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Ethics Instruction for International Graduate Students in Engineering

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PROJECT SUMMARY
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Forty percent of international engineering students remain in the United States and are employed in some facet of engineering research and practice. These students face acculturation challenges that domestic students do not encounter, making them a natural audience for an educational intervention. While our instructional materials will assist all engineering graduate students in acclimating to engineering ethics standards and expectations, we propose to design educational materials sensitive to the needs of the international graduate student. A robust three year research design will enable the team to refine the instructional materials to allow students to achieve ethics mastery upon completion of the modules. The technology-based delivery allows students to complete the training at their own pace and in an environment of their choosing.

Intellectual Merit: Our proposed project has assembled experts in engineering ethics, assessment, instructional technology, graduate engineering education, international student education, and acculturation. Our research design incorporates assessment of individual ethics competency after completion of the educational modules, compared to performance prior to instruction. As a result, we will be able to more clearly isolate variance in performance associated with the educational intervention, in order to determine the predictive validity of our instruction. We propose to link specific pedagogical and instructional design techniques to learning objectives measured by a cluster of questions on the assessment instruments. In this manner, we will be able to test the efficacy of specific aspects of the educational modules and vary our technique and design according to the performance data. Once the modules have been validated and tested, they will constitute a self-contained means of assisting international engineering students in understanding and mastering normative values relevant to all engineering disciplines.

Broader Impacts: Perhaps the largest and most direct impact of the proposed study will be on the private sector as we better train international graduate students, many of whom remain in the United States, to handle, practice, teach, and apply ethical standards in their various engineering capacities. Given that most higher education institutions have a unit designated to process and assess international graduate students, our program design is one that can easily integrate into existing institutional procedures and processes. While the fundamental goal is to help international graduate students acculturate to normative standards associated with United States engineering practice, the project engenders far broader benefits. International graduate students who elect to remain in academe will be better prepared to instruct undergraduate students on ethical matters; and those who practice abroad will be more sensitive to standard requirements in the United States. With the trend towards the globalization of engineering and science, we will be contributing to a clear articulation of ethical standards and expectations. In addition, by heightening the ethical acumen of international (future) faculty, the proposed study will raise the awareness and sensitivity to ethical issues and obligations in undergraduate engineering education, thus promoting ethics across the curriculum. Finally, many of the ethics principles and learning objectives for engineering overlap with the broader science disciplines, and as such, the proposed study would both reinforce and extend ethics training and education for the sciences.

In sum, the motivating need for international graduate student acculturation is common to all disciplines, and the proposed project is designed to serve as an educational model for ethics instruction where content is tailored to the specific needs of any particular engineering or science program.

PROJECT DESCRIPTION
Ethics Instruction for International Graduate Students in Engineering

Part I: Introduction

The proposed study is a combined education and research project aimed at improving ethics education for *international graduate students in engineering*. The major argument to be developed is that an educational intervention, consisting of a series of online ethics learning modules, will help international graduate students overcome the acculturation barriers to personally knowing and inculcating normative ethical obligations associated with engineering practice in the United States. This argument rests on four presuppositions: (1) the significant numbers of international students who remain in the United States after graduate school are expected to adhere to normative ethical obligations that have been established in this country for engineering research and practice; (2) these normative ethical obligations can be articulated with appropriate specificity such that the degree to which a person knows and understands these values can be measured; (3) international students experience acculturation issues – cultural competency, language proficiency, and acculturation stress – above and beyond the challenges faced by domestic engineering graduate students relative to knowing what is/would be ethically required of them; and (4) the acculturation factors mediate the relationship between ethics instruction and ethics competency.

Figure 1 presents the proposed research model. The fundamental relationship depicted by this model is that instructional strategy positively influences ethical competency for domestic students; however, for international students, acculturation factors partially mediate the relationship between instructional strategy and ethics competency. This means that in order to effectively teach ethics to international students, the instructional strategy (instructional design and pedagogy) must be sensitive to the unique needs of international student populations. The following paragraphs address each of the four presuppositions by presenting evidence in support of this model.

