy, Petrosino, Austin, & Goldberg, 2004; Birol, Liu, Smith, & Hirsch, 2006).

Several studies have supported the efficacy of the educational research projects carried out by VaNTH researchers. The final report published by VaNTH boldly claims that research reveals "that VaNTH sponsored innovations can be beneficial in enhancing the learning of students" (VaNTH ERC 2008, 37). Two types of research efforts were undertaken by VaNTH assessment and evaluation researchers to document the effectiveness of educational modules and courses developed by VaNTH bioengineering experts. These were: (1) surveys of students' and instructors' perceptions of the degree to which the four dimensions of the HPL framework were present in all VaNTH biomedical engineering courses (Cordray et al., 2003), and (2) direct observation of the pedagogical practices of instructors in selected VaNTH courses using the VaNTH Observation System (VOS), an observational system developed by VaNTH researchers (Harris & Cox, 2001). Via surveys, Cordray et al. (2003) directly compared biomedical engineering courses implementing HPL framework principles to traditional "non-HPL" courses, thereby highlighting the relationship between pedagogy and effective learning within courses taught at VaNTH institutions. Assessments of the impact of the HPL framework in biomedical engineering courses further provided a comparison of students' experiences at multiple universities (Giorgio, Brophy, Birol, McKenna, & Smith, 2002). VaNTH researchers developed the VOS for direct observation of interactions within classrooms. This system provides a method for both quantifying and qualifying student engagement as well as the presence of elements of the HPL framework in interactions that occur within classrooms (Harris & Cox, 2001). Deployment of the VOS in various bioengineering classrooms at VaNTH institutions revealed that classrooms in which instructors intentionally incorporated elements of the HPL framework into their course designs exhibited a greater number of instances of collaborative group work and higher-order thinking and questioning than courses where instructors had not intentionally incorporated elements of the HPL framework (Cox & Cordray, 2008).

Despite the prominent role of faculty within the VaNTH ERC, only a few research studies conducted by VaNTH researchers have focused specifically on faculty experiences. One such study by Cordray et al. (2003) used surveys to examine the instructional perceptions of instructors who had participated in the VaNTH ERC. Another study by McKenna and Yalvac (2007) used interviews with sixteen bioengineering faculty to identify differences in teaching strategies between participants and non-participants in the VaNTH ERC. In particular, this study explored relationships between faculty levels of teaching engagement and their approaches to teaching. Cox and Cordray (2008), as well as Cox (2009), identified pedagogical differences between three classes of faculty: (1) those who did not purposefully integrate HPL-based curricula in their courses (non-HPL faculty), (2) faculty who implemented HPL-based curricula for the first time ("novice" HPL faculty), and (3) faculty who had implemented HPL-based curricula over multiple semesters ("seasoned" HPL faculty). Cox and Harris (2010) explored differences in the pedagogical practices of pretenured and tenured faculty and found that pretenured faculty were more comfortable teaching using HPL framework principles than tenured faculty designated to teach HPL courses. VaNTH researchers noted that faculty exposed to HPL framework innovations differed in their pedagogical approaches compared to control groups with no exposure to HPL innovations. None of these studies, however, have explored (1) *why* faculty engaged in innovative teaching practices are more likely to use approaches linked to learner-centered pedagogy; (2) the impact of VaNTH curricular innovations upon VaNTH faculty, and (3) qualitative questions exploring *why* pedagogical differences exist between novice faculty and seasoned (i.e., tenured) faculty who participated in VaNTH.

Methods

The study presented in this paper explores the experiences of both faculty and postdoctoral professionals before, during, and after their affiliations with the VaNTH ERC and the impact these experiences had on these individuals. In particular, this study examines how respondents have implemented elements of the HPL framework both during and after participation in VaNTH. The findings reported in this paper were obtained from a web-based survey.

Respondents

One hundred thirty-three individuals who had participated in VaNTH at some time during its eight-year existence were invited to participate in this study. Because of the diversity of backgrounds of VaNTH respondents, anyone who was not a postdoctoral professional or a graduate student was classified in the "faculty" category. As a result, the final population for this study consisted of academic consultants, tenure-track faculty, academic staff, and postdoctoral professionals. After sending an initial request to respondents asking for confirmation of contact information, researchers narrowed the list of possible respondents down to 119 individuals. Invitations were then e-mailed to the individuals in this population requesting that they complete a web survey (Appendix). Thirty individuals responded to the invitation and completed the survey resulting in a final response rate of 25.2%. This is consistent with the median response rate for most web surveys (Kaplowitz, Hadlock & Levine, 2004; Trouteaud, 2004; Marcus, Bosnjak, Lindner, Pilischenko, & 2007).

