

Prospect for Success in Engineering: Assessing Freshmen Curriculum Engagement

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Abstract - The Prospect for Success is UNC Charlotte's Quality Enhancement Plan created to provide all incoming freshmen the opportunity to participate in an engagement curriculum during their first year of enrollment measured through three student learning outcomes: Commitment to Success, Cultural Awareness, and Inquiry. This engagement curriculum takes different forms in different colleges, but all versions of the curriculum share these three student learning outcomes. The College of Engineering chose to divide the three student learning outcomes between two engineering first year courses. Commitment to Success and Cultural Awareness are assessed in the Introduction to Engineering Practices and Principles I course. The assignment selected to assess these learning outcomes is titled the Whole Life Concepts Project (Whole Life Report). The Whole Life Report asks the student to analyze the Whole Life model as it applies to their career with a final piece that asks them to reflect on the career path they have laid out. Inquiry is assessed in the Introduction to Engineering Practices and Principles II course. This course is taught by each of the college departments to their discipline-specific students. The selected assignment is a reflective paper in which they are asked contemplate the processes they followed on their inquiry assignments (i.e. the process used to research and write a paper on a subject in their chosen discipline). This paper describes the development of our engagement program and the College of Engineering's effort to create a model which could be used by the University. Specific details of the implementation and assessment of the scoring statistics, along with corrective actions, are also included.

Index Terms – Introduction to Engineering, Inquiry, Cultural Awareness, Success.

INTRODUCTION OF PROSPECT FOR SUCCESS

The Prospect for Success is UNC Charlotte's Quality Enhancement Plan created to provide all first-time full-time freshmen with the opportunity to participate in a formal engagement curriculum during their first year of enrollment.

The Prospect for Success QEP had its roots in an analysis of institutional data including the National Survey of Student Engagement (NSSE), the Evaluating Academic Success Effectively (EASE) survey, and internal reviews of the campus Learning Communities and other student

success initiatives which showed that undergraduate student engagement could be improved at the university. A comprehensive planning process involving students, faculty and staff was launched in the fall 2010 leading to the selection of engagement as the overarching topic in May 2011. This analysis of institutional needs led the University to define students' engagement in terms of the three interconnected goals: Intentionality, Curiosity, and Awareness. For purposes of assessment, these three goals were translated into three student learning outcomes:

- **Commitment to Success:** Students will identify specific and realistic goals for their collegiate experience, develop or exhibit strategies for achieving those goals, and recognize the need to make change in light of experience.
- **Inquiry:** Students understand or experience inquiry as an open-ended process that explores evidence and/or approaches to generate ideas/conclusions
- **Cultural Awareness:** Students will demonstrate an understanding of themselves, and of others, as individuals whose worldview and capacities are shaped by culture and experience and a willingness to take the worldview and capacities of others into consideration.

Recognizing the diverse needs of students in the University's seven academic colleges, this engagement curriculum takes different forms in different colleges, but all versions of the curriculum have common elements to make manifest to students both aspirational 'ways of being' (the value of engagement) and practical 'things to do' (how to be engaged). The plan also involves co-curricular partners including the library, career center, Multicultural Resource Center, University Center of Academic Excellence (tutoring and supplemental instruction), the counseling center, and Venture outdoor programs.

The Prospect was launched in 2013 following approval of this QEP by the Southern Association of Colleges and Schools (SACS) with three of the seven colleges fully implementing the program in 2013-14. Full implementation of the program to include all incoming freshmen takes place in 2015-16.

Freshmen experience the curriculum through a course in their college that has the Prospect engagement curriculum typically taken during the fall semester with additional pieces of the program occurring through follow-up courses and/or advising in the spring.

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The Prospect for Success QEP is evaluated using both direct and indirect measures. Direct assessment of the three student learning outcomes (Commitment to Success, Inquiry, and Cultural Awareness) involves scoring of students' written reflections using rubrics developed for each SLO. Indirect measures include tracking of institutional data including 4-year and 6-year graduation rates, NSSE and EASE data, and student retention.