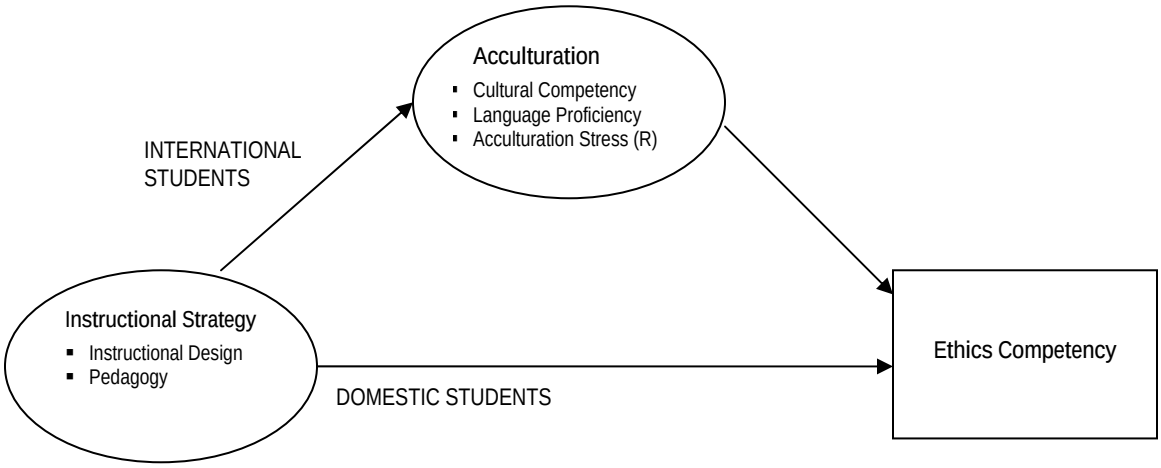

FIG. 1 Proposed Research Model Depicting Relationship Between Instructional Strategy and Ethics Competency for Domestic and International Graduate Students in Engineering

International Engineering Graduate Students Who Remain In The United States Are Expected To Adhere To Normative Ethical Obligations That Have Been Established In This Country

National Science Foundation data indicate that forty percent of all international graduate students in United States engineering programs elect to remain and work in the US after graduation, with seventeen percent reporting job offers in the private sector (Oliver, 2005). Interest in science and engineering education is increasing internationally as more countries strive to become innovators and compete in the global marketplace (Johnson & Coward, 2000). In fact, these international graduate students that remain in the United States are no longer considered "brain drain" on their countries of origin, as they support families and the development of the country using the income earned in the United States (Johnson & Coward, 2000; Shimahara, Holowinsky & Tomlinson-Clark, 2001). In a recent report on policy implications of international graduate student influx, the National Science Foundation (2005) reported that from 1985-2001, Chinese, Taiwanese, Indian, and South Korean students earned more than half of the 148,000 doctoral degrees awarded to foreign students. The report classified the following countries into the "Asian" category: China, Taiwan, India, South Korea, Japan, and Pakistan. Brown & Syverson (2004) concluded that the stay rate is highest for Asian engineering students, specifically Chinese and Indian. Given the significant fraction of Asian students in the international student population, education to prepare international graduate students for work in the United States must be sensitive to this group.

Knowledge of ethical standards, profession norms, and base values is an elemental and integral aspect of any engineering profession (Bird, 2004). Furthermore, understanding of these normative standards is critical for successful acculturation (Wilton & Constantine, 2003). Thus, it is essential that international engineering graduate students who remain in the United States develop a thorough understanding of and respect for ethical obligations and normative standards associated with their chosen occupation. Whether in the private or public sector, international students that remain will be expected to adhere to normative ethical obligations that have been established in this country for engineering research and practice, and in the case of teaching at academic institutions they will be expected to instill an understanding of and respect for those obligations in the students whom they instruct and supervise.

Normative Ethical Obligations for Engineering Practice in the United States Can Be Articulated and Measured

Normative ethical obligations exist for persons who engage in engineering research and practice in the United States. These obligations can be articulated at an appropriate degree of specificity, and the degree to which an international graduate student recognizes and understands these values can be measured. Such values are essential to understanding ethical considerations and issues specific to any particular engineering discipline. The diversity of ethical issues and dilemmas that will arise across all the disciplines and contexts of engineering practice, research, and education is vast, and it would be beyond the scope of any ethics instructional initiative to cover all possible scenarios. But it is possible to identify a set of key foundational principles, one or more of which is likely to be central to the resolution of almost any specific ethics issue. It is an understanding of this set of key principles that this proposal seeks to address. If students graduate armed with a reasoned understanding of these principles, they are more likely to make good decisions in the various specific situations they will encounter in the course of their careers.

There is no one universal or definitive source that articulates the key principles that undergird engineering practice and research. But there are many engineering and scientific professional organizations that have developed and articulated such principles in the contexts of their particular disciplines, and these articulations—or codes of ethics—tend to be variations on a few common themes. With respect to professional practice in engineering, the National Society of Professional Engineers (NSPE 2006), for example, maintains a code of ethics that includes six fundamental canons: i) hold paramount the health, safety and welfare of the public; ii) perform services only in areas of competence; iii) issue public statements in an objective and truthful manner; iv) act for each employer or client as faithful agents or trustees; v) avoid deceptive acts; and vi) conduct oneself honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession. Codes of other engineering professional organizations may vary in the precise number of canons, and in their wording and specificity, but nonetheless there is general agreement on a common core of principles (a compilation of various codes can be found in Unger, 1994).

