Effectively Assessing Student Learning Through Project Experiences

Abstract

A goal of Western Kentucky University (WKU) is to engage students during their academic careers. The Electrical Engineering (EE) Program at WKU defines student engagement through project experiences. Many engineering programs use student projects as a means for address a majority of ABET Criteria 3 A-K. This paper will address the effectiveness of projects as a means of student engagement and meeting ABET Criteria 3 A-K. The National Survey of Student Engagement (NSSE) is a popular self-assessment instrument used by many universities. The usefulness of NSSE in assessing ABET Criteria 3 A-K will also be discussed.

The ABET assessment data and the NSSE scores for upper division students will be examined. This paper will take a cross-sectional look at the value of projects in the engineering education process by studying the assessments of faculty and students.

Introduction

Western Kentucky University (WKU) University prides itself in engaging students across the campus. WKU has developed a Quality Enhancement Plan which states that

> *"Students will engage with communities other than their own in purposeful learning activities that explicitly address their capacity and responsibility to contribute to community and society."*[1]

Each department across the campus has developed venues for engaging students. One method that the university uses to measure engagement is through the National Survey of Student Engagement (NSSE) which is administered to each freshmen and senior student.

The Department of Engineering at WKU is an ABET accredited program that has a mission of project-based engineering education. The department has chosen to engage students through this type of educational experience. Since the programs in the Department of Engineering are ABET accredited, the ABET criterion must be satisfied. The three programs in the department; civil engineering, electrical engineering, and mechanical engineering; have created individual assessment programs in order to continuously improve the programs. Project courses and design experiences play an integral role in the delivery of the project based courses at WKU. This paper will examine the effectiveness of engagement in increasing student learning in the electrical engineering program while meeting the ABET Criteria 3 A-K requirements. The NSSE scores of the EE students will be compared to the results of the ABET assessment to determine if there is any correlation and if the NSSE is an accurate predictor of EE student engagement.

Definition of Engagement in Western Kentucky University Engineering Programs

The focus of the WKU Department of Engineering is project-based engineering education. An excerpt from departmental mission statement clearly states this focus[2]:

> "The mission of the Department of Engineering is to produce, as its graduates, competent engineering practitioners. An engineering practitioner is one who has

a foundation of basic science, mathematics, and engineering knowledge, combined with practical knowledge and experience in applying existing technology to contemporary problems. "

The mission of the EE program is to build a foundation of knowledge in electrical engineering by integrating a variety of project experiences at every level throughout the curriculum.[2] The program is to be relevant to the region and to produce graduates who can immediately contribute to the profitability of their employer. Specifically the graduates of the EE program should have following qualities[2]:

- Practical problem solvers with abstract thinking skills;
- Life-long learners capable of building their careers upon a solid foundation of knowledge;
- Competent in communicating technical materials and concepts in individual and group situations;
- Able to apply with confidence the basic sciences and mathematics to their professional activities; and
- Acclimated to individual and team project activities based upon numerous experiences relating to our project-based, industry-related curriculum.

It should be noted that the mission statement and desired qualities of graduates of the EE program directly support the ABET Criteria 3 A-K.[3]

During the creation of the engineering programs at WKU, much time and energy was devoted to defining project-based education and the engagement of students. The roles of the student as learner, observer, assistant, and practitioner have been clearly defined and articulated for this environment which is summarized in the table below.[4]

Table 1: Roles of Student in WKU Engineering Programs

Role	Characteristics
Learner	• Gain foundational knowledge of the field • Learning the language used by engineers in the field
Observer	• Understand foundation of the field • Able to intelligently observe engineering professionals with understanding
Assistant	• Able to assist with projects • Data collection and performing tests
Practitioner	• Solve open-ended problems • Develop own solutions to engineering design problems (such as in capstone design experience)

Throughout the curriculum, EE students are provided a variety of opportunities to grow in these roles. In the WKU Department of Engineering, an engaged student is a student who successfully develops as an engineer through the roles defined above and embodies the mission of the department.

