DEVELOPMENT AND VALIDATION OF SURVEYS MEASURING STUDENT ENGAGEMENT IN ENGINEERING, PART 2

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***Abstract**: This paper summarizes the development, testing and validation of the engineering versions of the National Survey of Student Engagement (NSSE) and its faculty version, the Faculty Survey of Student Engagement (FSSE). These engineering versions (E-NSSE and E-FSSE) assess the extent to which engineering students are being engaged by identified "best instructional practices" and are achieving certain learning outcomes desired of engineering graduates. These surveys were first pilot-tested at six engineering programs across the United States. Tests of validity and reliability were conducted on both instruments. The instruments were then refined and shortened based on the psychometric properties of the items in the original instruments. Ultimately, we hope to make the instruments available to the national engineering education community so that they might improve the ways in which they teach tomorrow's engineers. This paper will discuss the ongoing progress of both instruments as well as summarize results obtained from their administration.*

Introduction

Several recent reports lament the current state of engineering education (e. g., National Academy of Engineering [NAE], 2005, 2004; ,National Science Board [NSB], 2007) and call for faculty members to improve the career preparation that undergraduate engineering students receive (ABET, Inc., 2002). These improvements include greater attention to differing learning styles among students and using teaching methods that include all students (Felder & Silverman, 1988). Faculty have also begun focusing on effective and valid methods of assessing student performance and learning as well as their own teaching effectiveness (Olds, Moskal, & Miller, 2005). One construct that overlaps these variables is student engagement.

Although engagement can be defined in many ways, Chen, Lattuca, and Hamilton (2008) used "quality of effort" (p. 339) to operationalize student engagement. Faculty contribute to student engagement by creating the instructional practices, professional development activities, and attitudes that foster student engagement. Students who believe their professors care about them and their education remain engaged (Chen et al., 2008), and both student outlook and faculty pedagogy affect engagement as well (Smith, Sheppard, Johnson, & Johnson, 2005). The National Survey of Student Engagement (NSSE, 2007) and the Faculty Survey of Student Engagement (FSSE, 2006) are well-known and measure the many aspects of student engagement, but are not specific to engineering. The current project aims to develop, test, and validate engineering-specific versions of those surveys (E-NSSE and E-FSSE). Work on this project is ongoing and has been described previously (Cady, Fortenberry, Drewery, & Bjorklund, 2009; Drewery & Fortenberry, 2007; Bjorklund & Fortenberry, 2005; Cupp, Moore, & Fortenberry, 2004; Moore, Cupp, & Fortenberry, 2004). This paper presents results from recent validation and reliability testing. This phase of the project examined the test-retest reliability of the two surveys by correlating the item answers given by the same individual in two separate survey administrations.

Methodology

Engineering faculty members (19) and students (261) from five undergraduate institutions completed the current pilot testing for the E-NSSE and E-FSSE. Testing took place in the spring and fall semesters of 2008. As with prior survey administrations, the instruments were translated into online questionnaires using FormSite (www.formsite.com). All respondents completed the survey and were sent a reminder email to complete it again the following week. Respondents were told in recruiting letters that if they completed the survey twice they would be entered into a drawing for a cash prize. After the respondents completed the questionnaire a second time they were taken to a page to enter contact information for the cash drawing, but identifying information was kept separate from survey answers. Data were examined and analyzed in SPSS.

Results

Nineteen engineering faculty members completed the surveys twice. The average length of appointment was 21.5 years, although experience ranged from less than a year as a faculty member to over 40 years. Of the 19 professors, 13 were male and 13 came from chemical, civil, or mechanical engineering. The remaining 6 faculty members were aerospace, computer, electrical, or materials engineering faculty members, and one respondent did not indicate a discipline. For the E-FSSE, the test-retest reliability was calculated using the correlations for Time 1 and Time 2 responses to the items within the factors identified in Drewery and Fortenberry (2007). Overall, the components correlated moderately well both within factors and across time. The item correlations ranged from -.25 to 1.0, and 112 of the 142 total questions correlated significantly from Time 1 to Time 2. The E-FSSE factors are listed in Table 1, and more complete results are presented in Cady, et al (2009).

