

GLOBAL SYSTEMS: Advancing Global Competency in an Innovative Course for Sophomores

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Abstract – Twenty-first century engineers are practicing their profession in an increasingly globalized world. It has been widely recognized that the process of globalization should have an influence on how engineers are educated. This paper describes the goals for, and the design of, a course for sophomores – Global Systems – with a focus on the assessment strategies used. The main student learning objectives are to demonstrate content awareness of globalization, demonstrate growth in communication and teamwork skills, demonstrate the ability to frame complex issues systematically, and demonstrate motivation to act professionally and as a global citizen. Several assessment strategies were employed, including written examinations, video capture of solo and group presentations, and a self-assessment report based on guided reflection. Overall the course was successful in meeting its objectives in a cost-effective manner. Opportunities for improvement were identified by the assessment process and will be incorporated in subsequent course offerings.

Index Terms – assessment of student learning, communication skills, global engineering competency, globalization.

INTRODUCTION

Twenty-first century engineers are practicing their profession in an increasingly globalized world. International trade in goods and services has continued to grow and new nations, such as Brazil, Russia, India and China, are emerging as significant participants. The expansion of major global corporations continues. To cite just one example, General Motors recently made more money selling cars in China than it did in the United States. [1] Supply chains in goods and services are increasingly global. And recent experience with the international financial system showed that it has become truly global, perhaps with some unintended consequences. The human population is another major factor in globalization. The population is projected to grow to perhaps 9 billion by 2040 from about 7 billion now. A growing fraction of us, now more than half, are living in urban environments around the globe.

The Context for the Course Global Systems

The process of globalization should have significant influence on how we educate our engineers. As Dr. L. Katehi observes [2]: “U.S. engineers must become global engineers.” and “Future engineers ... must know how to communicate effectively and how to think globally.”

Chang, Atkinson and Hirleman [3], discussing the impact of the NSF-sponsored International Research and Engineering Education program, introduced a three-dimensional framework that includes (1) technical, (2) professional, and (3) global dimensions. Their study dealt with three issues, namely, “The Cause: Globalization of the Engineering Profession,” “The Challenge: Answering the Call for Global Engineers,” and “The Rationale: Globally-Prepared Workforce and Enhanced Research.” We have adapted their framework in our course.

Parkinson [4] articulated the concept of global competence in terms of thirteen attributes, among which are several that are specific to the engineering profession. The Global Systems course addresses four of these, namely, (1) familiarity “with the history, government and economic systems of several target countries,” (2) “understanding of the connectedness of the world and the workings of the global economy,” (3) “exposure to international aspects of topics such as supply chain management, intellectual property, liability and risk, and business practices,” and (4) viewing “themselves as ‘citizens of the world,’ as well as citizens of a particular country; appreciate challenges facing mankind such as sustainability, environmental protection, poverty, security, and public health.”

The development of engineers’ professional skills to complement their acquisition of ‘hard’ facts and solution methods for well-defined problems is recognized as an imperative. Shuman, Besterfield-Sacre and McGourty characterized these skills as follows [5]:

Professional process skills

- An ability to function on multidisciplinary teams.
- An understanding of professional and ethical responsibility.
- An ability to communicate effectively.

Professional awareness skills

- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.
- A recognition of the need for, and an ability to engage in, life-long learning.
- Knowledge of contemporary issues.

In response to the challenge of educating engineers to attain global competence the author developed a new undergraduate course about globalization. The course was offered in Fall 2008, in Fall 2009, and most recently in Fall 2010 as *Global Systems: Economics, Engineering and Environment* (EGR210). It is required for sophomores in the Applied Engineering Sciences Program, open to all other engineering majors with sophomore standing or above, and available by request to qualified students of sophomore standing or above in the university.

Next we present the course educational objectives, the course as delivered in Fall 2010, our experience in assessing the degree to which students attained the educational objectives, and plans for the next round of improvements. In the following section we present the educational objectives selected, followed by description of the course organization. Then we discuss assessment strategies and show the results from applying those strategies. Finally we summarize our experience in terms of next steps to be taken in course improvement.

COURSE LEARNING OBJECTIVES

There are two types of objectives we had to consider in the design of the course. The first are the student learning objectives. The second are longer-term objectives that will allow for enrollment growth cost-effectively.