SCORING OF STUDENT REFLECTIONS

The student reflections/reports are assessed using rubrics developed by the adapted from the AAC&U's Valid Assessment of Learning in Undergraduate Education (VALUE) rubrics [1]. A power analysis was conducted to determine the number of student papers needed to achieve a statistically significant sample size, and based on this a randomly selected representative sample of the submitted papers were evaluated. Each goal is divided into three dimensions. Each dimension is scored by two evaluators on a scale of 0-3, with a 0 being no evidence and a 3 being goal fully realized. A third evaluator compares the scoring of the first two evaluators and evaluates any papers with dimensions scores that differ by greater than 1. A score of 2 or 3 is considered as successful achievement of a dimension outcome. The percent successfully achieving each dimension within a goal is averaged. The university established a benchmark of 75% successfully achieving this average score which it recognized was ambitious.

FIRST YEAR ENGINEERING AT UNC CHARLOTTE

ENGR1201: Introduction to Engineering Practices and Principles I is the first engineering course incoming freshman complete. In this course students learn about the disciplines of engineering and tools to become a successful engineering student. These areas are addressed through a combination of lecture, reading, activities and both individual and team projects.

In the second semester of the freshmen year, students enroll in ENGR1202: Introduction to Engineering Practices and Principles II. This course has four different variants, since each department will teach this course to their own students and identify what skills are important for their students in their program:

- Electrical and Computer Engineering students learn design skills that they use to complete two major projects. Students use clean room facilities and manufacture a device on a wafer. They also build and program an electronic device or an autonomous robotic vehicle. This requires students to learn electronic device design principles, including hardware design tools, software programming tools, and wafer processing tools and systems.
- Systems Engineering students are introduced to two major methodologies that they will one day use within industry to either improve or design processes and products to meet the needs of their future customers. Over the course of the semester the students learn about

the methodologies known as Lean Six Sigma and the System Life Cycle through the use of case studies, games, and templates. At the end of the semester they are asked to produce a one page memo to answer three powerful questions that allows them to properly reflect on what they learned and how they will apply it to their future academic and professional careers.

- Mechanical Engineering students are introduced to two important tools used by engineers for the design and evaluation of mechanical systems and then the students are required to work with a team in the development of a new product. Students use the skills they have learned to complete the mechanical design of the product with the CAD software they have learned to use and create graphic representations (technical and artistic) to sell their designs to the public through a "corporate" webpage.

COMMITMENT TO SUCCESS AND CULTURAL AWARENESS

In administering the University's Prospect for Success Quality Enhancement Plan, the College of Engineering chose to divide the three goals between two engineering first year courses. Goal one, Commitment to Success, and goal three, Cultural Awareness, are assessed in the Introduction to Engineering Practices and Principles I, (Intro to Engr I) course. Goal two, Inquiry is assessed in the Introduction to Engineering Practices and Principles II (Intro to Engr II) course.

The assignment selected to assess goals one and three is titled the Whole Life Concepts Project and culminates in a Whole Life Report. The paper is preceded with a lecture on the Whole Life Concept and the model, Figure 1, is used to show students how to use the model to break down their goals and develop a career plan [2]. Students submit a proposal in the form of a memo sketching out in broad strokes how they apply this model to their individual career and what research they will do to prepare for the final Whole Life Report. They receive feedback on this assignment to help them properly apply the model and guide them to most useful resources before preparing the final report.

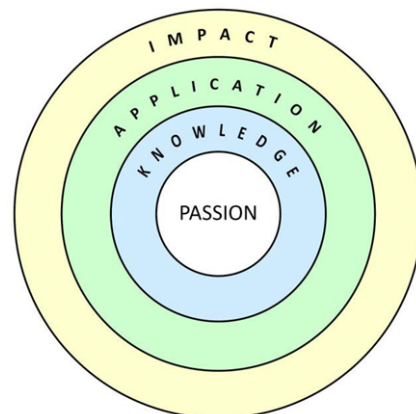


FIGURE 1. WHOLE LIFE CONCEPTS MODEL

The Whole Life Report asks the student to analyze each ring of the Whole Life model as it applies to their career with a final piece, that asks them to reflect on the career path they have laid out, if this has influenced a change in their plans and how committed they are to their goal of obtaining a degree from the College of Engineering in their selected major.