Assessment

In order to determine the engagement of students, two groups of seniors were ranked by program faculty on objectives, outcomes, and engagement in projects. The students were separated into thirds (top, middle, and bottom). The students also self assessed themselves using the National Survey of Student Engagement described in the next section. A rubric was generated for faculty to assess two groups of senior students in light of the program objectives, program outcomes, and student engagement. The first section of the rubric scored students on the project outcomes. The statements that were used on the rubric are listed in Table 2 below. The program outcomes directly support ABET Criteria 3 A-K.[6] The statements used in Table 2 were taken from an assessment instrument created by the Center for the Advancement of Scholarship on Engineering Education.[7] The faculty ranked the students according to the top third, middle third, and bottom third performance on each point.

Table 2: Rubric Qualities Used by Faculty to Rank Students on Program Outcomes

	Characteristic	Program Outcome Supported[6]	ABET Criteria 3 Supported
I.1	Use basic scientific and engineering principles to analyze the performance of processes and systems	1	A
I.2	Design an experiment	2	B
I.3	Analyze evidence or data from an experiment	2	B
I.4	Identify essential aspects of the engineering design process	3	C
I.5	Design solutions to meet the desired needs	3	C
I.6	Collaborate and communicate effectively with others when working on multidisciplinary teams	4	D
I.7	Do their fair share of working when working on multidisciplinary teams	4	D
I.8	Formulate a range of solutions for an engineering problem	5	E
I.9	Use feedback form an experiment to improve solutions to an engineering problem	5	E
I.10	Identify potential ethical dilemmas in engineering practice	6	F
I.11	Address ethical issues when working on engineering problems	6	F
I.12	Convey technical ideas in writing	7	G
I.13	Convey technical ideas verbally	7	G
I.14	Convey ideas in formal presentations	8	H
I.15	Estimate the impact of engineering solutions in a societal context (in a particular culture, community, state, nation, etc)	8	H
I.16	Participate in professional development	9	I
I.17	Apply engineering techniques (e.g. processes, methods) in engineering practice	11	K
I.18	Estimate how engineering decisions and contemporary issues can impact each other	10	J
I.19	Apply engineering skills (e.g. experimentation, machining, programming) in engineering practice	11	K
I.20	Apply engineering tools (e.g. software, lathes, oscilloscopes) in engineering practice	11	K
I.21	Integrate engineering techniques, skills, and tools to solve real-world problems	11	K
I.22	Estimate how engineering decisions and contemporary issues can impact each other	11	K

Faculty then ranked students on the faculty perception of the student engagement in engineering projects. A set of characteristics that describe an engaged student in the WKU EE program were written and are shown in Table 3 below. These characteristics are based on the role of the student in a project based curriculum as defined in Table 1 above. Once again, the students were ranked by thirds.

Table 3: Rubric Qualities Used by Faculty to Rank Students on Engagement

	Characteristic
II.1	Actively participate in project assignments with enthusiasm
II.2	Exhibit self-motivation in project assignment with enthusiasm (versus waiting on specific guidance from faculty)
II.3	Participate in extracurricular project activities
II.4	Desire to learn the art of engineering rather than simply earning grades
II.5	Embrace project experiences as vital to their educational experience

Finally, faculty were asked to rank students by thirds on their assessment of the program objectives. The questions used to assess the objectives are shown in Table 4.

