Global Learning Initiative – Interim Report

Dr. Phillip A. Mlsna
Associate Professor,
Phillip.Mlsna@nau.edu

Dr. Sheryl L. Howard
Assistant Professor,
Sheryl.Howard@nau.edu

Dr. Niranjan Venkatraman
Associate Professor,
Niranjan.Venkatraman@nau.edu

June 30, 2011

Department Chair: Dr. David R Scott, David.Scott@nau.edu

Electrical Engineering Program
Department of Electrical Engineeing and Computer Science
College of Engineering, Forestry and Natural Sciences
Northern Arizona University
Flagstaff, AZ 86011.

Contents

1 Introduction

In this report, the proposed changes to the Electrical Engineering curriculum, and to its program objectives and outcomes, to incorporate the Global Learning Outcomes into the Electrical Engineering program are introduced. The three thematic student learning outcomes, or Global Learning Outcomes, identified by the Task Force on Global Education's Global Learning Subcommittee at NAU are: 1) Global Engagement 2) Environmental Sustainability, and 3) Diversity Education. These Global Learning Outcomes may be seen by some to be unrelated to Electrical Engineering. In point of fact, they are a key subtext in our program, one that has gone somewhat unnoticed and unheralded until now. Today's engineer is a global engineer. Students who have a broader view of their engineering education, and understand how engineering solutions impact the environment and cultures, as well as how culture impacts engineering, are better prepared for their career as an engineer in a global society. The GLI allows us to bring out these aspects of our program, incorporate new material where the Global Learning Outcomes need strengthening, and directly assess how well EE students are integrating these learning outcomes as they advance through the Electrical Engineering program.

Curricular efforts in the EE program that already support the Global Learning Outcomes are presented in Section 2. From this list, we can determine which Global Learning Outcomes need additional support in our program. Also, even if curricular efforts currently support one or more of the Global Learning Outcomes, these efforts are not currently being assessed as to their efficacy in supporting these outcomes. A discussion of future efforts and assessment needed to fully incorporate each Global Learning Outcome into the EE program will conclude this section. Section 3 presents an overview of the current EE program outcomes and shows where they are lacking in the Global Learning Outcomes. Two new and three modified program outcomes that better support the GLI are developed in this section. Next, in Section 4, a mapping of the required EE courses to the revised EE program outcomes relating to the GLI is presented. This mapping indicates the level of contribution of each course to each modified or new program outcome. This assists us in determining where direct assessments should take place for the various outcomes. Development of a new multidisciplinary course, presenting the global contributions of engineering from many cultures over time, that would strongly support both global engagement and diversity education is then proposed.

Some of the EE program educational objectives (distinct from the program outcomes) are also modified to reflect the Global Learning Outcomes. The EE educational objectives with modifications are shown in Section 5, along with a mapping of the modified educational objectives to the modified program outcomes first presented in Section 3. A mapping of the program outcomes to the ABET Criterion 3 Outcomes (a) through (k) is then established in Section 6. ABET is the accreditation body of the Engineering programs. The assessment process we have developed addresses the program outcomes, of which the ABET Criterion 3 Outcomes are a subset. The program outcomes were established so that ABET Criterion 3 Outcomes could be measured and improved, as well as measuring and improving the

distinctiveness of the NAU EE program. Section 7 discusses the assessment methodology used for each new or modified EE program outcome. The process of assessment and any changes required to the outcome assessment are discussed. In the case of modified program outcomes, an assessment process already exists and is used to evaluate our program's level of achievement of the current program outcomes. This existing assessment process is most likely insufficient to assess modifications to the outcome. Changes required to the outcome assessment would then target the GLI modifications to the outcome.

Interim conclusions are presented in Section 8. As can be seen from the above outline of this report, the EE program's existing assessment structure for ABET accreditation has been a significant asset in support and incorporation of the Global Learning Outcomes in our program. Previously-developed EE program outcomes, educational objectives and assessment strategies in most cases needed only slight modification to be used for evaluation of the Global Learning Outcomes. Further, the modifications to outcomes and assessment will enhance the EE program's support and evaluation of several of the ABET Criterion 3 outcomes required for program accreditation.