One experience with the articulation of such engineering ethical principles in a cross-cultural setting was the development of a code of ethics for engineering practice under the North American Free Trade Agreement (NAFTA), which was led in the 1990s by investigators at the Murdough Center for Engineering Professionalism at Texas Tech University under support from the NSF (Smith & Barrington, 1996). This project required the careful integration of values and meanings across three cultures and three languages. Though the resulting NAFTA code of ethics contains ten canons, they are derived from the same basic principles as the six canons of the NSPE code. These principles can be interpreted to include:

1. A commitment to protecting human life and welfare
2. Competence; conscientiousness
3. Honesty; objectivity
4. Trustworthiness; respect for proprietary goods
5. Fairness; openness; avoidance of deception

These basic principles undergird the normative ethical obligations of engineers in all areas of engineering practice, including design, analysis, testing, project management, research and teaching. Since a significant percentage of the international graduate students who remain in the United States after graduation will pursue careers in the latter two engineering job functions—research and teaching—it is worth noting these in particular. The importance of teaching professional ethics to engineering students has gained widespread recognition over the past three decades (Weil, 1984; Herkert, 2000). The development of engineering ethical theory (e.g., Davis, 1998 & 2001; Herkert, 2001) and pedagogical tools (e.g., Martin & Schinzinger, 2005; Harris, Pritchard, & Rabins, 2000; Gunn & Vesilind, 2003; Johnson, 1991) has blossomed in that time span. The current EC2000 accreditation criteria for engineering undergraduate programs specifically requires that students be exposed within their curricula to issues of professional ethical responsibilities and the broader impacts of their work on society. To do this effectively requires an engineering professoriate that is itself knowledgeable about professional ethical responsibilities and is willing and able to communicate those responsibilities to students. Thus, enhancing the understanding of professional ethical responsibilities at the graduate level (i.e., with potential future faculty) can only bolster the larger goal of effective integration of ethical issues at the undergraduate level (Newberry, 2004).

With respect to the research function of engineering practice, which is similar in many ways to scientific practice, many scientific organizations maintain codes of ethics, and these codes reflect a similar common core of principles. The National Academies and the Institute of Medicine have published a booklet titled, *On Being a Scientist: Responsible Conduct in Research* (National Academies, 1995), which discusses several core principles that coincide with engineering practice--such as avoiding conflicts of interest, openness, fairness, competency, and honesty. Though their specific applications in research may be somewhat different than in other areas of engineering practice, these core principles overlap to a high degree with the set of core principles listed above for general engineering practice. For example, plagiarism is a common ethical transgression for international graduate students from countries where the perspective on intellectual property differs from United States mores (Borelli, 2006). In a similar vein, ethics case studies having to do with plagiarism of proposals (Bucknam 1998) and unauthorized use of engineering drawings through copying electronic files owned by others (Bucknam 2000) appear in the case studies of the NIEE Applied Ethics in Professional Practice program. We view research and teaching as two of the many applications of a graduate engineering degree, in addition to private and public discipline-specific services. As such, a common set of normative principles and values can be constructed to be of use to all engineering graduate students, and these principles will both reinforce and expand notions of science ethics and responsible conduct of research.

International Students Experience Acculturation Barriers to Ethics Competency Above and Beyond the Challenges Faced By Domestic Engineering Students

Acculturation is the assimilation into mainstream culture of the host society and integration of native country culture and traditions. Acculturation issues create barriers for international students who need to know and accept what is/would be ethically required of them were they to remain in the United States to practice engineering, teach engineering, or do engineering research. These barriers are above and beyond the challenges faced by domestic engineering graduate students (Huntley, 1993). As discussed below, factors that strongly predict successful acculturation are cultural competency, language proficiency, and specific acculturation stress indicators.

Cultural Competency. American culture is centered around a normative value system based on future orientation, mastery of environment, individualism, “doing”, and good/bad dimensions of humanity (Tomlinson-Clarke, 2001). In evaluating the cultural competency of international graduate students, Rahman and Rollock (2004) found that cultural competency strongly predicts successful acculturation. Their research delineated four components of cultural competency: intercultural attitudes, work (career and academic) productivity, personal/social efficacy, and intergroup comfort. In a similar study, Wilton and Constantine (2003) concluded that increased familiarity with cultural and professional norms leads to better adjustment and quicker acculturation. Huntley (1993) and Poyrazali, Kavanaugh, Baker, and Al-Timimi (2004) noted that Asian international students struggle the most with cultural competency, as Asian culture is grounded in principles of dependency and conformity, which are divergent from the individualism of American culture.