Table 4: Rubric Qualities Used by Faculty to Rank Students on Program Objectives

	Characteristic	Program Objective Supported
III.1	Have successful and productive engineering careers	1
III.2	Perform technically competent work with the ability to analyze and solve electrical engineering problems	2
III.3	Continue professional development and lifelong learning	3
III.4	Practice engineering in a professional manner demonstrating an awareness of legal issues	4
III.5	Practice engineering in a professional manner demonstrating an awareness of ethical issues	4
III.6	Communicate their ideas and designs effectively	5

Using NSSE in Assessing ABET Criteria 3 A-K

Western Kentucky University uses the National Survey of Student Engagement (NSSE) as a method for determining student engagement. The NSSE webpage describes the survey as "designed to obtain, on an annual basis, information from scores of colleges and universities nationwide about student participation in programs and activities that institutions provide for their learning and personal development."[8] The NSSE instrument is essentially a series of questions created to determine student perception of their engagement during their higher education experience. NSSE is described as a method for determining "level of academic challenge, active and collaborative learning, student-faculty interactions, enriching educational experiences, and supportive campus environment."[8]

The NSSE instrument poses questions that allow students to rate themselves on activities that relate to the specific academic program, the resources that the university offers, and other activities present on campus.[9] For this study, several NSSE questions were chosen that related directly to the ABET Criteria 3 A-K as seen in Tables 5-9 below.

In Table 5, students responded to the following question:

> "In your experience at your institution during the current school year, about how often have you done each of the following?"

With the following answers: very often, often, sometimes, and never.

Table 5: NSSE Questions in Support of ABET Criteria 3 A-K

	NSSE Number	Statement	ABET Criteria 3
IV.1	1B	Made a class presentation	G
IV.2	1D	Worked on a paper or project that required integrating ideas or information from various sources	C
IV.3	1G	Worked with other students on projects during class	B,C,E
IV.4	1H	Worked with classmates outside of class to prepare class assignments	B,C,E
IV.5	1I	Put together ideas or concepts from different courses when completing assignments or during class discussions	A,C,E
IV.6	1L	Used electronic medium (listserv, chat group, Internet, instant messaging, etc) to discuss or complete an assignment	K
IV.7	1O	Talked about career plans with a faculty member or advisor	I
IV.8	1U	Had serious conversations with students of a different race or ethnicity other than your own	D
IV.9	1V	Had serious conversations with students who are very different from you in terms of their religious beliefs, political opinions, or personal values	D

For the statements in Table 6, students responded to the following question:

> "During the current school year, how much has your coursework emphasized the following mental activities?"

With the following answers: very much, quite a bit, some, and very little.

Table 6: NSSE Questions in Support of ABET Criteria 3 A-K

	NSSE Number	Statement	ABET Criteria 3
IV.10	2A	Memorizing facts, ideas, or methods from your courses and readings so you can repeat them in pretty much the same form	A
IV.11	2B	Analyzing the basic elements of an idea, experience, or theory, such as examining a particular case or situation in depth and considering its components	A,B,C,E
IV.12	2C	Synthesizing and organizing ideas, information, and experiences into new, more complex interpretations and relationships	C,E
IV.13	2D	Making judgments about the value of information, arguments, or methods, such as examining how others gathered and interpreted data and assessing soundness of their conclusions	B
IV.14	2E	Applying theories or concepts to practical problems or in new situations	C

In Table 7, students responded to the following question:

"Which of the following have you done or do you plan to do before you graduate from you institution?"

With the following answers: done, plan to do, do not plan to do, and have not decided.

Table 7: NSSE Questions in Support of ABET Criteria 3 A-K

	NSSE Number	Statement	ABET Criteria 3
IV.15	7A	Practicum, internship, field experience, co-op experience, or clinical assignment	I
IV.16	7D	Work on a research project with a faculty member outside of course or program requirements	I,J
IV.17	7E	Foreign language coursework	H
IV.18	7F	Study abroad	H
IV.19	7G	Independent study or self-designed major	I
IV.20	7H	Culminating senior experience (capstone course, senior project or thesis, comprehensive exam, etc)	J,K

In Table 8, students responded to the following question:

"To what extent has you experience at this institution contributed to your knowledge, skills, and personal development in the following areas?"

With the following answers: very much, quite a bit, some, and very little.