The titles, responsibilities, methods of recruitment to VaNTH, and length of participation varied across respondents. When asked to describe their titles in VaNTH, six defined themselves as educational module developers, and four defined themselves as researchers. Other respondents described their titles within VaNTH as bioengineering domain consultants, developers of web-based materials, course developers, and affiliates with the K-12 component of the ERC. Respondents also had engaged in multiple responsibilities within VaNTH – research (80%), teaching (50%), and administration (23%). Over two-thirds of respondents were recruited to VaNTH by an individual or group already engaged in the ERC. Finally, during the eight-year existence of the VaNTH ERC, 50% of survey respondents participated for more than three years, while 10% participated for less than a year.

Data Collection

The survey used in this study was created by the authors. This instrument was developed to obtain from respondents perceptions of both their past and present experiences with HPL-oriented instruction. Survey questions were constructed so that: (1) respondents could explain how they came to participate in the ERC, (2) respondents' pre-VaNTH understandings of the HPL framework as well as concepts of effective teaching could be reconstructed, (3) respondents could comment on their experiences within VaNTH, particularly with respect to learning about the HPL framework and the STAR Legacy Cycle, (4) researchers could identify whether participation in VaNTH contributed to respondents' continued use of the HPL framework in their post-VaNTH careers, and (5) if so, how?

Nineteen closed-ended quantitative questions and five open-ended qualitative questions were developed to gather self-reported responses from respondents. The quantitative questions asked respondents to provide responses using a Likert scale. An initial draft of survey questions was developed and piloted with several researchers who had experience applying the HPL framework and were familiar with the unique features of the VaNTH ERC. These individuals also served as expert judges providing content validity to the survey. After the survey was piloted it was deployed on-line with a respondent

consent form as a cover page. Approval for this study was obtained from the Purdue University Institutional Review Board (IRB).

Data Analysis

Responses to the quantitative, closed-ended survey questions were analyzed using chi-square tests to identify statistically significant items and/or trends. Responses to the open-ended questions were analyzed using open coding and grounded theory (Lincoln & Guba, 1985). During analysis, the resolution of responses to several of the quantitative questions was reduced in order to more easily identify trends in the data. This was accomplished by reducing the number of Likert scale items on several questions.

The process for coding, identifying, and making assertions from the qualitative data began with several initial readings of the data in order to become immersed in participants' responses. After several passes, the data were parsed using key words that captured the essence of each response. An entire response to a question was coded as opposed to single key words or phrases. Coded responses were then grouped into thematic categories. Assertions reported in this paper are based upon how participants described their ideas of effective teaching before, during, and after participation in the VaNTH ERC.

Results

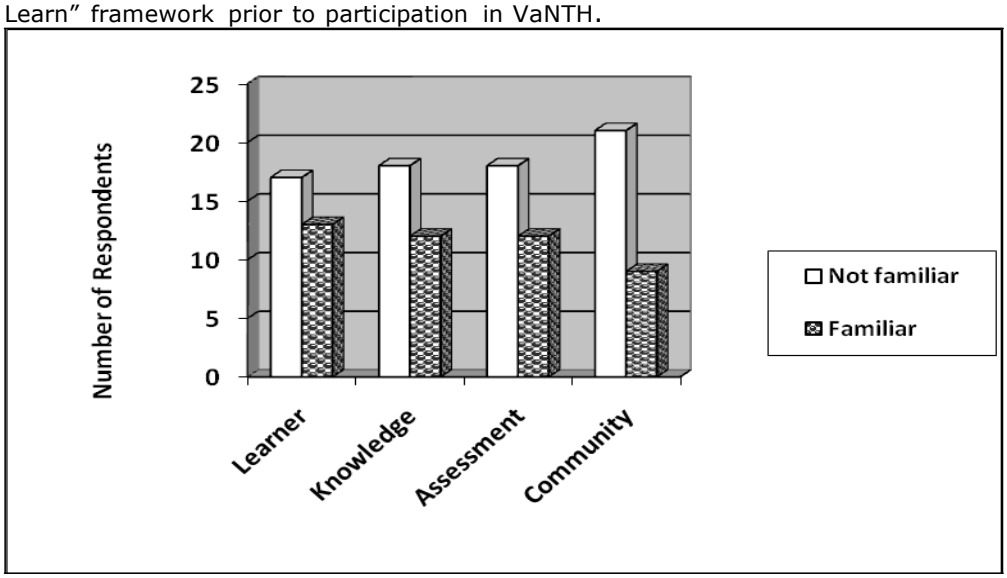
This section presents results from the open- and closed-ended survey questions in two separate sections.

Quantitative Results

To explore participants' perceptions of the impact that participation in VaNTH had on their professional development, responses from several questions were combined to create Figures 1-4. Significantly statistical findings are presented later in this section of the paper.