Table 1: Student Outcomes and Instructional Practices Scales for E-FSSE

Student Outcomes	Instructional Practices
An ability to apply knowledge of mathematics, science, and engineering *	Encourage student-faculty interaction
An ability to design and conduct experiments, as well as to analyze and interpret data * +	Develop reciprocity and cooperation among students *
An ability to design a system, component, or process to meet desired needs * +	Communicate high expectations
An ability to function on multi-disciplinary teams * +	Give students feedback
An ability to identify, formulate, and solve engineering problems * +	Use active learning techniques * +
An understanding of professional and ethical responsibility * +	Emphasize time on task
An ability to communicate effectively * +	Respect diverse talents and ways of thinking
The broad education necessary to understand the impact of engineering solutions in a global and societal context * +	Build on correct preexisting understandings, dispel false preconceptions
A recognition of the need for, and an ability to engage in, lifelong learning *	Provide factual knowledge, facilitate understanding of facts and ideas in context of a conceptual framework and organizing knowledge that facilitates retrieval of application
A knowledge of contemporary issues *	Encourage students' motivation to learn *

An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice *	
An ability to manage a project (including familiarity with business, market-related, and financial matters) * +	
A multidisciplinary systems perspective * +	
An understanding of and appreciation for the diversity of students, faculty, staff, colleagues, and customers *	
A strong work ethic	

** Cronbach's α for factor greater than .7* + *Test-retest correlations significant for all items in factor*

Two hundred sixty-one students completed the surveys twice. Seventy-three respondents indicated a major other than those listed on the survey, 55 students were mechanical engineering students, 35 were electrical, 33 were civil, and 27 were chemical engineering students. Another 14 were computer engineering students, 11 were aerospace, 10 were industrial, and 3 were materials engineering students. The majority were male (184, 70%), full-time students (257, 99%), and had started college at their current institution (221, 85%). Self-reported grades of the respondents were generally above average, with 96% indicating that most of their grades were above a C+ and 74% indicating that most of their grades were B+ or higher. The students ranged in their expected graduation dates, with many indicating they would graduate in Spring 2010 (51, 20%), Spring 2011 (59, 23%), Spring 2009 (35, 13%), or Spring 2012 (31, 12%).

As with the prior analysis of the faculty responses, the student data were examined using an exploratory factor analysis with varimax rotation. Because this step had not been completed prior to the current testing phase, the Time 1 responses were used for this analysis. Originally, 20 factors resulted from the analysis, but 5 were removed because they did not contain any items with factor loadings of .4 or greater (Mertler & Vannatta, 2002). The final 15 factors and their Cronbach's α reliability, along with the items composing them, are shown in Table 2. For each of the individual items, the test-retest Pearson's coefficient was significant.

Table 2: Factors and Item Correlations for Time 1 E-NSSE Responses

Factor, α score	Item
General Engineering Skills α = .979	Use basic scientific principles to analyze the performance of processes and system
	Use basic engineering principles to analyze the performance of processes and systems
	Formulate and evaluate mathematical models describing the behavior and performance of systems and processes
	Design an experiment
	Analyze evidence or data from an experiment
	Interpret results of an experiment
	Use evidence to draw conclusions or make recommendations
	Identify essential aspects of the engineering design process
	Apply systematic design procedures to open-ended problems
	Design solutions to meet desired needs
	Identify problems for which there are engineering solutions
	Formulate a range of solutions to an engineering problem
	Test potential solutions to an engineering problem
	Use feedback from an experiment to improve solutions to an engineering problem
	Identify potential ethical dilemmas in engineering practice
	Estimate the potential for ethical dilemmas due to budget or time constraints
	Address ethical issues when working on engineering problems
	Apply an engineering code of ethics
	Apply technical codes and standards
	Convey technical ideas in writing
	Convey ideas verbally
	Convey ideas in formal presentations
	Convey ideas in graphs, figures, etc.
	Estimate the impact of engineering solutions in a societal context (in a particular culture, community, state, nation, etc.)

	Estimate the impact of engineering solutions in a global context
	Apply engineering techniques (e.g., processes, methods) in engineering practice
	Apply engineering skills (e.g., experimentation, machining, programming) in engineering practice
	Apply engineering tools (e.g., software, lathes, oscilloscopes) in engineering practice
	Integrate engineering techniques, skills, and tools to solve real-world problems
	Manage a team's time to meet deadlines when leading a project
	Determine equipment and personnel needed when managing a project
	Apply interpersonal skills in managing people
	Integrate knowledge and skills learned in engineering disciplines other than their specific majors
	Recognize the need to consult an expert from a discipline other than their own when working on a project
	Recognize the limitations or validity of other professional engineers' opinions
	Consider contemporary issues (economic, environmental, political, aesthetic, etc.) at the local, national, and world levels
	Consider contemporary technical issues in your discipline at the local, national, and world levels
	Estimate how engineering decisions and contemporary issues can impact each other
	Use knowledge of contemporary issues to make engineering decisions
Instructors and Classes Followed Best Practices α = .896	Instructors were enthusiastic about engineering research or practice
	Instructors were enthusiastic about teaching engineering
	Instructors recognized that some students learn in different ways than others
	Instructors conveyed material in more than one way (in writing, using diagrams, verbally, using real-life examples, etc.)
	Instructors explained new concepts by making explicit links between what students already know and the new material
	I have learned to apply fundamentals to problems I haven't seen before
	Instructors used simple, common sense examples or metaphors to introduce new concepts
	Instructors introduced new concepts by requiring students to engage in hands-on activities, class discussions, etc.
	I found meaning, value, and interest in my engineering course material
	My engineering courses had an open and positive atmosphere
	I felt like a valued member of the engineering community at my university
Relationships With Peers α = .918	I worked cooperatively with other students on course assignments
	Students taught and learned from each other
	Classmates and I worked in groups
	I discussed ideas with my classmates (individuals or groups)
	I got feedback on my work or ideas from my classmates
	I interacted with classmates outside of class
Teamwork α = .923	Work in teams where knowledge and ideas from many disciplines (business, public policy, engineering, etc.) must be applied
	Work in teams where knowledge from many engineering disciplines must be applied
	Collaborate with others when working on multidisciplinary teams
	Communicate effectively with others when working on multidisciplinary teams
	Effectively manage conflicts that arise when working on multidisciplinary teams
	Do their fair share of the work when working on multidisciplinary teams
Discriminatory Behavior α = .900	I observed the use of offensive words, behaviors, or gestures directed at students because of their backgrounds or identities
	I observed other engineering students being ignored or excluded (from projects, discussions, lab work, etc.) because of their backgrounds or identities
	I was harassed or discriminated against by others in my major because of my background or identity
Professional and Personal Growth α = .816	Set and pursue your own learning goals
	Take new opportunities for intellectual growth or professional development
	Seek the latest information or advances in your field
	Engage in critical, reliable, and valid self-assessment
	Apply new knowledge gained to the practice of engineering