Table 8: NSSE Questions in Support of ABET Criteria 3 A-K

	NSSE Number	Statement	ABET Criteria 3
IV.21	11A	Acquiring a broad general education	H
IV.22	11B	Acquiring job or work-related knowledge and skills	I
IV.23	11C	Writing clearly and effectively	G
IV.24	11D	Speaking clearly and effectively	G
IV.25	11E	Thinking critically and analytically	B,C,E
IV.26	11F	Analyzing quantitative problems	A
IV.27	11G	Using computing and information technology	K
IV.28	11H	Working effectively with others	D
IV.29	11M	Solving complex real-world problems	C,H,J
IV.30	11N	Developing a personal code of values, and ethics	F
IV.31	11O	Contributing to the welfare of your community	F

Results

A large amount of correlation data was generated from the faculty rankings, student self-assessment (NSSE data), and student institutional grade point average. A correlation value greater than the absolute value of 0.3 indicates a strong linear relationship between two items. A correlation value less than the absolute value of 0.3 indicates that there is no relationship between the items. Figure 1 shows the correlation between the faculty assessment of students in regard to the engagement (Table 3) and fulfillment of the program objectives (Table 4).

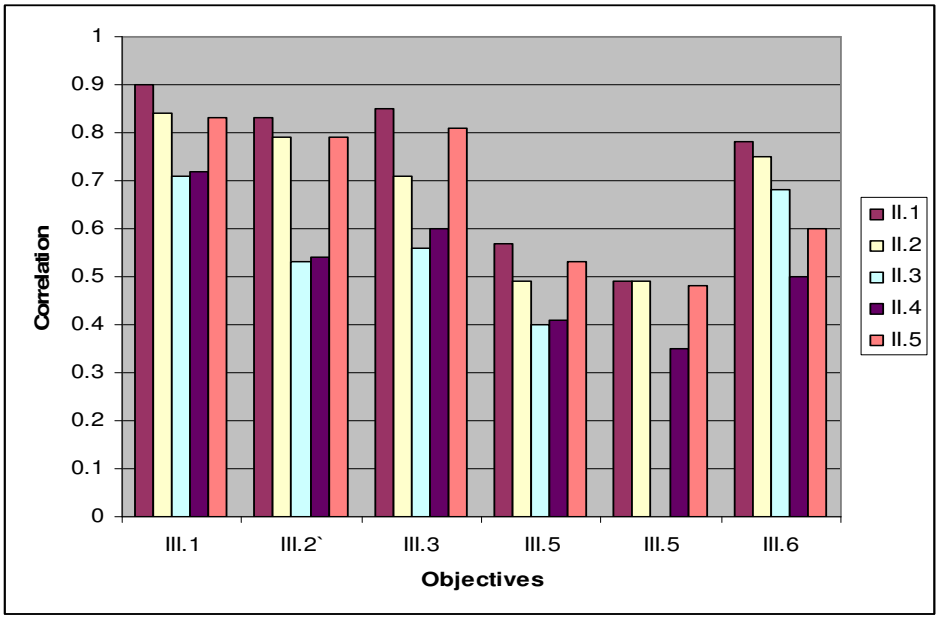

Figure 1: Correlation between Faculty Assessment of Engagement (II.1-II.5) and Objectives (III.1-III.6)

As seen above, the faculty perception of students fulfilling the program objectives and students that are engaged is very strong. Therefore, the faculty perceive that an engaged student fulfills the program objective. Figures 2 and 3 below show the correlation between program outcomes and student engagement.