Student Learning Objectives

We introduced the topic of globalization at the sophomore level so that students could use their awareness of globalization in their subsequent educational and living experiences, thereby moving toward greater global competency. We selected four student learning objectives within the three-dimensional framework mentioned earlier.

- (1) Global dimension. Demonstrate knowledge of the basic elements of the globalization process. Organize these in terms of three interacting systems: economic, engineering, and environmental.
- (2) Professional dimension. (a) Demonstrate effective communication and teamwork skills; (b) demonstrate motivation to act constructively as a professional and as a global citizen.
- (3) Technical dimension. Demonstrate the ability to frame and analyze complex issues in a systematic manner.

At a higher level of learning, we wanted our students to become comfortable confronting complex situations that

have no obvious right answer. We wanted them to avoid the temptation to reduce such situations to ‘sound bite’ size. Furthermore, we wanted them to learn to find credible sources of information and to establish source credibility in a way they could defend to others.

Course Growth Objectives

In organizing the course we kept two practical long-term considerations in mind. The first is that we want the course to serve a potentially large group of students in a cost-effective manner. The second is that we want all aspects of the course to be exportable, so it can be used for a variety of audiences.

The design of the course addressed the student learning objectives as first priority. The third offering gave us the opportunity to test the scale-up aspects of the design, as we moved from twenty students initially to more than sixty students. The current implementation is described in the next section.

COURSE ORGANIZATION

Globalization is a complex evolving process. As such it presents many options for selecting course content and organizing it. We settled on three major systems for framing issues. These were economic systems, engineering systems, and the environment.

The importance of a fourth type of system – socio-political – was acknowledged. We pointed out to the students that time constraints prevented us from giving it its due in this course. This meant that such important issues such as social justice and distribution of economic benefits were not discussed in any depth. Students were encouraged to pursue those important topics through other educational experiences.

The course adopts a systems perspective in studying globalization. This approach is supported by many current economic and technological developments globally. Examples include the use of “smart systems” to deal with emerging needs, such as “smart grids” [6], “smart buildings” [7], and “smart cities” [8]. Such natural systems as the Earth’s annual energy budget and the annual water cycle also lend themselves to a system interpretation.

The content of the course was organized into fourteen presentations around three main themes (the ‘three Es’):

- Introduction to Globalization
- The Environment: Spaceship Earth
- The Environment: How to think globally
- The Environment: Sustainability
- Economics: International trade
- Economics: International finance
- Economics: International business
- Economics: The Michigan economy
- Engineering: Energy

- Engineering: Water
- Engineering: The Internet
- Engineering: Security
- Engineering: Urbanization
- Globalization: a retrospective

The presentations emphasized the nature of the situation rather than a given perspective or position. It became clear to the students that it is not likely that the global human population can meet all of its expectations for a rising standard of living in the near future using any one approach or 'set of truths.' At the Futurology Panel held at the end of the course the several guest panelists often disagreed as to what might happen next and what ought to be done now. We stress that this is a course about identifying and framing important issues, rather than one about answers.

The entire student group met once a week to hear the presentation for that week. They met in groups of twenty once a week in an active learning session. The students developed both teamwork skills and communication skills through a set of twelve activities, listed below. They worked in teams of four for the most part and were allotted eight minutes for their group presentation, unless noted otherwise below.

- Meet My Teammate – 2 team members, 2 minutes
- Spaceship Earth – 4 minutes
- Thinking Globally – 4 minutes
- International Trade
- Letter-to-the-editor – solo, free topic, letter submitted to paper of student's choice
- International Business
- Energy – solo, 3-minute 'elevator talk' to Michigan Senator (actor)
- Water – solo, 3-minute 'elevator talk' to US Senator (actor)
- The Internet – included formal Q&A session
- Water Scarcity – Q&A session
- Final Project Proposal – 6 minutes, Q&A session
- Final Project – 20 minutes, Q&A session

Topics for presentation were chosen by teams from a short list provided to add more content to the preceding guest lecture topic. For example, to follow the International Trade lecture, teams presented the economic and resource profiles of a set of countries. To follow the International Business lecture they profiled a set of global corporations. Teams could also submit a topic for approval if they wished. In this way the students contributed to their collective learning about globalization. It also emerged that many felt a degree of empowerment by 'owning' some of the course content.