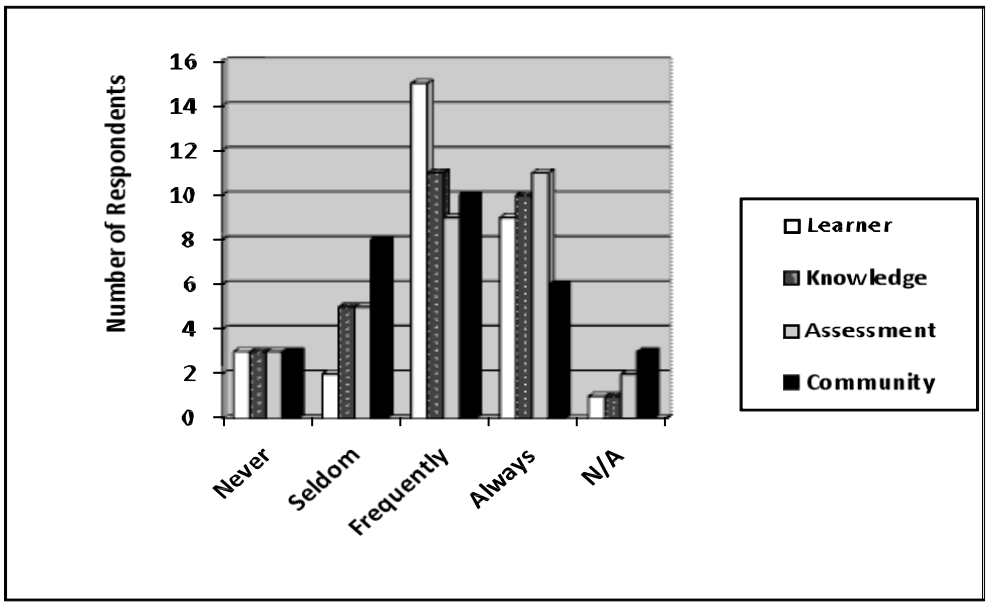
Figure 1 display shows respondents' familiarity with the four dimensions of the HPL framework *prior to* engagement in the VaNTH ERC. Familiarity was rated on a four-point Likert scale where 1=not at all familiar, 2=not too familiar, 3=somewhat familiar, and 4=very familiar. Responses of 1 and 2 have been presented as "not familiar" and responses of 3 and 4 have presented as "familiar". The HPL dimension that participants were most familiar with prior to participation in VaNTH was the learner-centered dimension.

Figure 1. Respondents' familiarity with each of the dimensions of the "How People Learn" framework prior to participation in VaNTH.



Respondents were also asked how frequently they use HPL framework elements in their *current* educational and research activities (Figure 2). Again, frequency was rated on a four-point Likert scale where 1=never, 2=seldom, 3=frequently, and 4=always. The majority of respondents reported that they frequently or always use HPL framework elements. In addition, respondents reported that they are most likely to apply the learner-centered dimension.

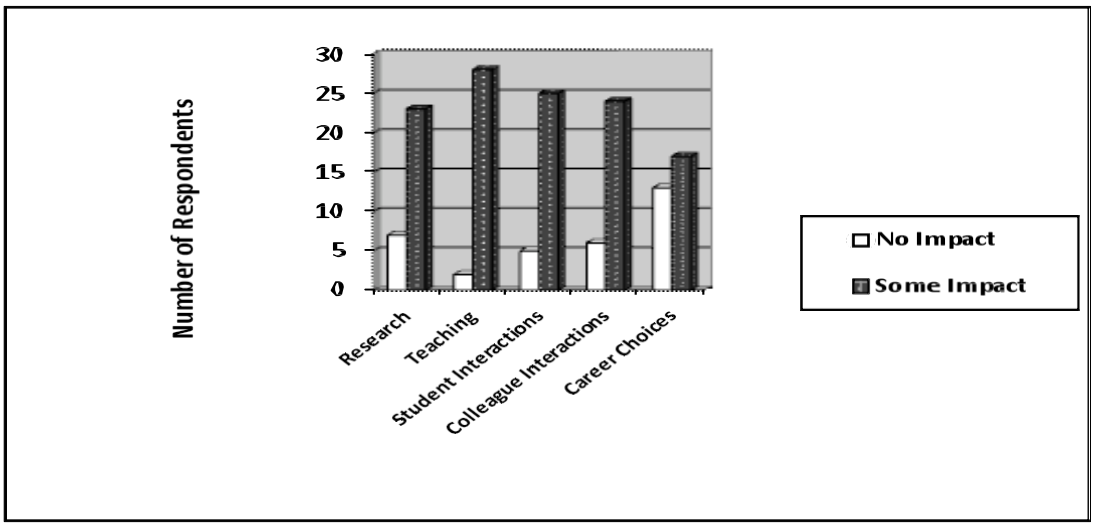
Figure 2. Respondents' frequency of use of "How People Learn" framework elements within their current activities.