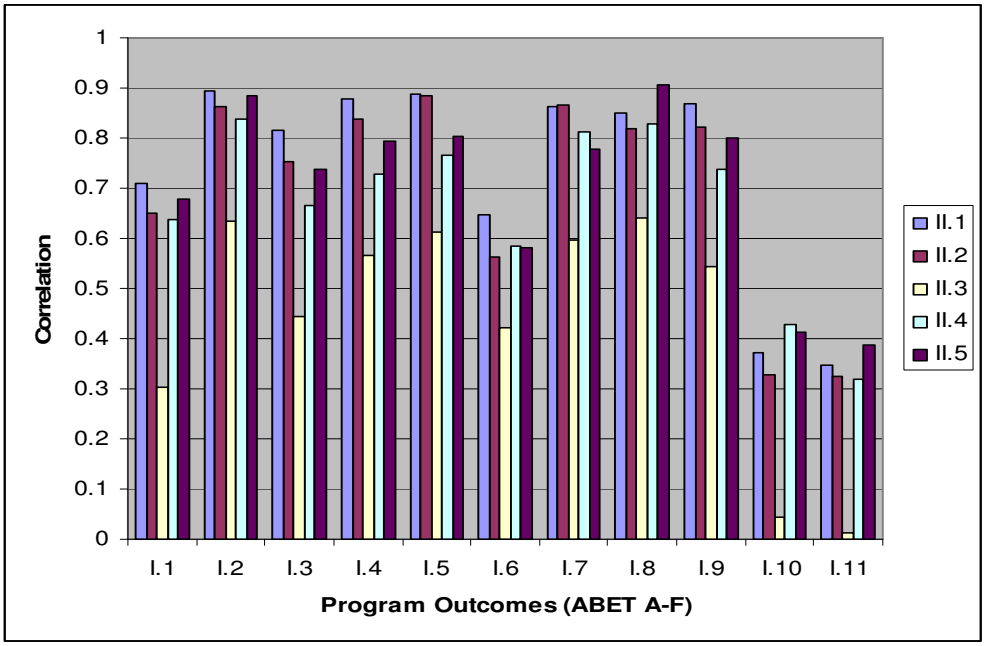

Figure 2: Correlation between Faculty Assessment of Engagement (II.1-II.5) and Program Outcomes (I.1-I.11)

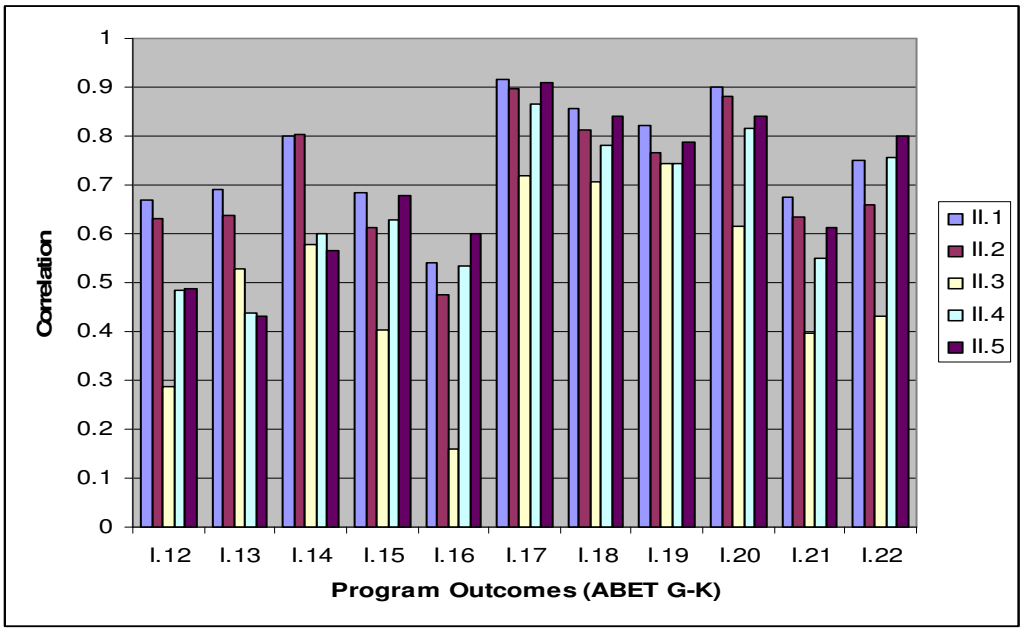

Figure 3: Correlation between Faculty Assessment of Engagement (II.1-II.5) and Program Outcomes (I.12-I.22)

There is strong correlation between the program outcomes and student engagement. The faculty perceive that engaged students also meet the program outcomes and the ABET Criteria 3 A-K. Another result that was obtained from this exercise was that there was a very high correlation between faculty perception of program outcomes and objectives.