Each of the student presentations was video-captured and made available on the internet for their review. This capability played an important role in our assessment plan,

as is discussed below. All letters-to-the-editor were submitted externally; ten were published.

COURSE IMPLEMENTATION FALL 2010

The course EGR210: Global Systems was taken by sixty-four students in Fall 2010. They were drawn from eight majors in three colleges, most of them coming from the College of Engineering. They ranged from those who were sophisticated about aspects of the course content (e.g., having taken a course about sustainability) to those who were quite naïve (e.g., 'The human population is THAT BIG? I had no idea.') None had ever been involved in combining such a broad range of interacting views as the three Es presented, nor had they grappled with such complex issues in a technically oriented course.

The staff established a course environment organized along professional lines. We asked the students to behave as if they were working 'in the real world,' rather than attending a class. What this meant in practice was that the staff acted primarily as managers and coordinators. Student learning evaluation by staff grading was downplayed to the extent possible. Some students were dismayed in the early going by the staff's tendency to provide suggestions for how to pursue questions, rather than to provide answers.

Professional behavior was expected both in class and as a team member. In class meetings the students listened respectfully to one another during their presentations. They organized their presentation material thoughtfully to add to the knowledge of all, building on the previous lecture on the topic. In this way we were able to explore many significant issues in reasonable depth.

ASSESSMENT STRATEGIES

Grading was based on the following:

- Demonstration of awareness and understanding of globalization: 50%
- Demonstration of growth in communication skills: 35%
- Demonstration of growth as a professional and as a global citizen: 15%

Prior experience had shown that the course organization was a novel experience for virtually all of the students. Therefore we took considerable care to explain why we were doing it this way. Nonetheless, the low ratio of grading to activity level made some students uncomfortable during the course. They were reassured frequently and reminded that constant feedback from supervisors is not provided on the job, where they are expected to do good work and learn as they go in its absence.

The course learning objectives stressed individual growth in skills acquisition and content awareness, starting from whatever initial condition each student brought to the class. By reminding them of this many students were able to settle into a productive mindset and learned to enjoy the

challenges of taking a course ‘professionally.’ This strategy allowed for a wide range of maturity among the students.

The students demonstrated their individual awareness of globalization by taking a set of written examinations. This served well for assessing their state of knowledge but not their ability to think systematically with respect to complex issues (objective (3)). The reason was that not enough course time could be allocated to giving the students multiple exposures to a variety of system models as the course progressed. We will return to this point in the final section of the paper, where next steps for course improvement are discussed.

Assessing the growth in individual communication skills on the part of sixty-four students is an interesting challenge. Prior experience had shown us that, due to the relatively large amount of practice in making group presentations to their peers, virtually all students improved their communication skills. We wanted to formalize the assessment process and develop data-based evidence of individual growth in a cost-effective way.

It was not feasible to use experienced reviewers for individual students and have the reviewers render detailed judgments. Furthermore, there would have been little or no growth in the students’ ability to make a self-assessment and that was also an important learning goal. Prior efforts to use peer evaluation for assessing communication by individuals had not produced good results. So we decided to use guided reflection, a process in which a learner is asked to review thoughtfully his or her educational experience with certain guidelines in mind. [9]

We provided guidelines that would lead our students to review their communication experience in depth, make a data-based self-assessment, and submit the evidence and conclusions about growth in a final report. Through the use of guided reflection we expected that the students would recognize their growth, identify issues still to be worked on, and feel good about their communication skill improvement. Furthermore we expected that the reports would provide a ready basis for the staff to make the necessary evaluation at the end of the semester. Many details about our use of guided reflection in assessing students’ communication skill growth can be found in [10].

The students were asked to do several tasks in order to assess their growth in communication skills, namely:

- Define criteria to rate presentation effectiveness.
- Define a scoring metric for each criterion.
- Select at least three of their presentations to review.
- Review the presentations and develop a table of data.
- Show examples from presentations, both video frames and slides, as evidence for their ratings.
- Review the assembled data and assess their growth as communicators.