The survey also asked participants to rate the impact of participation in VaNTH on their research interests, teaching, interactions with students outside of class, interactions with colleagues, and career choices (Figure 3). Although the majority of respondents identified participation in VaNTH as having at least some impact in each area,

respondents felt that the area of greatest impact had been teaching. In contrast, the area in which participants reported the least impact was career choices.

Figure 3. Impact of participation in VaNTH upon respondents.



A number of additional findings emerged as a result of Chi-square tests. Respondents who engaged in research while participating in VaNTH report using the assessment-centered dimension in their current work more often than those who did not engage in research as participants in VaNTH (chi-square=8.611, $p<.10$). Respondents whose participation in VaNTH was the longest are the most frequent users of the following three HPL dimensions in their current work: (1) the knowledge-centered dimension (chi-square=19.506, $p<.10$), the assessment-centered dimension (chi-square=30.197, $p<.01$), and the community-centered dimension (chi-square=26.871, $p<.01$).

Qualitative Results

Responses to the five open-ended survey questions varied in length from a single word to several sentences. These questions included the following:

- Prior to participating in the VaNTH ERC, how would you have described your concept of effective instruction?
- Before participating in the VaNTH ERC, how familiar were you with the STAR Legacy (SL) Cycle?
- Briefly describe your primary role within the VaNTH ERC.
- In your VaNTH ERC experience, briefly describe how your pre-participation expectations were and/or were not accurate.
- What other information not covered in this survey would you like to share regarding the impact of VaNTH on your professional development?

Responses to the five open-ended questions were coded separately by two researchers and percent agreement was calculated between the coding of the two researchers to provide a measure of intercoder reliability. On the first question 84% agreement was calculated between the two coders. On the second question there was 92% agreement between the two coders, on the third question there was 86% agreement, and there was 100% agreement on the fourth question. Because of the nature of the fifth question, intercoder agreement was not calculated.

Responses from the open-ended questions are discussed in the following three sections. These sections discuss participants' concepts of effective instruction, the pre-participation expectations of participants, and participants' responses to the fifth survey

question, which allowed participants to share additional information about their experiences.

Concepts of Effective Instruction

The first open-ended survey question asked respondents to think back to before their participation in VaNTH and describe what their concepts of effective instruction had been. Respondents were most likely to describe themselves as student-centered instructors who believed in *engaged learning*. Respondents described *engaged learning* as learning that "engages students, presents concepts clearly, [and] gives practice," in "an interactive classroom that challenges students," and is "driven by strong knowledge of student thinking about the relevant discipline. It is also informed by a repertoire of tasks, tools, talk, notations, and assessment that are effective in building student knowledge." The views of such respondents align well with the pedagogy grounded in the HPL framework that was promoted by VaNTH. Some respondents, however, indicated that they view of effective teaching had been lecture-based, an idea that is held by numerous engineering faculty (Donald, 2002) and is not aligned with the innovative principles of the HPL framework. Respondents explained that their pre-VaNTH instructional philosophies had been developed based upon accreditation, institutional, or departmental goals.

The second open-ended question asked respondents how their concepts of effective teaching were influenced by their participation in the VaNTH ERC. Respondents clearly felt that their thinking had been influenced by their participation in VaNTH. In response to this question, respondents used the vocabulary of the HPL framework by writing down explicit HPL framework language (e.g., learner-centered or knowledge-centered). Some respondents even claimed that *"HPL"* was part of their new concept of effective teaching. A limitation is that respondents might be parroting the vocabulary of the HPL framework without a deep understanding of its principles or an ability to apply the framework to their instruction. Other respondents did not explicitly use HPL framework vocabulary in their responses to this question, but their responses nonetheless illustrate an understanding of elements of the HPL framework. For example, one participant wrote, "Effective instruction involves presenting material in a number of different ways, and giving learners an opportunity to explore the material interactively, receiving formative feedback to allow learners to evaluate their own learning process." Another respondent described effective instruction as "open ended, authentic, challenge based instruction, with lots of group projects and community enhanced collaborations. Students should work in communities of practices and learn from one another or from experts in the field- not from the teacher."

These respondents elaborated more specifically using HPL language in a nuanced way that indicates an assimilation of HPL principles within their conceptual beliefs about learning. Although it is not clear how committed respondents are to the use of HPL principles, it is likely that most utilize parts of the HPL framework within their concepts of effective teaching. Several respondents identified no change, or only a slight shift in their beliefs about effective teaching.

Pre-Participation Expectations

The third open-ended question asked respondents if their pre-participation expectations of VaNTH had been accurate. Seven respondents noted that their expectations were met or were accurate, seven respondents noted that their expectations were not met or were not accurate, six respondents indicated that they had no expectations or could not remember their expectations, and the remaining ten respondents were either unsure

about their expectations, felt mixed about these expectations, or had their expectations exceeded.