Figures 4, 5, and 6 contain the correlation data of the student GPA with the program objectives, engagement, and outcomes, respectively. There is a high correlation between the program objectives and outcomes with student GPA as seen in Figures 4 and 6. There was no correlation between the faculty perception of engagement and student GPA (Figure 5). Therefore, student GPA is not a good indicator of student engagement but can be used as one data point to assess program outcomes and objectives.

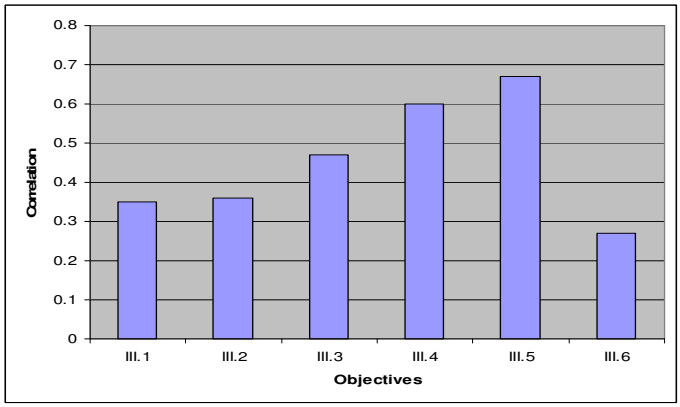

Figure 4: Faculty Perception of Objectives and Student GPA Correlation