Skills associated with working effectively in teams were not dealt with in a systematic way in Fall 2010. Some students reported that they ‘got better’ as a team member

and learned what made a good team effective, but we did not provide a setting for students to make a data-based assessment of their skill growth or that of their teammates. This point will be discussed further in the last section of the paper.

Finally, there was the goal of demonstrating growth as a professional and as a global citizen. There were systematic data about attendance, including absences and related communications. There were anecdotal data about team participation derived from direct observation during presentations and from off-line comments made by teammates. Because these latter data were not collected in a systematic manner it was not possible to put them to effective use in assessing students’ growth in professionalism.

Students were asked to reflect on their growth as professionals and as global citizens and include a final report. Part of the final report asked the students to cite specific actions they had taken, if any, to change their life style as a result of learning in the course. There was no independent verification of the students’ claims about this issue.

ASSESSMENT RESULTS

The use of written examinations was satisfactory for assessing students’ awareness of key issues in globalization and their knowledge of supporting facts. The aim of mastery of content was largely met. A few systematic weaknesses will be addressed in detail in subsequent course offerings.

There was no significant attempt to assess growth in students’ ability to think systematically about large-scale, complex, controversial issues, because effective assessment would have required an unsupportable degree of evaluation effort. And, as mentioned previously, time constraints precluded the spending of enough time to make serious skill growth likely. Recognition of systems framing of an issue was achieved to a limited degree, as assessed by straightforward questions. This issue will be discussed in the final section.

Data derived from the guided-reflection self-assessment reports provided strong evidence of growth on the part of all students with respect to communication skills. The one exception was a freshman enrollee, who lacked the requisite academic maturity to be effective. It is clear that sophomores generally possess the level of maturity required to function successfully in the professional course environment.

Here are a few typical observations about communication made by students in their self-assessment reports (*author’s notes in italics below*):

- “ ... I have grown as a presenter and communicator thanks to this course. I have made great strides in the areas of body language, use of support aides and preparedness. I went from an awful score of 1 to a good score of 3 in my body language. ... this class has already helped me outside of this class. Last week I had to give a formal presentation ... My partner and I took

second place thanks to the priceless presenting techniques I picked up from this class.”

- “I hope from this paper I have shown that I have learned a great deal about presenting and thus have improved my skills greatly. Even though I still have a lot of work to do I believe I will get there over time if I keep practicing and critiquing myself afterwards. The videos that were taken and posted play a great part in my ability to do that critiquing that I believe is necessary to become a great presenter ...”
- “At the beginning of this class I started off as a nervous wreck, not being able to talk without stuttering in my presentations, all the while my power points were scattered and not well organized. But from being in this class, I have learned to create well organized presentations, and to better prepare myself in presentations so I smoothly talk through my presentation.”
- “Speaking in front of an audience or giving a presentation has never been too much of a problem for me ... I have taken speech classes in high school, and have had to give presentations before in class. It was not until I took this class where I actually critiqued myself. ... This class ... allowed me to improve my communication abilities throughout the semester.”
- “My growth as a communicator began to be quite obvious to me as I was completing the above activity (*i.e., reviewing her videos and critiquing them*). I can now see my growth from the beginning of the semester, to the middle, to the end, and in many different aspects of communication.”

The reports showed that students were able to choose reasonable criteria, devise sensible scoring mechanisms, apply them constructively to a sample set of their presentations, and interpret the findings with integrity. Many students could see that this approach is a very useful one for their careers if they want to continue to improve their communication skills. One might also hope that some students will generalize the idea of practice with feedback and adjustments for continuous quality improvement as a broadly applicable, valuable technique for professional and personal growth.

We turn now to assessment results related to the learning objective (2)(b): Demonstrate motivation to act constructively as a professional and as a global citizen. The objective of persuading students to behave professionally throughout the course was largely met, at least insofar as class behavior is concerned. The attendance data and related communications bore out their willingness to be challenged in this way. The behavior in class was attentive and respectful, especially important early in the semester, as the teams were learning to present effectively. Since all students shared this experience, they were a kind and supportive audience, rather than an indifferent or contentious one. Perhaps this is not typical of the work world, but it is conducive to learning by trial and error.