One respondent who felt that their expectations had been met wrote, "Things went pretty much as expected." Another respondent whose expectations had been met wrote, "It more or less played out as I expected -- a lot of work!" Comments from respondents who felt that their expectations had been met were generally short. These respondents may have had a good idea about what participating in VaNTH entailed prior to joining. As noted earlier, more than two-thirds of respondents were recruited to VaNTH by an individual or group already engaged in the ERC. In contrast to respondents who felt that their expectations had been met, a faculty member with unmet expectations wrote:

> "I expected that all faculty would 'buy-into' the [HPL] approach and implement it to learn how well it worked. This assumption was quite false; some rejected the idea at the outset (and wouldn't come to the VaNTH workshop on use of the ideas). Others did warm to the ideas and have continued to use items of the VaNTH method."

Additional reasons that faculty gave for unmet expectations stemmed from a disappointment in the low level of support they felt they received from the ERC or their home institutions. In addition, some of these respondents noted that their own personal expectations had been set too high. One such respondent wrote, "[I] expected more support - faculty were required to perform the duties normally associated with research assistants and PIs." Another respondent in this group wrote:

> "My expectations and hopes were not met, but that's not anyone's fault... I perhaps could have tried harder, but I didn't see that there were sufficient resources to support the people who would be needed to do this versus to work on the other basic issues, (e.g., curriculum development)."

It is common for individuals engaging in new opportunities to have expectations that vary in scope based on personal aspirations. It is surprising, however, how widely the expectations of respondents varied given that more than two-thirds were already acquainted with individuals participating in VaNTH.

Open-Ended Responses

The final open-ended survey question asked, "What other information not covered in this survey would you like to share regarding the impact of VaNTH on your professional development?" The most common response to this question was "none," or something similar. Respondents who felt that participation in the VaNTH ERC had had an impact on their professional development appreciated the "exposure" that they received as a result of participation in VaNTH. Respondents noted different kinds of exposure. One respondent wrote that "it provided a forum in which to develop my professional network and made me aware of research in education."Another respondent said, "It exposed me to the community of engineering education and also gave me the opportunity to work with bioengineers from whom I learned quite a bit regarding aspects of their disciplines."

Other respondents identified additional areas or ideas in which they would have liked to engage as well as topics that were not addressed by the survey. One such respondent wrote:

> "The survey did not address use of technology to deliver the instruction in an explicit manner; the VaNTH style of instruction can be used in a low-tech manner -- with the hand-held response units -- and in a much stronger manner -- with

the computer administered programs for out of the classroom instruction and ensuring of minimum capability of all students. Regarding your question -- my professional development needs to be augmented in these areas of technology. And the VaNTH experience has helped to an extent."

Discussion

Implementation of the HPL Framework

The respondents in this study were able to identify ways in which HPL-based curricular innovations developed within the VaNTH ERC had an impact on their professional development. Teaching was identified as the area of greatest impact by respondents. Unlike most ERCs, which tend to focus solely on technical research, the VaNTH ERC purposefully integrated technical and educational research with the aim of improving the pedagogical knowledge and skills of respondents. At the end of their tenure in VaNTH, many respondents explicitly referred to the HPL framework as the foundation for the pedagogy that they currently employ, although levels of detail about the use of the HPL framework differed across respondents. It is not clear, however, whether respondents were merely repeating terms and phrases that they had picked up while participating in VaNTH or whether they are actively applying the HPL framework in their classrooms. In addition, this study did not explore other professional development activities that respondents might have engaged in that could have increased their comfort in implementing HPL framework principles.

Respondents reported that they had been implementing the knowledge-centered, learner-centered, and assessment-centered dimensions of the HPL framework prior to having developed a formal understanding of these dimensions from participation in VaNTH. The high level of understanding of knowledge-centeredness prior to participation in VaNTH may not be surprising given the familiarity that most faculty have with content in their academic disciplines. However, it is surprising that respondents reported less frequent use of community-centeredness (e.g., working in collaborative groups or teams) even after the end of participation in VaNTH. It may be that faculty find it difficult to incorporate community-centered elements into traditional lecture-based engineering classes.

Several respondents reported using assessment-centered principles after their VaNTH experiences. It may be that assessment relates to the questioning and inquisitive nature of research practice.

Faculty Responsibilities in an ERC

The combined technical and educational mission of the VaNTH ERC might have provided a challenge for many respondents. Engineering faculty are not typically trained in pedagogy (Donald, 2002) thus increasing the challenge of working in an ERC with an educational focus. Many respondents experienced increased teaching expectations from their institutions as a result of participation in VaNTH in addition to the challenge of working on educationally oriented research – a new experience for those whose prior experiences were strictly in the technical domain of bioengineering.