Goal one, Commitment to Success, is divided into three dimensions: 1.1 Goal setting, 1.2 Strategies and 1.3 Experience causing change. Our rubrics describe these dimensions as:

- Goal setting (1.1): Goals are specific and realistic
- Strategies (1.2): Articulates several specific strategies for achieving goals
- Experience leading to change (1.3): Recognizes and specifically describes the need to make changes in light of experience

With respect to Goal Setting, our students were typically able to articulate a goal. Frequently these goals appeared to be a shallow attempt to respond in an appropriate way rather than apply the level of reflection called for, 55.8% of students were successful at scoring a 2 or 3 on this dimension. Commitment to Success dimension 1.2, Strategy, seemed slightly more difficult for students to define, 49.7% scoring a 2 or 3. Students' descriptions of strategies for reaching the goal often appeared vague, in spite of having been coached in class about the resources available to them. The third dimension 1.3, Experience causing Change was poorly completed with a score of 24.8%. Few students scored well in this dimension and those who did were often using the experience to stimulate a change of major. An average 43.4% achieved success on goal one, far below our benchmark of 75%.

Goal three, Cultural Awareness is also divided into three dimensions: 3.1 Awareness of self, 3.2 Awareness of others and 3.3 Openness. The rubric describes these dimensions as:

- Awareness of self (3.1): Strong awareness of how culture and experience shape own perspectives and capacities
- Awareness of others (3.2): Strong awareness of how culture and experience shape others' perspectives and capacities
- Openness (3.3): Strong consideration of multiple points of view

For dimension 3.1, Awareness of self, students scored well, with 66.9% achieving success with this outcome. On dimensions 3.2 and 3.3 students did not score as well, with success achieved at a rate of 37.2% and 21.4% respectively. With an average success rate of 41.8%, again, students performed far below the benchmark goal of 75%.

The students who scored well in section 3.2 and 3.3 often wrote about taking part in some activity that put them in contact with people who were unlike themselves, often mission work. Through an experience such as a mission trip

they were often able to recognize the difference between themselves and others and consider why those differences exist. A second route some wrote about that scored higher on 3.2 and 3.3 was facing a cultural challenge, such as being in a minority group. It helped them through a maturity plateau.

Research over the last half century suggests that prior to about the age of 16 children are primarily egocentric [3]. They see themselves and their beliefs as primary and correct (3.1-3.2). They aren't capable of understanding that there are other valid belief systems (3.2). As they grow out of adolescence, a child typically begins to outgrow this egocentrism and develop empathy for others views. They can think more in the abstract, recognize flaws in their way of thinking and respect other viewpoints. The ability to make and keep long term goals is another sign of maturity (1.1-1.2). In many of the papers, it appears that student have not reached this level of maturity and is writing as an egocentric adolescent.

We found we are measuring how mature the students are who are in our program. This is in contrast to our goals for the class, since our class is not necessary designed to greatly affect their maturation process. Non-traditional and students who faced a cultural challenge typically students score better on 3.2 and 3.3 because their life experience often provides fuel for maturity.

INQUIRY

Inquiry is assessed in the Introduction to Engineering Practices and Principles II course. Each discipline determines its own assignment for measuring how students understand or experience inquiry as an open-ended process that explores evidence and/or approaches to generate ideas/conclusions. Though specific inquiry activities are assigned throughout the semester, the final assignment that assesses this understanding is a short reflection paper.

Inquiry is also divided into three dimensions: 2.1 Exploratory Process, 2.2 Evidence/Approaches, and 2.3 Generation of Ideas/Conclusions. The rubric describes these dimensions as:

- Exploratory process (2.1): Discussion and/or results indicate that the focus of inquiry evolved
- Evidence/approaches (2.2): Discussion and/or results indicate substantial exploration of appropriate evidence or approaches
- Originality (2.3): Strong evidence of originality in discussion or results of inquiry

The following sections describe the primary assignment given by each department, how the inquiry reflection was conducted, and the results of the scoring for each department.

1. Electrical and Computer Engineering

The Introduction to Engineering Practices and Principles II course for Electrical and Computer Engineering (ECE) students includes the introduction of ECE skills, but also

includes a broad survey of the discipline. The two major projects are supported with instruction, demonstration, and lab exercises. Guest speakers also visit the class to introduce one of the department's five core sub-disciplines.