Student comments related to professionalism provide data about which to judge how well that goal was met. Here are a few typical comments:

- “I feel like I handled this class like I was working in a professional environment. I only missed two classes, and both times I let (the professor) know about my absence. I also acted and behaved professionally as a team member when we were split up into groups. I would be lying if I said I enjoyed all of my team members, but when you are part of a team you need to set aside some of your emotions and get the job done.”
- “Attendance is critical for anyone’s success in the classroom. At the beginning of the year I missed a class without an excuse which resulted in a firm email from (the professor) ... needless to say that didn’t happen again.”
- I can honestly say that I never missed a class. I feel that that is just a simple sign of my commitment to the class and those working to teach it. I also believe I was a very professional team member often the one going out of the way to get presentations started and always made sure to pull at least my weight if not more.”
- “In terms of professional growth my experiences have produced less growth than I had anticipated. During group meetings to prep for presentations I took on my usual role of stimulating a little conversation and initiating a general direction for where we wanted to take our presentation. After that my interaction was only of a level I deemed necessary to complete the project. I should have capitalized on this experience and handled group inefficiencies with a little more tolerance and a more proactive approach.”

The concept of what it means to be a global citizen was left to them to work out individually. From comments in their reports it is clear that some were very thoughtful about this and some were less so. Here are some representative comments:

- “I feel that a global citizen is someone who genuinely cares about the future of not only the environment but also the people that inhabit it.”
- “A global citizen is a person who looks at each and every aspect of life from the broader picture.”
- “I have changed my everyday actions in multiple ways from what I used to do at the beginning of this course. ... I even started turning off my roommates’ lights and electronics when they are not using them and saying something to them so they turn them off in the future.”
- “My growth has not been so much in what I do, more so what I think about. It’s hard to be “sustainable” in a house with four other guys that have little to no sensitivity to sustainability.”
- “Over Thanksgiving, I started a conversation around my table about clean/green energy and my parents were very impressed, I even taught them a thing or two!”

Most students responded very positively to the relative novelty of the course organization, content and activity requirements. The overall rating on the anonymous Student Instructional Rating System forms (a student post-course survey required by the University) was 3.8 out of 4.0 maximum. In the words of some of the students:

- “Easily the most interesting and thought provoking class I have ever taken. I would recommend it for all students who plan to succeed in the global setting.”
- “I think that this course will influence my life after the course ends. It already has and has been since the beginning.”
- “If there was any class that I would take something away from, it would be this class for sure. ... This class taught useful material that can be used in life.”
- “I do think that my experience in this course will influence my life (in fact more than any other course has) because instead of memorizing plain facts, our goal was to understand global systems and emerge from the course with key takeaways.”

CONCLUSION

Based on data in the self-assessment reports and on observations made during the course, we drew conclusions about how well the course met its goals and what we might do next to improve it.

The first change concerns the main topics. The Internet and Security will be combined into a single lecture, thereby freeing one main presentation day. The topic of Food will be added. The importance of the global food supply situation is evident daily in the media news stream. Furthermore, the impact of changing weather is likely to make the topic even more significant in the future, as are pressures arising from the growing human population and rising expectations about its standard of living.

A second change is organizational. We will reduce the time for main topic presentation to one class hour (fifty minutes) and increase the time allocated to the active learning session to two class hours (100 minutes) per week. Also we will reduce the number of student group presentations somewhat, because the evidence suggests that their gains in communication skills can be achieved with somewhat fewer presentations. In the time thus made available we will be able to introduce active student engagement with systems models and simulation tools. The goal is to meet student learning objective (3) more effectively than we have done so far.

As a third change we will introduce a formal way to assess each student's performance as a team member, relying on student feedback to provide the data. We will draw on the existing literature to devise the instrument.

Finally, we will provide more extensive guidelines for student reflection about growth as a professional and as a

global citizen, based on the successful approach used for assessing communication skill growth. Carefully drawn guidelines can make the task of assessing the impact on student learning objectives much easier.

Consider again Dr. Katehi's imperative for engineering education as stated in the Introduction, which was that “Future engineers must know how to communicate effectively and how to think globally.” We believe that the course Global Systems is helping our students to achieve both of these goals in a professionally motivating, cost-effective educational environment. It is our hope that the course will leave a life-long imprint, making our students better professionals and global citizens for having had the experience.

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