Respondents in this study noted both positive and negative aspects of working in VaNTH. Related to challenges, they faced internal conflicts which inhibited them from fully meeting the expectations they had for participation in VaNTH. These internal conflicts included misalignment in expectations about ERC support and unrealistically high expectations about opportunities to participate in VaNTH activities. Explicit details about this misalignment and these expectations are not provided in this paper, since respondents did not go into great detail about these within the on-line survey. On a positive note, the ERC model is one that encourages faculty to collaborate with

colleagues from different disciplines as well as different universities. Although many respondents did not know what to expect from participation in the VaNTH ERC, several appreciated working as members of interdisciplinary teams.

Implications for Teaching and Learning in Large-Scale, Multidisciplinary Centers

While faculty in higher education institutions often experience tensions between research, teaching, and service, respondents in VaNTH might have experienced increased tensions with regard to balancing their existing responsibilities at their home with those of the ERC community. This finding is consistent with those of Ailes et al. (2001) who report that faculty participating in ERCs recognize the incongruence between the missions of ERCs and the expectations of their home institutions. Faculty respondents in ERCs could benefit from developing detailed professional development plans that spell out exactly how their work in an ERC integrates with institutional expectations regarding promotion and tenure, research, teaching, and service. This is particularly important for early career faculty who are engaged in the tenure and promotion process. Developing such a plan requires meetings with department heads as well as center directors. Such meetings would also help faculty involved in centers to align their curricular expectations with the goals of the institution in which they are involved ERC.

Although the VaNTH ERC was an eight-year project with a primary emphasis was on research in bioengineering education, other models that encourage collaborations between stakeholders in technical domains (e.g., science, technology, engineering, and mathematics (STEM)) and educational domains (i.e., pedagogical and other educational practices) have been developed. Among these include engineering education departments (e.g., Clemson University, Purdue University, Virginia Polytechnic University, and Utah State University), divisions of engineering education (e.g., University of Southern California), and centers of engineering education (e.g., Michigan State's Center for Engineering Education Research (CEER), Princeton's Keller Center for Innovation in Engineering Education, and Southern Methodist University's Caruth Institute for Engineering Education). In this way, sustainable institutional centers can extend the work of VaNTH and can assist faculty in their integration of research and teaching.

This work confirms the need for professional development and teaching and learning activities for faculty and for postdoctoral professionals who work in research centers. Prior research on VaNTH has noted that faculty exposed to HPL innovations use different pedagogy than faculty who employ traditional, lecture-based instructional methods (Cox & Cordray, 2008). This work confirms a need for models that allow faculty to operationalize elements of the HPL framework within their classrooms. Such workshops would be similar in nature to those presented at national engineering education conferences and in other educational venues.

Future Work

Building off of the results of this study, future work will focus on interviewing respondents about the quality of their VaNTH ERC experiences. Initially, it is important to understand why, on average, respondents differed in their applications of the dimensions of the HPL framework. Researchers might determine if certain curricular elements are more prevalent depending upon the roles of the respondents. Such a question has been raised since respondents who engaged in a research role were more likely to use assessment-centered principles than individuals in teaching or administrative roles. Finally, clarification about the expectations of faculty can be explored. Although some activities within the ERC might have been controlled by the ERC, others might not have been controllable.

The comments of respondents in this study are the foundation for the generation of new questions for a follow-up explanatory study. This follow-up study will allow researchers to engage more deeply in conversations with survey respondents about HPL framework components and to discover the underlying stories associated with VaNTH's impact on faculty and postdoctoral researchers. Potential research questions this follow-up phase might include:

- What are respondents' understandings and interpretations of HPL elements and effective instruction?
- How do VaNTH experiences differ by respondents' time in the ERC, their ERC role, their ERC expectations, and their professional development experiences?

Conclusions

Aligned with the goals of the National Science Foundation's Engineering Research Center program and with previous studies about ERCs, findings within the current study begin to answer quantitatively and qualitatively questions about the long-term impact of this ERC on a subsample of VaNTH faculty and postdoctoral professionals. Although traditional ERCs have most likely impacted faculty's research efforts, VaNTH is unique in its integration of research and education in the area of bioengineering education technologies. The impact of both is evident in the initial responses. On average, most respondents acknowledge the importance of their VaNTH experiences upon their professional development, particularly their teaching. In addition, participation in VaNTH positively impacted respondents' research interests and collaborations. VaNTH faculty and postdoctoral professionals, regardless of discipline, also were exposed to interdisciplinarity, to a collaborative model of engagement during the tenure of the ERC, and to elements of effective teaching, particularly related to the "How People Learn" framework.

Acknowledgements

This work was supported primarily by the Engineering Research Centers program of the National Science Foundation under annual grant EEC-9876363. The research group would like to acknowledge additional support from Dr. Thomas R. Harris, Dr. Alene H. Harris, Mrs. Jean Alley, Dr. Patrick Norris, and our survey respondents.