2 Existing Curricular Efforts Supporting Global Engagement, Sustainability and Diversity Education in the EE Program

As part of our GLI analysis, we examined the EE program to determine what curricular efforts, if any, already addressed global, sustainability or diversity aspects. These efforts are enumerated below under each GLI outcome heading. As noted below, many of these existing efforts are not currently being assessed. As part of our GLI initiative, several of these aspects will be specifically included in assessment, to evaluate their corresponding GLI outcome, the appropriate EE program outcome and ABET objective(s).

1. **Global Engagement**
   (a) Contemporary issues and the impact of electrical engineering on global society: EE386 Engineering Design (required course). Students present a slideshow as a group on team-selected contemporary ethical topics in electrical engineering. Current assessment efforts in EE386 evaluate ethical concerns, but not global impact.
   (b) Historical perspective and biographical information on inventors and scientists: presented briefly in many courses, including EE 110 Digital Logic, EE 188 Electrical Engineering I, EE 215 Microprocessors, EE 325 Engineering Analysis II, EE 348 Signals and Systems (all required) and EE 430 Communication Systems (elective). No current assessment efforts.
2. **Environmental Sustainability**
   (a) EE 364 Electromagnetics (required course) Junkyard Generator Lab: students build generator out of "found" or recycled items. Labs are graded each year but no assessment evaluation is performed.

(b) Sustainable methods of power generation discussed in EE 386 and EE 401 Power Systems (elective). No ongoing assessment with respect to sustainability.
(c) Ethical concerns in electrical engineering: issues which may impact the environment, such as power generation and semiconductor fabrication, are discussed in EE 386. Assessment of an ethics paper in EE 386 is ongoing for ABET accreditation.
(d) Efficiency via design minimization: EE 110 and EE 215. Ongoing assessment with K-map problem on EE 110 final exam and assessment quiz in EE 215.
(e) Spectral efficiency, maximizing use of limited spectral resources: presented in EE 348 and emphasized in EE 430. No ongoing assessment, although exam problem(s) in EE 430 cover this topic. EE 430 is taught every 2 years as senior elective.

3. **Diversity Education**
   (a) The EE program has both a diverse student population and diverse faculty. Assessment of student population breakdown by gender, ethnicity and nationality is ongoing for ABET accreditation.
   (b) Several international exchange students take classes in our EE program each year. This is an ongoing effort through NAU's Center for International Exchange as well as through CS faculty connections with German universities. Most of our exchange students are from European countries. No current assessment or enumeration of exchange students is currently being done at the EE program level.

From the list shown above, we observe that, while each Global Learning Outcome has some curricular resources and efforts that already support that outcome, very few of these efforts presented above are currently being assessed. To implement the GLI more fully in the EE program as well as improve evaluation of related ABET and program outcomes, assessment methodologies for important efforts will be developed as part of this GLI. We also note that Global Engagement and Diversity Education have only two existing curricular efforts listed under each outcome. Further efforts should be developed for implementation of each outcome in our EE program.

Future efforts to enhance inclusion of each Global Learning Outcome in our EE program and improve assessment are outlined below. Evaluation of the proposed efforts will be conducted with all EE faculty after a program meeting regarding GLI implementation and assessment is held at the start of Fall 2011. Some efforts may be discarded at that time as impractical.

1. **Global Engagement**
   (a) Development of a new multidisciplinary course that presents the global contributions of engineering by many different cultures over time. This course could be a liberal studies course or seminar, and would be taught at a level accessible to all engineering, and probably all science, students.
   (b) Examination of 4-year EE program to allow study abroad without delaying graduation: a 6- or 8-week summer semester abroad for engineering students between freshman and sophomore year is being trialed next summer. Courses required for most engineering disciplines would be offered in this summer study abroad engi-

neering program. The EE program would encourage student participation in this study abroad program.

(c) Assessment of historical perspective presented in existing courses: possible exam or quiz question, clicker-based, multiple choice or short paragraph.

(d) Assessment of impact of EE on global society in EE 386 possible, although EE 386 is becoming multidisciplinary EGR 386 next year, so assessment may not be feasible.

2. **Environmental Sustainability**

(a) Develop clearly-targeted assessment methods for this Global Learning Outcome that also support our newly-developed program outcome 4.4 on sustainability.

(b) Increase student awareness of CENE 150 Intro to Environmental Engineering and ENV 181 Environmental Sustainability as possible Science Elective choices in their EE program. Each EE student must take two Science Elective courses.