Language Proficiency. Mastery of the English language poses a major challenge for most international graduate students. In addition to typical writing skills, Gorsuch (2003) discussed language competency in terms of sociolinguistic mastery (speaker ability to use appropriate language in various contexts), and textual proficiency (the organization of language in

accordance with normative rhetoric guidelines). Huntley (1993) noted that the development and requirement of the TOEFL – Test of English as a Foreign Language – is a testament to the barrier that English language proficiency poses to international graduate students. The TOEFL is now required, as the language barrier is extremely common for international students. In terms of Asian international students, Jiali (2005) and Poyrazli, Kavanaugh, Baker and Al-Timimi (2004) found that language barriers are one of the most prominent obstacles to successful acculturation.

Acculturation Stress. Acculturation stress is a psychological manifestation of maladaption to the host culture. Poyrazali, Kavanaugh, Baker, and Al-Timimi (2004) identified ethnicity as the major predictor of acculturative stress and noted that Asian international students suffer higher levels of acculturative stress, compared to other ethnicities. Further, Jiali (2005) identified four measurable variables that diagnose acculturative stress: fear, perceived hatred, perceived discrimination, and cultural shock. Rahman and Rollock (2004) concluded that acculturative stress was predictive of perceived cultural competency and successful functioning for international engineering students.

The point of this discussion is that both domestic students and international students who remain in the United States must address the same normative ethical obligations relative to engineering practice. However, acculturation issues are unique to the international student population, *unlike* the case of domestic students where cultural competency, language proficiency, and acculturation stress are not at issue. Ultimately, this means that international students face additional hurdles when it comes to ethics instruction, and the proposed research is about helping this group. Empirical evidence suggests that compared to other international students, Asian students in particular may well benefit more from a training program preparing them for engineering work in the United States (Anderson & Louis, 1994; Poyrazli, Kavanaugh, Baker & Al-Timimi 2004; Sarkodie-Mensah, 1991).

Acculturation Factors Partially Mediate the Relationship Between Ethics Instruction and Ethics Competency for International Students

The research model shows that acculturation issues influence learning for international graduate students. The educational process – for our purposes, ethics instruction – will be effective only to the extent that acculturation factors permit learning to occur. This is in contrast to domestic students, where learning is more directly linked to instruction. We are proposing an instructional strategy directed specifically at alleviating the acculturation barriers, thereby improving ethics education for international graduate students. That is, acculturation barriers for international graduate students can be mitigated by an education intervention (web-based ethics learning modules) designed with appropriate regard to distance learning pedagogy and the unique needs of international student populations.

The timing of the educational intervention is paramount to aiding students with acculturation with respect to engineering ethics. Huntley (1993) delineates four stages of acculturation: (1) anticipatory (before leaving native country); (2) passive spectator (first few months in the US); (3) disenchantment (follows passive spectator and varies in duration based on psychological and cognitive individual differences); and (4) adaptation. Research indicates that all students who stay reach a point of "adaptation" that may include poor language skills, cultural misconceptions, and a misunderstanding of normative values. Once a student reaches this point of "maladaptation," they are less malleable and less willing to re-learn information about the host

country (Constantine, Anderson, Berkel, Caldwell, & Utsey, 2005; Wilton & Constantine, 2003). As such, we will seek to expose students to the learning modules during the passive spectator stage of their acculturation, in an attempt to maximize the benefit of our educational intervention.

The most efficacious intervention strategies include the following pedagogical components: education about specific expectations and demands; education concerning specific skills required for success in the field; and decision-making strategies (Rahman & Rollock, 2004). With regard to normative ethical instruction for engineering students, our educational materials will focus on both declarative knowledge (definitions of ethical guidelines, rules, and regulations) and procedural skills (application exercises, decision-making exercises, and recognizing ethical dilemmas).

In terms of delivery modality, international students are typically proficient with Internet-based technologies, as they use these technologies for socialization and communication with their families at home (Tomlinson-Clarke, 2001). Furthermore, web-delivered modules support an educational paradigm and environment that international students, especially Asian students, are comfortable using. The role of both the student and teacher in Asian culture is very formal and non-interactive, much like traditional American education in the 1950s (Hillman & Gunawardena, 1994). Web-based environments allow students to actively learn through the interface without the stress of public-speaking and face-to-face interactions. For example, Huntley (1993) and Gorsuch (2003) indicated that the international educational cultures are often dramatically different from American educational culture.

Hypotheses

The proposed educational research project improves ethics education by helping international graduate students in engineering overcome the acculturation barriers to personally knowing and inculcating normative ethical obligations associated with engineering practice in the United States. We hypothesize the following:

- International student technology efficacy meets or exceeds the technology efficacy for domestic students.
- Web-based training modules will improve the understanding and mastery of ethical norms, values, regulations, and expectations for international students, compared to domestic students, regardless of institutional affiliation.
- Controlling for language proficiency, our educational intervention will reduce international student acculturation stress and improve their performance on the ethics' mastery test.
- Our educational intervention will improve Asian student performance on the ethics' mastery test more than other international students.