We decided to encourage students to investigate one aspect of ECE in more detail, by asking them to delve into a specific sub-discipline, technology, or historical figure. This is manifested by a short writing assignment. The assignment is simply stated as:

Write a short essay that can either be on the historical development of some area of an ECE related technology, its contemporary/societal impact or can focus on some person who contributed in either of these areas. The choice is yours so choose a topic that interests you. Also, describe why you are interested in this particular person or area of technology. The essay should be 2-3 pages with 3-4 figures and/or tables. The essay should be properly constructed to have an outline and/or summary, the core text, figures, etc., a conclusion and references and/or bibliography.

We implemented several mandatory “scaffolding” assignments. We supported the students' development of their topic with the establishment of a short statement of their topic, which they "pitched" to a peer during one of the classes. Students then expanded this statement into a paragraph, which is also peer-reviewed. We provided instruction on methods to investigate topics and how to best assess the value of resources and reference materials. Students turned in a draft of their paper, which is instructor graded and peer reviewed. Students then corrected their paper and turned in a final draft.

Students then completed a short reflection paper where they are asked to consider the inquiry process they used to explore their Electrical and Computer Engineering writing assignments. In the paper we asked them to consider these questions with respect to their main paper:

- How did you choose your topic for inquiry?
- How did you conduct this inquiry and in so doing refine and adapt your topic?
- How did you assemble information in order to craft a conclusion?
- What did you learn? What new knowledge, insights, or ideas did you generate by undertaking this inquiry process?
- What's next? How could you apply the methods, skills, and knowledge developed during this inquiry process to other problems?
- What new questions or problems have emerged out of your work?

As described earlier in the paper, these reflections were scored with respect to the three dimensions of Inquiry: Exploratory Process, Evidence/Approaches, and Generation of Ideas/Conclusions. As shown in Table I, students scored better in 2015 than 2014 in two of three dimensions. This is likely because the main assignment was supported by

scaffolding sub-assignments through the semester, like the processes of seeking/assessing resources and how to develop conclusions. We also included peer review of drafts, which helped students discover errors they made as well as errors others had made.

It should be noted that all of these measurements still do not meet the goal of 75% achievement of the dimension for inquiry.

TABLE I: ECE STUDENT PERFORMANCE - PERCENTAGE OF STUDENTS WHO SCORED A 2 OR 3 ON EACH DIMENSION

Inquiry Dimension	2014	2015	Change
2.1 Exploratory process	55.7%	69.2%	+13.5
2.2 Evidence/approaches	67.2%	64.1%	-3.1
2.3 Originality	44.3%	51.5%	+7.2
Average	55.7%	61.5%	+5.8

The assignment will not change next academic year. Instead, more instruction on Inquiry processes will be provided.

An additional instruction module will be added in the course near the start of semester to cover how to identify a topic for the primary essay. This will include small group discussions during class where students will use other students as a "sounding board" to help them narrow their topic ideas.

After the main assignment is due, an additional instruction module will be added in the course to cover how to reflect on their Inquiry processes. This will include small group discussions during class where students tell other students their own inquiry process used. The observation of scorers is that many students had difficulty assessing the process they used and how they can learn from that process and apply it to later work (students often wrote about applying knowledge about the particular subject of their essay).

II. Systems Engineering

The Introduction to Engineering Practices and Principles II course for Systems Engineers uses a series of smaller in class team based assignments to bring home the application portion of the two Systems Engineering methodologies discussed earlier. They also answer a powerful reflective question each week using 250 words or less on the topic they learned that week and how it applies to their life and future career. The combination of these assignments and forum posts prepares them for the final memo assignment where they answer the three powerful questions shown below.

1. *You have learned how to apply the System Life Cycle and Lean Six Sigma methodologies to product and process design. Think back to how you collected the voice of the customer and translated it into the project's requirements. As a customer who purchases products and services, how do you see the knowledge and skills learned in this class connecting to your experience now and in the future?*

2. *Think about the System Life Cycle and Lean Six Sigma methodologies that you studied this semester and learned through applied case studies and projects. How are these methodologies similar and how are they different from each other?*
3. *You have now been exposed to the basics of Systems Engineering. What are some of the topics you are curious to learn more about over the next few years, why do you want to learn more about them, and how will they change your life?*

These reflections were also scored with respect to the three dimensions of Inquiry: Exploratory Process, Evidence/Approaches, and Generation of Ideas/Conclusions. Students typically scored very well in each of these dimensions because they had practice all semester in answering powerful reflective questions about what they learned in class through the weekly forum posts. There were 33 memos graded and for the powerful question that had to do with the exploratory process the students scored an average of 2.72 out of 3 possible points. For the evidence/approaches question they scored an average of 2.78 out of 3 possible points. Finally, for originality they scored an average of 2.57 out of 3 possible points.