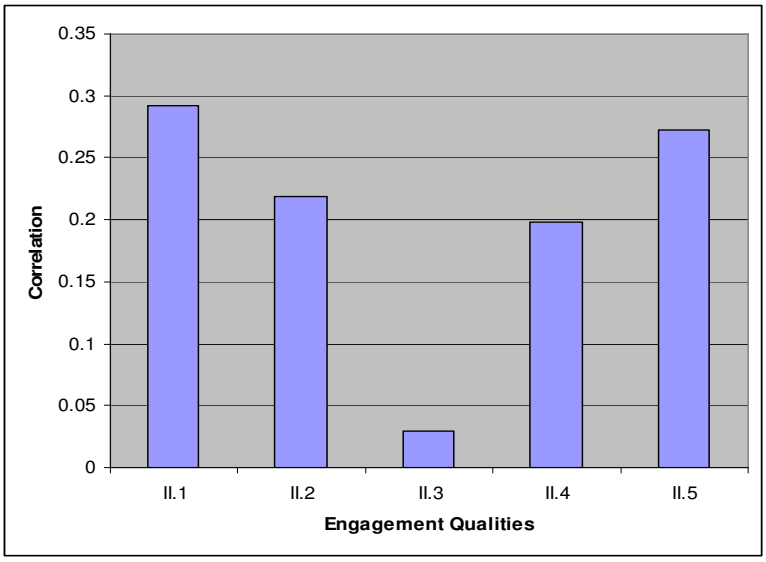

Figure 5: Faculty Perception of Engagement and Student GPA Correlation

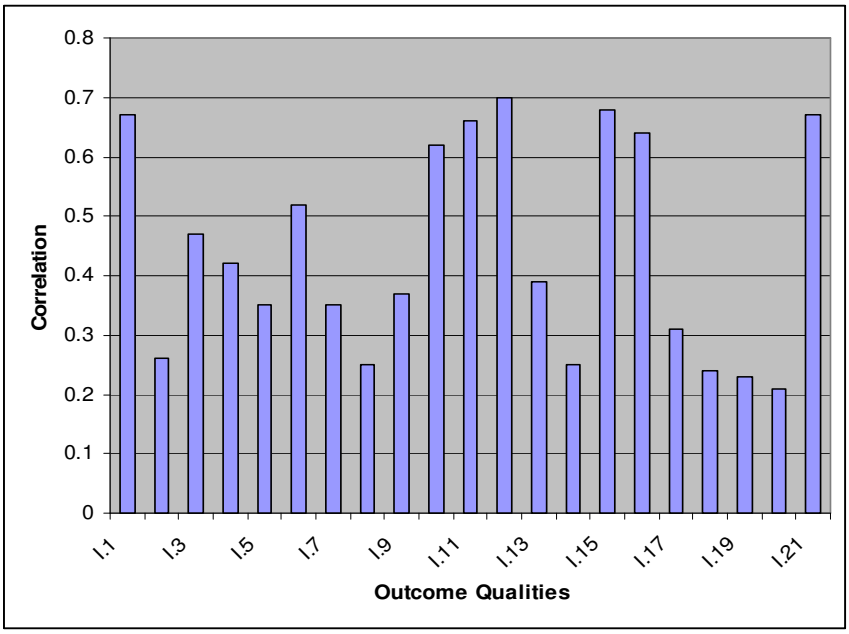

Figure 6: Correlation Between Faculty Perception of Outcomes (I.1-I.21) and Student GPA

The NSSE data was examined for correlation to engagement. The absolute value of the correlation data is shown in Figures 7 and 8 below. As seen there is some correlation between student self-assessment and faculty assessment of student engagement.

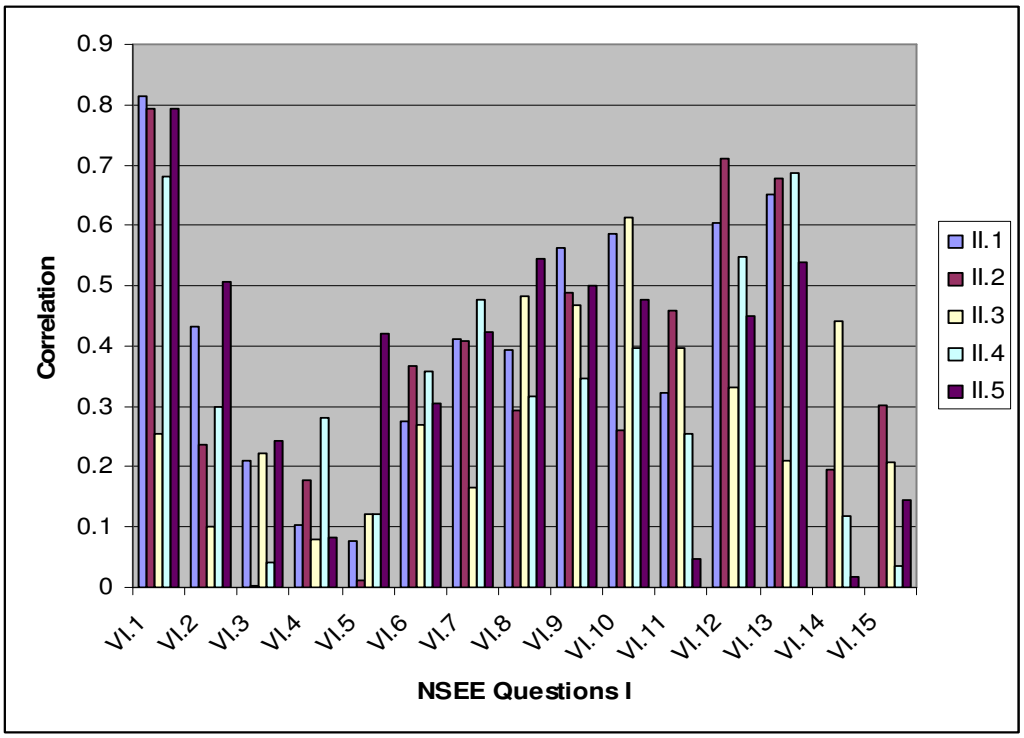

Figure 7: Correlation Between NSEE Questions (VI.1-VI.15) and Faculty Assessment of Engagement (II.1-II.5)