3. **Diversity Education**

(a) Development of new multidisciplinary course previously discussed also supports this outcome.

(b) Potential inclusion of material on differing engineering solutions for different cultures, due to varied cultural/environmental/economic constraints. One of the engineering design courses would be best for this topic. EGR 286 is becoming discipline-specific, and changing to EE 286 over the next few years. EE 286 might be a good venue for this material. EE 476C could be another venue. Assessment of student understanding of the need for engineering solutions that consider cultural, environmental and economic requirements would be developed if this material is presented.

(c) Gather data on number of exchange students per year taking EE classes. Potentially develop survey for exchange student to assess their educational experience with respect to the EE program.

3 Overview of EE Program Outcomes and Proposed Changes

One of the first steps taken by this GLI team was to analyze the current program outcomes of the Electrical Engineering program with respect to their effectiveness in addressing the Global Learning Objectives. These outcomes are listed as follows.

1.1 - Be a leader in educational innovation and the use of technology in providing a quality educational experience.
1.2 - Attract and retain well-qualified students.
1.3 - Foster advising and mentoring relationships between faculty, industry and students.
2.1 - Possess professional skills and knowledge of the design process.
2.2 - Ability to function in disciplinary and multi-disciplinary teams.
2.3 - Possess abilities to effectively communicate orally.
2.4 - Possess abilities to effectively communicate in writing.

2.5 - Abilities in creativity, critical thinking and problem identification, formulation and solving.
3.1 - Ability to apply knowledge of physics and mathematics (including calculus, linear algebra, complex variables and differential equations).
3.2 - Ability to apply knowledge of probability, statistics, Laplace transforms and Fourier transforms.
3.3 - Ability to design and conduct scientific and engineering experiments.
3.4 - Motivation and skills needed for lifelong learning.
3.5 - Ability to use industry standard analysis and design tools.
4.1 - Ability to relate a broad education and contemporary issues to engineering solutions and their impact in a societal and global context.
4.2 - An appreciation and understanding of professional and ethical responsibility.
4.3 - Attract and retain under-represented students.

Our analysis of the above outcomes showed that they were clearly lacking in the very outcomes required by the GLI. In order to address these concerns, we modified some of the existing outcomes and added new outcomes to the above list. The modified/new outcomes are listed below, with changes in bold; the aspects of the GLI covered by each outcome are clearly shown at the start of the outcome statement. Outcome 4.1 did not require any changes to its definition.

1.4 - *(GLOBAL, DIVERSITY)* An appreciation and understanding of the global and diverse nature of science and engineering.
2.1 - ***(SUSTAINABILITY)*** Possess professional skills and knowledge of the **engineering** design process, **with an emphasis on sustainability**.
2.2 - ***(DIVERSITY)*** Ability to function in disciplinary**,** ~~**and**~~multi-disciplinary **and diverse** teams.
4.1 - ***(GLOBAL)*** Ability to relate a broad education and contemporary issues to engineering solutions and their impact in a societal and global context.
4.2 - ***(GLOBAL, SUSTAINABILITY)*** An appreciation and understanding of professional and ethical responsibility **in a sustainable, societal and global context**.
4.3 - ***(DIVERSITY)***Attract and retain **a diverse group of** under-represented students.
4.4 - *(SUSTAINABILITY)* Ability to apply concepts in sustainable development to engineering solutions.

Table 3.1 is a significant table which shows the achievement levels of the various program outcomes that have been assessed till date. From the below table, it is evident that the new or modified outcomes have not been assessed fully as yet, so their achievements are listed as uncertain, or in some cases, adequate. The outcomes related to the GLI are shaded in grey in the below table.

Table 3.1 Current Achievements of EE Program Outcomes

	Electrical Engineering Program Outcomes																	
Achievement	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3	4.4
High	●	●	●								●							
Good							●	●	●	●		●	●	●				
Adequate					●	●									●	●	●	
Uncertain				●														●

4 Mapping of Required EE Courses to Program Outcomes

One of the tools used by the Electrical Engineering faculty to assess whether the curriculum is addressing its program outcomes is the mapping shown in Table 4.1. This table lists the contribution that each required course taught by Electrical Engineering faculty makes to the seven program outcomes related to the GLI. Students take elective courses and required courses in the sciences and mathematics, but the courses listed represent the core knowledge and abilities that we intend for every graduate to develop in our program. The rating scale used in this mapping is shown below; the higher the number, the more direct the relationship. We must emphasize that while there are many courses that can potentially be used to assess the given outcomes, the courses with higher relationship numbers will probably be used in the actual assessment process. The other courses are mentioned to stress the fact that students are exposed to the concepts in those courses as well. The faculty who teach these courses determined the course contribution for each outcome on a scale of 1 to 5, where the table entries mean the following:

- NA if the outcome is not addressed in the course
- 1 indicates exposure to the outcome is the goal
- 2 indicates the goal is to build toward familiarization
- 3 indicates that familiarization is the goal
- 4 indicates that the goal is to reinforce and build towards mastery
- 5 indicates that the goal is to achieve mastery of that outcome.

Table 4.1 Relationship Between EE Required Courses and EE Program Outcomes

	Outcomes Related to GLI →						
EE Required Courses ↓	**1.4(G,D)**	**2.1(S)**	**2.2(D)**	**4.1(G)**	**4.2(G,S)**	**4.3(D)**	**4.4(S)**
XX 101 – Engineering and Civilization	5	3	2	3	1	N/A	N/A
EE 110 – Digital Logic	3	3	1	N/A	N/A	2	2
EE 188 – Electrical Engineering I	3	N/A	1	N/A	N/A	2	2
EGR 186 – Intro. Engineering Design	2	3	2	3	3	2	3
EE 286 – Engineering Design: Process	2	3	1	2	4	2	3
EE 310 – Fund. of Computer Engineering	N/A	3	1	N/A	2	N/A	3
EE 348 – Fund. of Signals and Systems	2	3	1	N/A	N/A	N/A	3
EE 364 – Fund. of Electromagnetics	2	5	N/A	N/A	4	N/A	5
EE 386 – Engineering Design: Methods	N/A	5	2	4	5	N/A	4
EE 476C – Eng Design Procedures	2	4	2	3	5	N/A	4
EE 486C – Capstone Design	N/A	5	2	5	4	N/A	5

This GLI team proposes to introduce a new course tentatively called "Engineering and Civilization", XX 101. Its purpose is to provide students with perspective and appreciation for the historical and cultural contexts in which key technologies were developed. Besides the important people and historical events involving each major scientific or technological development addressed, emphasis will also be placed on societal and environmental impacts, both positive and negative. Students will be expected to be able to explain these developments and their impacts from multiple viewpoints such as the nature of the technical progress, the changes in the society that produced it, the effect on the subsequent careers and fortunes of its developers, and its importance and usefulness in today's engineering practice.

This course is envisioned as based upon work done at Rutgers University and the University of California at Merced. Their courses have been built on the concept of covering ten to fifteen

key technological developments structured as learning modules. The focus will not be on strictly covering the historical flow of technological development *per se*, but rather using selected major topics from technological history as springboards from which to examine cultural context, societal and personal impacts, the enabling of subsequent advances, and even ethical issues. A few examples of key technological advances we are considering as module topics include the sailing ship, the steam engine, the development of electrical components and key circuits, computers, gunpowder, industrialized agriculture, steel, and refrigeration. The list of potential topics is quite extensive. By including several topics of a relatively contemporary nature, such as nanotechnology or the internet, the course will help students better understand some of the current trends and emerging technologies that are likely to affect their own careers.

5 Relationship Between Program Outcomes and Educational Objectives

In order to explicitly show the GLI objectives, the program educational objectives were modified as displayed in Table 5.1, with the existing educational objectives in the left column and the modified educational objectives in the right column. EE educational objectives relating to the GLI are shaded in grey.

Table 5.1 Program objectives, before and after modification

Current	**Proposed**
1. Graduates integrate quickly into the workplace and advanced education due to an emphasis on high quality teaching, advising and mentoring.	1. Graduates integrate quickly into the workplace and advanced education due to an emphasis on high quality teaching, advising and mentoring.
2. Graduates are technically competent and prepared for leadership and professional practice with strength in design, problem solving, communications and teaming.	2. **(GLOBAL)** Graduates are technically competent and prepared for leadership and professional practice **in a global workplace** with strength in design, problem solving, communications and teaming.
3. Graduates are grounded in mathematics and engineering science fundamentals and prepared for advanced education and lifelong learning.	3. Graduates are grounded in mathematics and engineering science fundamentals and prepared for advanced education and lifelong learning.
4. Graduates are experienced with and understand diverse populations, such as that existing in the American Southwest.	4. **(DIVERSITY)** Graduates are experienced with and understand diverse populations.
	5. (SUSTAINABILITY) Graduates are well grounded in sustainable engineering design guidelines and environmental policies.