References

Ailes, C., Feller, I., & Coward, H. (2001). *The impact of engineering research centers on institutional and cultural change in participating universities*: Arlington VA: SRI International. Retrieved from http://www.sri.com/policy/csted/reports/sandt/documents/ERCCulturalImpact.pdf.

Barr, R., Pandy, M., Petrosino, A., Austin, B., & Goldberg, J. (2004, June). Classroom testing of VaNTH biomechanics learning modules. Paper presented at the annual meeting of the American Society for Engineering Education, Austin, Texas.

Birol, G., McKenna, A. F., Smith, H.D., Giorgio, T.D., & Brophy, S.P. (2002). Integration of the "How People Learn" framework into educational module development and implementation in biotechnology. Paper presented at the *Second Joint EMBS/BMES Conference*, Houston, Texas.

Birol, G., Liu, S.Q., Smith, H.D., & Hirsch, P. (2006). Educational modules in tissue engineering based on the "How People Learn" framework. *Bioscience Education E journal,* 7.

Boardman, C., & Bozeman. B. (2007). Role strain in university research centers. *Journal of Higher Education* 78, 430-463.

Bransford, J., Brown, A., & Cocking, R. (2000). *How people learn:Brain, mind, experience, and school*. Washington, DC: National Academy Press.

Cordray, D. S., Pion, G. M., Harris, A., & Norris, P. (2003). The value of the VaNTH Engineering Research Center. *IEEE Engineering in Medicine and Biology Magazine* 22, 47-54.

Cox, M. F., & Cordray, D.S. (2008). Assessing pedagogy in bioengineering classrooms: Quantifying elements of the "How People Learn" model using the VaNTH Observation System (VOS). *Journal of Engineering Education* 97, 413-431.

Cox, M.F. 2009. Operationalization of innovative and traditional pedagogical practices within undergraduate bioengineering courses. *International Journal for the Scholarship of Teaching and Learning*, 3, no. 1. Retrieved from http://academics.georgiasouthern.edu/ijsotl/v3n1/articles/_Cox/index.htm (accessed May 5, 2009).

Cox, M.F., &. Harris, A.H. (2010). Comparison of pretenured and tenured engineering professors' pedagogical practices within undergraduate bioengineering courses. *International Journal for the Scholarship of Teaching and Learning*, 4, 1. Retrieved from http://academics.georgiasouthern.edu/ijsotl/v4n1/articles/PDFs/Article_CoxHarris.pdf (accessed February 15, 2011).

Donald, J. G. (2002) *Learning to think: Disciplinary perspectives.* San Francisco: Jossey Bass.

Giorgio, T. D., Brophy, S. P., Birol, G., McKenna, A. F., & Smith, H. D. (2002). Assessment of educational modules based on the "How People Learn" framework delivered to biotechnology learners at two universities. Paper presented at the *Second Joint EMBS/BMES Conference* (pp. 2642-2643). Houston: IEEE.

Greenberg, J. E., Smith, N.T., & Newman, J.H. (2003). Instructional module in fourier spectral analysis, based on principles of "How People Learn." *Journal of Engineering Education* , 92, 155-165.

Harris, A.H., & Cox, M.F. (2003). Developing an observation system to capture instructional differences in engineering classrooms. *Journal of Engineering Education* 92, 329-336.

Kaplowitz, M., Hadlock, T., & Levine, R. (2004). A comparison of web and mail survey response rates. *Public opinion quarterly, 68*(1), 94.

Lincoln, Y.S., &. Guba, E.B. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage Publications.

Marcus, B., Bosnjak, M., Lindner, S., Pilischenko, S., & Schutz, A. (2007). Compensating for low topic interest and long surveys: A field experiment on nonresponse in web surveys. *Social Science Computer Review, 25*(3), 372.

Martin, T., Rivale, S.R., & Diller, K.R. (2007). Comparison of student learning in challenge-based and traditional instruction in biomedical engineering. *Annals of Biomedical Engineering* 35, 1312-23.

McKenna, A.F., & Yalvac, B. (2007). Characterizing engineering faculty's teaching approaches. *Teaching in Higher Education* 12, 407-420.

National Research Council. (1986). *The new engineering research centers: Purposes, goals, and expectations.* Washington, DC: National Academy Press.

Roselli, R.J., & Brophy, S.P. (2006). Effectiveness of challenge-based instruction in biomechanics. *Journal of Engineering Education* 95, 325-334.

Suh, Nam P. (1986). The concept and goals of the Engineering Research Centers. In *The new engineering research centers: Purposes, goals, and expectations*, 37–43.Washington D.C.: National Academy Press.