	Recognize the unique skills, abilities, and contributions of all students in your engineering courses
	Recognize the need for diverse perspectives in solving engineering problems
Interactions with Instructors α = .814	I interacted with instructors as part of my courses
	I interacted with instructors outside of class (office hours, advising, committees, etc.)
	Instructors knew my name
	I used email to communicate with instructors
	I discussed grades or assignments with my instructors
	I received positive feedback from instructors that I can do well in engineering courses
Own Work Habits α = .705	Do you fail to do your best work (reverse coded)
	Do you turn in completed assignments on time
	Do you complete your share of tasks on time, when working in teams
	Are you dependable on your coursework
Respect for Diversity α = .732	My engineering courses emphasized acceptance of and respect for differences (of opinion, background, etc)
	My engineering instructors and I discussed diversity issues
	My engineering instructors emphasized the importance of diversity in the engineering workplace
Instructors' Positive Behavior α = .808	Assignments and activities were clearly explained
	Instructors made clear what is expected of students in the way of activities and effort
	Instructors gave me detailed feedback on my work
	Instructors gave me prompt feedback on my work
Negative Experiences α = .504	Instructors expected a lot of work from me
	Instructors expected high quality work from me
	Engineering assignments, projects, or examinations have been too difficult for me to be successful
	I felt intimidated by some of my engineering instructors
Working with Diverse Others α = .826	Comfortable working with engineering clients and colleagues from diverse racial/ethnic backgrounds
	Comfortable working with engineering clients and colleagues of the opposite gender
Lifelong Learning α = .826	Do you seek ways to improve a design or project, even after it's been turned in
	Do you take initiative in your learning process
Business Skills α = .826	Create and follow a budget when managing a project
	Address the business, financial, and market related matters associated with project engineering
Inclusive Behaviors α = .620	My engineering courses' content reflects contributions of all engineers, including women and people of color, etc.
	Students of all backgrounds/identities participate in class (in discussion, in-class assignments, team projects, etc.)

Conclusions

Overall, the test-retest reliability of the E-FSSE and E-NSSE was satisfactory. The student survey items were all correlated from Time 1 to Time 2, as were a majority of the faculty survey items. Interestingly, while the faculty responses yielded several different factors that describe student outcomes in engineering education, the student responses showed one large scale that was labelled "General Engineering Skills" because it encompassed a majority of the learning outcomes. Future research should examine the reasons behind this difference.

The validity of the individual scales was also satisfactory, with most of the factors having reliability scores above the generally-accepted .7 level. However, future testing is needed to determine whether the weaker factors should remain as-is in the surveys or should be modified to yield stronger scales. In addition, confirmatory factor analyses should be conducted with large groups of respondents. The small sample size of faculty respondents precluded this confirmatory analysis in the present study, although the exploratory analysis previously conducted indicated the 25 different factors.

These results indicate that the E-NSSE and E-FSSE may be used to determine elements of student engagement in engineering departments. In particular, the Student Outcomes scales in the E-FSSE had acceptable reliability (with the exception of the "Strong Work Ethic" scale), as did the highly inclusive "General Engineering Skills" scale in the E-NSSE. The items of the E-NSSE also had significant test-retest reliability, indicating that the survey items will give consistent and dependable results across respondents. On the other hand, the Instructional Practices scales on the E-FSSE were less reliable, and several of the individual items did not have significant test-retest reliability. This indicates that further testing of the E-FSSE may be necessary.

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