The new educational objectives for the electrical engineering program are related to the modified/new program outcomes in Table 5.2, with educational objectives as columns and program outcomes as rows. A full circle indicates a direct relationship between the objective and the outcome, while a half circle indicates a lesser relationship. By assessing the program outcomes, we help ensure that the program educational objectives are also being met. Educational objectives relating to the GLI are shaded grey.

Table 5.2 Mapping of the new/modified EE Outcomes to proposed EE Educational Objectives

	1. Graduates integrate quickly into the workplace and advanced education due to an emphasis on high quality teaching, advising and mentoring.	2. **(GLOBAL)** Graduates are technically competent and prepared for leadership and professional practice in a global workplace with strength in design, problem solving, communications and teaming.	3. Graduates are grounded in mathematics and engineering science fundamentals and prepared for advanced education and lifelong learning.	4. **(DIVERSITY)** Graduates are experienced with and understand diverse populations.	5. **(SUSTAINABILITY)** Graduates are well grounded in sustainable engineering design guidelines and environmental policies.
1.4 Understanding of global and diverse nature		●		◗	
2.1 Professional skills, sustainable design process					●
2.2 Disciplinary, multi-disciplinary and diverse teams		◗			●
4.1 Broad education, contemporary issues and impact on society		◗		◗	
4.2 Professional and ethical responsibility		◗		◗	
4.3 Attract and retain underrepresented students				●	
4.4 Apply concepts in sustainable development					●

6 Relationship Between Program Outcomes and ABET Outcomes

The relationship between the Electrical Engineering program outcomes at NAU is a fairly direct mapping of the ABET (a) through (k) outcomes. Table 6.1 displays the mapping showing the direct and lesser dependencies that we feel exist between the two sets of outcomes. For purposes of compactness, the EE outcomes are indicated by their numbers and the ABET outcomes are referred to by their familiar letter designation. A full circle indicates a direct relationship between the outcomes, while a half circle indicates a lesser relationship.

The ABET outcomes are listed below, with the outcomes that relate most to the GLI in bold:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

The EE program outcomes that were modified for the GLI are expressed in bold. It must be stressed that the mapping for these particular outcomes is tentative and may change before the submission of the final report. The ABET outcomes and the EE outcomes that relate to the GLI are also shown in grey in the table.

Table 6.1 Mapping of Electrical Engineering Program Outcomes and ABET Outcomes

	ABET Criterion 3 Outcomes										
EE Program Outcomes	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1.1 Innovation, technology, quality educational experience					●			◗			
1.2 Attract and retain well-qualified students									◗		
1.3 Advising and mentoring relationships									◗		
1.4 Understanding of global and diverse nature				◗				◗		◗	
2.1 Professional skills, sustainable design process		◗	●						◗		
2.2 Disciplinary, multi-disciplinary and diverse teams				●							
2.3 Communicate orally							●				
2.4 Communicate in writing							●				
2.5 Creativity, critical thinking and problem solving			●		◗						
3.1 Apply physics and mathematics	●		◗								
3.2 Apply probability, statistics, & transforms	●		◗								
3.3 Scientific and engineering experiments		●									
3.4 Lifelong learning									●		
3.5 Analysis and design software tools			◗								●
4.1 Broad education, contemporary issues and impact on society			◗					●		●	
4.2 Professional and ethical responsibility in global context			◗			●					
4.3 Attract and retain under-represented students				◗							
4.4 Apply concepts in sustainable development			●					◗		◗	

7 Assessment of New and Modified EE Program Outcomes

In this section we will discuss the assessment process and methodology to be used for each new or modified EE program outcome. Assessment of the outcomes below will also directly lead to assessment of the proposed program objectives related to the GLI. It must be stressed that these changes will be finalized only after discussion at the first EE program meeting of the Fall 2011 semester. Following faculty approval of these changes, the assessment efforts and changes will be included in the following semesters.