Schwartz, D. L., Lin, X., et al. (1999). Toward the development of flexibly adaptive instructional designs. In *Instructional design theories and models: Volume 11*. (Ed.) C. M. Reigelut. Hillsdale, NJ: Erlbaum.

Trouteaud, A. (2004). How you ask counts: a test of internet-related components of response rates to a web-based survey. *Social Science Computer Review, 22*(3), 385.

VaNTH Web Site. (n.d.). *VaNTH ERC Home*. Retrieved April 30, 2009 from http://www.vanth.org/

VaNTH Engineering Research Center. (2008). Final Report to the National Science Foundation.

Appendix

Questions about Pre-VaNTH ERC Experience

Questions #1 through #4 address your experiences prior to participating in the VaNTH ERC Program.

1. Rate the frequency with which you engaged in the following research before participating in the VaNTH ERC.

		Never	Seldom	Frequently	Always
A.	STEM Oriented Research	1	2	3	4
B.	Education Oriented Research	1	2	3	4

2. Prior to participating in the VaNTH ERC, how would you have described your concept of effective instruction?

3. How familiar were you with the following elements of the "How People Learn" framework before starting the VaNTH ERC?

		Not at all familiar	Not too familiar	Somewhat familiar	Very familiar
A.	Learner-centered	1	2	3	4
B.	Knowledge-centered	1	2	3	4
C.	Assessment-centered	1	2	3	4
D.	Community-centered	1	2	3	4

4. Before participating in the VaNTH ERC, how familiar were you with the STAR Legacy (SL) Cycle?

Questions about VaNTH ERC Experience

5. Who initiated your involvement in the VaNTH ERC program? (select one)

- ☐ VaNTH Colleague
- ☐ Non-VaNTH Colleague
- ☐ Institution (Your university / non-VaNTH)
- ☐ Other

6. What was your primary academic position upon entering the VaNTH ERC?

- ☐ Post-Doc
- ☐ Associate Professor
- ☐ Assistant Professor
- ☐ Full Professor
- ☐ Other

7. In what roles did you engage during your VaNTH experience? (check all that apply)

- ☐ Research
- ☐ Teaching
- ☐ Administration
- ☐ Other

8. Briefly describe your primary role within the VaNTH ERC.

9. How would you rate the ease of implementation of the "How People Learn" framework into your VaNTH research and/or activity?

Not Applicable	Very Easy	Easy	Difficult	Very Difficult
0	1	2	3	4

10. How would you rate the ease of implementation of the STAR Legacy (SL) Cycle in your VaNTH research and/or activity?

Not Easy	Very	Easy	Difficult	Very Difficult	Applicable
0	1	2	3	4	

11. How often were you engaged in VaNTH ERC activities at your institution?

Never	Rarely	Sometimes	Often
1	2	3	4

12. In your VaNTH ERC experience, briefly describe how your pre-participation expectations were and/or were not accurate."

Questions about Post-VaNTH Experience

13. After participating in the VaNTH ERC, how would you now describe your concept of effective instruction?

14. How frequently do you use the "How People Learn" framework elements within your current research and/or activities?

		Never	Seldom	Frequently	Always
A.	Learner-centered	1	2	3	4
B.	Knowledge-centered	1	2	3	4
C.	Assessment-centered	1	2	3	4
D.	Community-centered	1	2	3	4

15. How frequently do you use the STAR Legacy Cycle within your current research and/or activities?

Not Applicable	Never	Seldom	Frequently	Always
1	2	3	4	5

16. What impact has participation in the VaNTH ERC had on each of the following for you?

No Impact	Small Impact	Medium Impact	High Impact
1	2	3	4

17. Would you recommend participation in the VaNTH ERC to one of your colleagues?

Not at all	Possibly	Most likely	Absolutely
1	2	3	4

18. How would you rate the impact VaNTH ERC has had on bioengineering/biomedical engineering education at a national level?

No Impact	Small Impact	Medium Impact	High Impact
1	2	3	4

Demographic Questions

19. How long did you actively participate in VaNTH ERC activities?

0 – 1 year 1 – 3 years 3 – 5 years 5+ years

20. What position do you currently occupy within your career?

- ☐ Associate Professor
- ☐ Assistant Professor
- ☐ Full Professor
- ☐ Industry
- ☐ Other

21. Gender

- ☐ Female
- ☐ Male

22. Race/Ethnicity

- ☐ American Indian or Alaskan Native
- ☐ Asian
- ☐ Black or African American
- ☐ Hispanic or Latino
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White
- ☐ Other

23. Citizenship

- ☐ U.S. Citizen
- ☐ Permanent Resident
- ☐ Other Non-U.S. Citizen

24. What other information not covered in this survey would you like to share regarding the impact of VaNTH on your professional development?

THANK YOU FOR YOUR PARTICIPATION IN THIS SURVEY!