Part II: Method

Subjects

The research subjects proposed for this project are graduate students enrolled in engineering at Texas Tech University, Baylor University, and the University of Texas at Austin. At this time, we have submitted Institutional Review Board Human Subjects' Committee review documents for the host institution. Given the educational nature of the present project, we strongly anticipate that we will be exempted from full review and approved to proceed. While we will design our educational modules relative to the specific acculturation issues of

international graduate students, our plan is to offer ethics instruction to both domestic and international students in order to compare performance by group. The educational strategy proposed in this study will support biculturalism — that is, learning normative values and culture while maintaining native culture, and integration — thus forming a hybrid of US normative values and native country culture (Cemalicar & Zeynep, 2004).

According to the institutional research departments of the collaborating institutions, spring 2005 and fall 2005 engineering graduate enrollments were as follows:

Institution	Fall		Spring	
	Total	International	Total	International
Texas Tech University	558	233	570	81
University of Texas	2061	785	2284	292
Baylor	35	0	7	0
TOTALS	2654	1018	2861	373

Note that these enrollments are typical of class sizes in the last three years. The three collaborating institutions represent a broad spectrum of engineering graduate programs and academic environments. Baylor is a small, private institution. The University of Texas is one of the largest public programs in the United States, and Texas Tech University is a medium-sized public institution. The diversity of institutions will allow us to create robust educational materials suitable for a implementation in a broad spectrum of educational programs and institutions.

We propose to measure both domestic and international group performance on the normative value assessment instrument, and we will also evaluate performance by cultural group. As indicated by aforementioned empiric research, Asian (includes students from India, Pakistan, Japan, Taiwan, China, and South Korea) students have demonstrated higher acculturation stress and face a larger barrier to cultural competency acquisition, given the divergent value systems of the United States and Asian countries. In order to be sensitive to the needs of Asian students, who compose a large percentage of international graduate engineering students and have the highest stay rates, we will rely on our Cultural Advisory Panel that represent the Asian block of countries. The expert panel is described in detail below and will provide guidance, feedback, and advice as we construct the educational modules.

While acculturation issues are common to all international graduate students, we have elected to focus on engineering graduates students. The engineering disciplines are heavily governed by Federal and State regulatory bodies that posit ethical standards and expectations. Furthermore, engineering disciplines have domain-specific professional organizations that articulate common normative values and ethical criteria. Indeed, ethics instruction and proficiency are included in ABET accreditation standards. The broader sciences do not have such a cohesive requirement and common standard that we could use to construct assessment measures and curricula.

The current proposal focuses on ethical standards relevant to the United States for practical reasons; our agenda is not to claim superiority or to devalue another country's

approaches. Our aim is to assist international graduate students, many of whom choose to remain in the United States after graduation, in learning the private and public expectations prominent in the various engineering fields, to allow them to prosper and thrive in that environment. Whether they are teaching undergraduate students, conducting research, or practicing in the public or private sector, international individuals will be required to adhere to these normative values and ethical standards. Though our principle target group is international graduate students that remain and work in the United States after graduation, the value of the ethics modules is not limited to that group. The modules will be a valuable intervention for all international graduate students, helping to acculturate them to normative expectations and values during their stay in the United States as graduate students, and as they practice abroad.

Cultural Advisory Panel

The first step to successful acculturation of international students is to listen to them and understand their needs. To this end, we have assembled an expert panel of advisors that will aid in curriculum development and design. We will listen carefully to their advice and guidance as our team designs and refines the educational modules. The expert panelists have demonstrated successful acculturation in their respective engineering fields:

- Karlene Hoo, Ph.D.
  Professor and Associate Dean of Research
  Co-director Process Control & Optimization Consortium
  Department of Chemical Engineering
  Texas Tech University
- Kishor Mehta, Ph.D., P.E.
  Paul Whitfield Horn Professor
  Member, National Academy of Engineering
  Department of Civil Engineering
  Texas Tech University
- Javad Hashemi, Ph.D.
  Professor
  Director of Graduate Studies and Graduate Advisor
  Department of Mechanical Engineering
  Texas Tech University

Development of Ethics Educational Modules

The instructional materials to be developed for *Ethics Instruction for International Graduate Students in Engineering* will comprise eight online lesson modules, each of which will be designed to require approximately 50 minutes of interactive work at the computer. Sessions will not be time-limited, so that students who work more slowly or who are less fluent in English can work at a pace appropriate to their needs. Overall, the eight modules will require approximately eight hours of interactive learning and will introduce students to the main ethical principles and obligations associated with engineering work in the United States. Each of the eight modules will focus on a particular principle or obligation. The potential topics include:

1. Protecting human life and welfare
2. Professional responsibility (codes of ethics and laws)
3. Competence

4. Honesty
5. Conflicts of interest/disclosure
6. Respect for proprietary goods/intellectual property (copyright, plagiarism)
7. Data integrity (data collection and analysis)
8. Fairness/equality

Each module will be designed with some or all of the following elements (not necessarily in a particular order), depending on what may be most appropriate pedagogically for a given topic.