Outcome 1.4: *(GLOBAL, DIVERSITY)* An appreciation and understanding of the global and diverse nature of the origins and development of science and engineering.

a. Process – This outcome will be assessed by evaluating student essays in the proposed new course, XX 101. The essays will ask the students to describe their understanding of the global nature of the development of the engineering disciplines, as well as the diverse nature of the development. The essays will be assessed by three faculty members by using a rubric which will be generated for the purpose.

b. Changes to be adopted – One of the major developmental changes will be the introduction of

an XX 101 freshman/sophomore seminar course, which will introduce the students to the historical development of the engineering disciplines. This course will be a mandatory course for all incoming EE freshmen, and may be co-taught by more than one faculty member. This course may also be adopted as a required course by programs other than Electrical Engineering. This course will also be organized so that students can satisfy their liberal studies requirement in Diversity and Cultural Understanding as well.

Outcome 2.1: ***(SUSTAINABILITY)*** **Possess professional skills and knowledge of the engineering design process, with an emphasis on sustainability.**
a. Process – This outcome is assessed by evaluating student reports and certain topical essays in EE 386 and EE 486, with possible surveys in EE 476C as well. These essays ask the students to describe the phases of a typical design process and then describe in detail the phases they went through each semester. The reports detail the students' perception of the design process, as well as sustainable engineering concepts applied to the process.
b. Changes to be adopted – It is proposed that a topic on the Sustainable Design process be included during lectures in EE 386, EE 476C and EE 486C. Further, it is also proposed that the student reports contain a clear section explaining how sustainable engineering guidelines were used in the design phase of the EE 386 and EE 486C projects.

Outcome 2.2: ***(DIVERSITY)*** **Ability to function in disciplinary, multi-disciplinary and diverse teams.**
a. Process – Current assessment evaluates group presentations on student capstone projects in EE 486C. Teams are typically disciplinary, but a few teams are multi-disciplinary, usually including Mechanical as well as Electrical Engineering students. Assessment of the senior capstone final presentations occurs during CEFNS' Undergraduate Research and Design Symposium, with evaluation conducted by both faculty and industry representatives; assessment is also performed during the junior and senior design in-class presentations in EE 386 and EE 486C. The in-class presentations are evaluated by faculty and students. A previously-developed rubric, which covers many aspects of the team presentation, is used to evaluate the students with respect to this outcome for one category, "Team member interaction".
b. Changes to be adopted – The current rubric category does not include diversity. A question on diversity, while not applicable to the rubric, would be an appropriate topic for a class survey in EE 386 and/or EE 486C. A survey question or questions could ask the student to i) evaluate the diversity of their own capstone team; ii) evaluate the diversity of the class as a whole; iii) evaluate what they learned as a result of a diverse class population. Data can also be collected by the course instructor as to the composition and diversity of each year's course. Assessment would be easier in EE 486C, simply because EE 386 is changing to the multidisciplinary EGR 386; evaluation in EGR 386 might be difficult if the instructor is not an EE faculty member.

Outcome 4.1: ***(GLOBAL)*** **Ability to relate a broad education and contemporary issues to engineering solutions and their impact in a societal and global context.**
a. Process – Student performance on this outcome is analyzed based on twenty-minute team presentations of electrical engineering contemporary issues given in EE 386. Two faculty members observe the presentations and assess them based on a developed rubric. A third faculty member assesses the students' slides. Both an alumni survey question and graduating senior survey ques-

tion were also used to assess this outcome. Alumni and graduating seniors were asked to rate the effectiveness of their NAU education in developing their understanding of the impact of engineering solutions in a global and societal context, and their knowledge of contemporary issues.
b. Changes to be adopted – Incorporation of contemporary engineering issues that clearly have a global and societal impact into the contemporary issues module of EE 386 would be an ideal method to address this outcome. However, as EE 386 is becoming multidisciplinary next year, the EE program may not have the option to introduce this material in the new EGR 386. Another option would be to incorporate contemporary engineering issues with a clear global and societal impact into the evolving EGR 286 as it becomes EE 286, or into EE 476C. The Engineering Design sequence seems an appropriate place to include this material.