III. Mechanical Engineering

The Mechanical Engineering Introduction to Engineering Practices and Principles II course is designed to introduce Mechanical Engineering students to important tools for subsequent design courses in our curriculum. Design is an important component of our curriculum and the tools they are trained to use are necessary for their successful completion of the sequence of design courses. Throughout the course students are introduced to contemporary technology and presentations are made by currently enrolled students to promote their personal pursuit of a career in mechanical engineering.

At the end of this course students are required to write a paper describing their future career:

At this point in your academic career, it is important to reflect on your academic and professional goals, the choices you've made, the actions you've taken, your learning journey, and where you go from here. Thoughtfully and clearly address their goals, motivation and importance in their trade.

1. *Identify one academic, one professional, and one personal goal that you hope to achieve in your collegiate experience*
 - a) *The goals must be meaningful, specific, realistic, and informed based on what you have learned to date.*
 - b) *What strategies have you identified to achieve each goal?*
 - c) *What support networks are available on- and off-campus to help you achieve each goal and how do you intend to use them?*

- d) *Give examples of how you have demonstrated personal responsibility in achieving each goal.*
2. *Discuss your personal motivation to learn and/or to be curious.*
 - a) *Give an example of how you have gone "above and beyond" the minimum requirements this semester.*
 - b) *Describe how this semester has fueled your curiosity about a particular topic of interest.*
 - c) *Describe how the knowledge and skills learned in this class connect now and will support your further education and career in the future.*
3. *Describe how your chosen profession impacts a global society.*
 - a) *What is your role as a professional working in a global society?*
 - b) *How will your personal point of view influence your interpretation, judgment, and actions?*
 - c) *How do you intend to navigate the differences between yourself and others that are unlike you?*

As described earlier in the paper, these reflections were scored with respect to the three dimensions of Inquiry: Exploratory Process, Evidence/Approaches, and Generation of Ideas/Conclusions. In 2014 students scored 58% in each of these dimensions. It should be noted that all of these measurements still do not meet the goal of 75% achievement of the dimension for inquiry.

In 2015 course changes were made such that the inquiry/future career paper was de-emphasized. Participation was poor, so the resultant measurements were also poor and deemed not representative of the assignment. Corrective actions will be made to in future semesters to improve the preparation for the assignment and to allocate sufficient time for participation.

CONCLUSIONS

This paper describes the development of the Prospect for Success engagement program and the College of Engineering's effort to create a model which could be used by the University. Our analysis of students' written assignments that address the three Prospect for Success goals—Commitment to Success, Inquiry, and Cultural Awareness—make clear that we and our students are making progress but have much work to do. For example, as it relates to the Commitment to Success goal, most students showed they can set goals and some articulate strategies for achieving those. However, few were able to describe a need to make changes (go to class, seek tutoring or counseling, join a student organization, meet with a librarian, etc.) that could benefit their academic and social success at the university. As we seek to prepare our students to be success in an increasingly diverse and globally connected world, the data suggests that our students go through the freshman year retaining a sense of self but struggling in other dimensions of the Cultural Awareness outcome. Many lack an

awareness of others or an openness to multiple viewpoints. Our students were showed greater competence as it related to three facets of inquiry address in in the Inquiry rubric. Our hunch is that the inquiry process entailed in the Whole Life Project pushes students to think more deeply about the process of inquiry. This suggests to us that we need to consider ways in which we can get students to think more deeply about strategies for success and cultural awareness as we move into 2015-16 and beyond.

The Prospect for Success has become a signature part of the first-year experience for our students at UNC Charlotte. In fall 2015, all of our entering freshmen will be in Prospect courses. The benefits of the program for engineering students is that it provides them with important foundational engineering content as well as potentially life-changing tools to help them achieve success in college and beyond. For faculty and staff in engineering and other undergraduate programs at the university, Prospect gives us a common set of tools to help students navigate the first year and beyond. It also gives us meaningful data to analyze the effectiveness of this engagement curriculum.

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