Definitions/Theory: We will define base principles/obligations, along with related ideas and terminology. The focus will be on discussing the underlying reasoning for the importance of each principle/obligation. Using hypertext, we will design an extensive index and glossary for students to use as they progress through the learning materials.

Applications: We will describe the common ways in which issues related to the principle/obligation are likely to be encountered by professionals. What are the common dilemmas encountered? What are the common pitfalls or the common mistakes that are made? How can those problems be avoided? The dilemmas will be illustrated through short audio and video clips that allow the student to witness the dilemma. Active learning exercises will be designed to test the student's ability to recognize the mistake.

Illustrations/Cases: Specific examples or brief case studies of the principle/obligation being upheld and/or violated, along with the consequences, will be presented. For example, we may use excerpts from the NSF-sponsored ethics film, *Incident at Morales – International Edition* (Smith 2005), produced by the National Institute for Engineering Ethics (NIEE). Other sources of content include the case studies published through the NIEE Applied Ethics in Professional Practice program (Lawson 2003-2006).

We will provide multimedia vignettes that describe a situation and allow the students to navigate through video clips, images, and text that describe case studies of common ethical dilemmas. Students will be asked questions throughout the application exercises and provided immediate feedback and explanation.

Practicum: We will build formative quizzes/scenarios embedded in the various instructional elements that allow the students to test their knowledge and receive instant corrective feedback. We will use a variety of testing formats to assist students in recalling and applying the information in multiple formats.

Exit Assessment: A summative quiz will be used to determine mastery of the subject material. A minimum score must be achieved for successful module completion.

The educational modules will be designed to help students master declarative (facts) and procedural (skill-based) knowledge, with the goal of long-term retention and transfer learning. We will use multimedia as a means to cognitively engage students and a variety of assessment techniques that require them to practice using various formats. With each combination that we provide, we will be improving the likelihood of retention and application--not simply rote recall of information.

In order to design materials sensitive to the needs of international students, our Cultural Advisory Panel will review the educational materials and recommend modifications. In addition, we will use culturally neutral language and symbols (Lin, 2002). Our materials must not assume the students understand nuanced meanings, cultural symbols, or unfamiliar cultural situations. We will also use illustrations and case studies that represent situations that are most likely to be problematic for international students, for example, plagiarism and data integrity issues (Borrelli, 2006). Note that our goal is not to assert any superiority of United States individualistic mores, but rather to have the students understand the differences and be able to adapt their behavior to function appropriately in this culture. We will use materials that have demonstrated success in addressing international and ethical issues; such as, the *Incident at Morales – International Edition* (Smith 2005), produced by the National Institute for Engineering Ethics.

Effective web module pedagogies include interface and cognitive interactivity, feedback, and rich information communicated through text, images, and audio. In addition, educationally valuable web learning modules are user-centered, consistent, logical, organized, and designed based on pedagogy, not technology (Smith & Stalcup(Austin), K., 2001; Taraban, Rynearson & Austin Stalcup, K., 2001; Zanglein & Austin-Stalcup, 1999). Indeed, Jaili (2005) and Ye (2005) reported that technology-based training is an effective means to teach international students materials that reduced acculturation stress. Given the eclectic international educational cultures, technology mitigates the discomfort of conflicting traditional classroom norms that many international students experience (Gorsuch, 2003).

Research Design

Using a multivariate, three-tiered time series design, we propose to methodically create, measure, adjust, and evaluate our educational intervention. Over the course of three years, we propose to administer versions of the educational intervention to incoming international and domestic graduate students. Students will complete the assessment prior to participating in the educational intervention (pre-test) and upon finishing the online instructional material (post-test).

Prior to and following pilot-testing, the expert panel will be asked to review the materials and provide feedback. The curriculum will be developed in an interactive web-based environment and pilot-tested with Texas Tech University, University of Texas, and Baylor University domestic and international engineering students. Students will complete an open-ended questionnaire regarding the usefulness and design of the modules. Note that prior to administering the formal pilot, the modules will undergo usability testing by international engineering student volunteers, as well as review by the Cultural Advisory Panel at Texas Tech University.

The normative value assessment instrument administered prior to training and upon completion will include question sets linked to specific pedagogical approaches contained in the educational modules, such as interactive exercises, multimedia, and trial/error quizzes. This design will allow us to measure the efficacy of the pedagogies and strategies deployed in each

module version. After each year, item-level data will be analyzed to determine the validity of the instructional technique. With the assistance of our expert panel, we will make pedagogical and strategic adjustments as necessary.