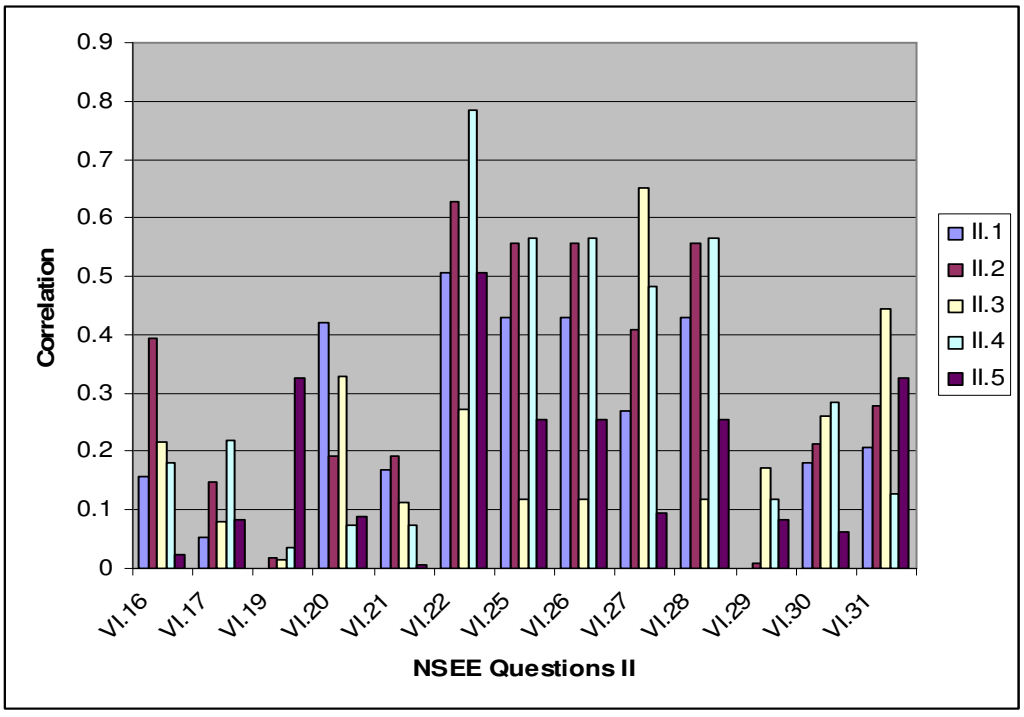

Figure 8: Correlation Between NSEE Questions (VI.16-VI.31) and Faculty Assessment of Engagement (II.1-II.5)

Further data was generated which showed that faculty and student different perceptions of outcomes and objectives were different. The student self-assessment data from the NSSE did not show as much correlation to engagement, outcomes, and objectives as the student grade point average correlated with the same items.

Conclusion

The Western Kentucky University EE program is a project based program that engages students throughout the curriculum with a variety of project experiences. Students were ranked by faculty on their level of engagement in projects, program outcomes, and program objectives. A strong correlation exists between the faculty perception of student ability to meet the program outcomes, program objectives, and student engagement. Student grade point average is also correlated with program outcomes and objectives. However, GPA is not correlated with student engagement. The NSSE responses for these students on a select set of questions which support ABET Criteria 3 A-K was examined for correlation with the program outcomes, program objectives, and student engagement. The results from the NSSE survey did not appear to be a strong indicator of student performance on the program objectives and outcomes of the EE program. This is suggests that student and faculty perceptions vary greatly and provides an excellent foundation for further exploration.

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