Outcome 4.2: ***(GLOBAL, SUSTAINABILITY)*** **An appreciation and understanding of professional and ethical responsibility in a sustainable, societal and global context.**
a. Process – Student performance on this outcome will be analyzed by three Electrical Engineering faculty members from EE 386 individually-prepared ethics papers using a rubric developed by the EE faculty for this purpose. An individually prepared ethics paper in EE 476C will also be used to assess ethics as related to sustainable engineering design. In addition, graduating seniors and alumni who graduated since 2000 will be asked to rate how well their NAU education assisted them in developing their understanding of global professional and ethical responsibility through a survey.
b. Changes to be adopted – The students in the Electrical Engineering program are required take a course on Ethics, PHI 105, early in their program. In their junior year, the students are required to take EE 386. It is proposed that the instructor for this course build on the student learning in PHI 105, and include lecture material on global ethics - how ethical perception varies in a global and societal context. Further, in EE 476C and EE 486C, it is proposed that the students write an essay on ethics related to sustainable engineering design. The current rubric will be redesigned for this purpose.

Outcome 4.3: ***(DIVERSITY)*** **Attract and retain a diverse group of under-represented students.**
a. Process – Data on the number of incoming under-represented students in EE, as well as graduating under-represented EE students, and yearly retention data for EE students, categorized by gender and ethnicity, is collected from the Planning and Institutional Research department. Although the number of under-represented students is small, overall trends can be evaluated on a yearly basis using under-represented students in the entire EE program. These numbers are also compared to the average NAU-wide percentage of incoming under-represented students, as well as retention and graduation rates.
b. Changes to be adopted – Efforts to recruiting under-represented students with a potential interest in EE can be enhanced by sending letters or flyers discussing NAU's Electrical Engineering program to appropriate high schools, targeting qualified students. Data on Multicultural Engineering Program support of our students via scholarships and hiring can be collected and analyzed. Data on faculty support of under-represented students through recommendation letters for scholarships, internships, research experience or hiring can similarly be collected and analyzed to discern trends. Data on under-represented EE student participation in the URM (undergraduate research mentoring) program (which supports qualified students, with an emphasis on under-represented

students) through the Wireless Networks Research Lab can also be collected and analyzed.

Outcome 4.4: *(SUSTAINABILITY)* Ability to apply concepts in sustainable development to engineering solutions.
a. Process – This outcome will be assessed by evaluating student reports in EE 386 and EE 486C, and student reports and essays in EE 476C. A section of the reports would ask students to detail the design process (with an emphasis on sustainability) though the semester, and the essays will evaluate student understanding of sustainable design.
b. Changes to be adopted – This is a new outcome, proposed to explicitly assess sustainable engineering concepts. It is proposed that the junior and senior design classes - EE 386, EE 476C and EE 486C - include topics which discuss the Sustainable Engineering guidelines as developed by the World Engineering Partnership for Sustainable Development. Since 1992, there have been immense developments in policy and technology to aid sustainable development practices; including them in the pedagogy of the above-mentioned courses will encourage the students to directly apply these guidelines in their junior and senior capstone design projects.

8 Interim Conclusions: Incorporation of Global Learning Outcomes Into the EE Program

This interim report presented existing curricular efforts that already support the Global Learning Outcomes, and examined existing EE program outcomes and educational objectives. Shortcomings in each of these with respect to their inclusion of the Global Learning Outcomes were discovered. Modifications were made where appropriate to incorporate all three Global Learning Outcomes into the EE program.

Assessment of student realization of the Global Learning Outcomes is a critical part of implementing the GLI into our EE program. As part of our ABET accreditation process, we have already developed assessment methodologies and tools for each of our EE program outcomes and educational objectives. Enhancement of our existing assessment methodologies to support the modified program outcomes that support the Global Learning Outcomes was relatively straightforward. Assessment of the Global Learning Objectives can also directly assess these ABET objectives relating to diversity, sustainability and global engagement. Incorporation of the GLI into the EE curricular process also strengthens the EE program in its accreditation process.

The changes in assessment methodologies and new materials for assessment to support the modified program outcomes and educational objectives must be discussed with all EE faculty members. A program meeting including all EE faculty regarding GLI changes to our program will be held the week before classes resume in Fall 2011.

All in all, the changes made to our EE program outcomes and objectives, and the resulting enhancements to their assessment, to incorporate the Global Learning Outcomes should result in a stronger learning experience for our students. This may translate into better job opportunities for our more globally-oriented EE students and potentially serve as an advantage in student recruitment to our program. As well, the enhanced assessment of the Global Learning Outcomes translates directly to better, more thorough, assessment of our ABET outcomes for accreditation purposes.