Baseline - Year One: Development of Normative Ethics Assessment Instrument and Initial Web-based Educational Modules

The focus in year one will be to construct the educational modules, with guidance from our expert panel. Once the curriculum, instructional design, and pilot testing is completed, we will offer the educational modules to the spring 2007 class of engineering graduate students at all institutions. The team will provide various incentives allowed by Institutional Review Boards, such as food and token institution gifts. During the spring semester and summer, the normative assessment instrument will be analyzed for validity. Based on the quantitative analysis, the team will derive a list of changes to the educational modules and the assessment instruments.

Alpha - Year Two: Holding Language Proficiency Constant, Evaluate the Predictive Validity of Educational Intervention with Respect to Cultural Competency, Acculturation Stress, and Ethics Mastery

Materials. The revised educational modules will be linked to a production database to collect respondent information, module activity, and assessment answers. In addition, the team will use the Cultural Adjustment Difficulties Checklist (CADC, Rahman & Rollock, 2004), the Technology Efficacy and Attitude Survey (Gorsuch & Austin-Stalcup, 2002), and collect international engineering student TOEFL scores. These instruments will adequately measure the acculturation variables of interest in the proposed project.

Procedure. As in the previous semester, we will administer the educational modules to the fall 2007 and spring 2008 classes of engineering graduate students at all three institutions. As an incentive to complete the modules and participate in the research, all students completing the educational materials will be awarded an *NIEE Engineering Ethics Certificate*. Our experience is that this type of educational credential will be highly valued by both international and domestic students.

During the spring semester and summer, the data will be analyzed and the normative assessment instrument will be assessed for reliability and validity. In addition, a multivariate regression analysis will be conducted to determine the predictive validity of the educational intervention, holding language and acculturative stress constant. In addition, responses from Asian students, as defined by the National Science Foundation (China, Taiwan, South Korea, India, Japan, and Pakistan) will be coded so that we can conduct group-specific analyses. We will compare performance on the ethics mastery assessment tool for Asian students to all other international engineering graduate students, as well as domestic students. Based on the quantitative analysis, the team will refine the educational modules and the assessment instrument.

Beta to Production - Year Three: Refine Educational Intervention and Prepare Modules for Public Release and Use

Materials. We will use the same instrument and materials as for the alpha stage, with any refinements made to the educational modules. We will once again seek the input and advice of the expert panel in evaluating our previous assessment and modifying the curriculum and interface design.

Procedure. We will offer the educational modules to the fall 2008 and spring 2009 classes of engineering graduate students at all three institutions. As an incentive to complete the modules, all students completing the educational materials will be awarded an *NIEE Engineering Ethics' Certificate* for training program completion.

In addition to the analyses performed in the previous year and allowing for a year to calibrate the materials across institutions, we will code students by institution and compare the efficacy of the educational modules across institutions. We anticipate that domestic student ethics mastery will improve from pre-to-post assessment, but that international students will demonstrate greater improvement from pre-to-post. We further anticipate that the Asian sub-group of international students will demonstrate a higher marginal change from pre-to-post assessment, compared to non-Asian international students. We do not anticipate any main effects for institution, but are likely to experience varying levels of pre-to-post assessment improvement as we calibrate the learning modules. Based on the research findings, the team will prepare the modules for public dissemination.

Dissemination Plan

We propose a dissemination plan that includes both active and passive mechanisms to share our findings with public universities, private universities, industry, and the scientific community. In terms of active dissemination strategies, first, we have obtained letters of endorsement from the institutional leaders (provosts and deans) at each sponsoring institution. These letters not only express clear support for the research phase of this study, but represent administrative approval to implement the research findings. In addition to implementation at our own universities, we plan to attend three major conferences in the engineering ethics education field and share our findings and materials: American Society for Engineering Education (ASEE), the Association for Practical and Professional Ethics, and the Gonzaga Conference. Our budget includes funds for two team members to attend and present at each conference. Second, the team will conduct educational workshops at Texas Tech University, Baylor University, and the University of Texas. The workshop will target administrators, international student centers, engineering leadership, institutional leadership, and other relevant departments that contribute to the acclimation and education of international engineering graduate students. Third, and in the last phase of our process, once we have baseline and alpha testing completed, we will develop a pre-conference workshop for ASEE. Fourth, we will design a plan to distribute the modules to institutions with active international graduate student training programs. In addition, during the course of the project and beyond, we will provide passive dissemination through a web site, emails to lists of interested parties/professional organizations (listserv technology), and at least two scholarly publications in appropriate journals.

Intellectual Merit

Our proposed project has carefully assembled experts in engineering ethics, assessment, instructional technology, graduate engineering education, international student education, and acculturation. In addition, our Cultural Advisory Panel will provide endemic culture knowledge and experience as successfully acculturated professionals. The eclectic and dynamic team will create portable ethics learning materials ubiquitous to the engineering field. The robust research design will allow for evaluation of individual performance on the assessment after completion of the educational modules, compared to performance prior to instruction. The large sample size provides more than adequate statistical power to detect the effects of an educational intervention.

By administering validated instruments, we will be able to extract variance in performance associated with language proficiency, cultural competency, and technology efficacy. As a result, we will be able to more clearly isolate variance in performance associated with the educational intervention, to determine the predictive validity of our treatment. As a part of our assessment, we will link specific pedagogical and instructional design techniques to learning objectives measured by a cluster of questions on the assessment instruments. In this manner, we will be able to test the efficacy of specific aspects of the educational modules and vary our techniques and design according to student performance data.

Broader Impacts

Perhaps the largest and most direct impact of the proposed study will be on the private sector, as we better train international graduate students, many of whom remain in the United States, to handle, practice, teach, and apply ethical standards in their various engineering capacities. While the societal role of engineers differs drastically across the globe, our curriculum will be designed to acclimate international graduates students to domestic ethical norms and expectations, as well as to help them understand the role of an engineer in the United States.

In addition, the project engenders far broader benefits and merit, including specific activities designed to broaden the participation of underrepresented groups. First, those international graduate students that elect to remain in academe will be better prepared to instruct undergraduate students on ethical matters. By heightening the ethical acumen of international (future) faculty, we will raise the awareness and sensitivity to ethical issues and obligations in undergraduate engineering education and promote instruction of ethics across the curriculum. Second, with the trend towards the globalization of engineering and science (Newberry, 2005; Johnston, 2001), we will be contributing to a clear articulation of ethical standards and expectations in the United States. As a result, dissemination of our research and materials in higher education and the private sector will raise awareness and sensitivity to domestic ethical standards within the international scientific community.

Finally, many of the ethics principles and learning objectives for engineering overlap with the broader science disciplines. The proposed study would both reinforce and extend ethics in the sciences; for example, instruction on the responsible conduct of research. Further, the ethics educational modules proposed for this study could be readily modified to accommodate other science domains. In sum, the motivating need for international graduate student acculturation is common to all disciplines, and the proposed project could serve as an educational model for ethics instruction where content is tailored to the specific needs of any particular engineering or science program.

Part III: Current and Pending Support

The proposed research team brings a plethora of substantive research experience in engineering ethics, instructional technology, assessment, and curriculum design. Each researcher has successfully obtained funding for projects within his or her area of expertise. In addition, the principal investigator is the Deputy Director for the National Institute of Engineering Ethics, housed at the Murdough Center for Engineering Professionalism, a national leader in ethics

issues and instruction, and has served as an NSF grant proposal reviewer for the Ethics Education in Science and Engineering solicitation.

As noted in the table below, each team member brings unique expertise to the project: applied linguistics, engineering philosophy; engineering ethics; technology-based pedagogies; international student instruction; and assessment.

Name	Institution	Project Role	Expertise
William D. Lawson, P.E., Ph.D.	TTU	PI	Practical & applied ethics Engineering professionalism Trust & trustworthiness Assessment Instructional technology Fundamentals of engineering exam
Katherine A. Austin, Ph.D.	TTU	Co-PI	Research methods and statistical design Assessment Instructional technology Learning/cognitive psychology
Byron Newberry, Ph.D., P.E.	Baylor	Co-PI	Engineering ethics Philosophy of engineering Instructional design
Greta G. Gorsuch, Ed.D.	TTU	Co-PI	Applied linguistics International student instruction Educational culture Assessment
Thomas J. Darwin, Ph.D.:	UT-Austin	Senior Consultant	Graduate education Professional ethics Cross-cultural communication Instructional technology

While the present project principal and co-principal investigators do not have current NSF support, our Cultural Advisory Panel members are all prior NSF investigators with internationally recognized research records. As examples and relevant to the present research, the expert panel has received NSF funding for the following:

- Kishor Mehta, Ph.D., P.E., principal investigator for the Texas Tech University Wind Science and Engineering Integrative Graduate Education and Research Traineeship (IGERT), a ten-year collaborative program with Colorado State University, has incorporated a 3.0-credit hour graduate class in engineering ethics into the IGERT program.
- Javad Hashemi, Ph.D., NSF CCLI Grant, DUE-0231406, “Elements of a Realistic Virtual Laboratory Experience in Materials Science: Development and Evaluation”
- Karlene Hoo, Ph.D., NSF CCLI Grant, “The Virtual Chemical Engineering Unit Operations Laboratory”

Note that Dr. Hoo and Dr. Mehta have also received NSF honors and awards. These distinguished engineers/scientists will assist our team with the formulation of materials, as well as the administration of the grant.

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