Cross-disciplinary Collaboration and General Education

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Introduction

One of the objectives of a college education is to prepare students for their future careers. Nonetheless, today's students face the challenge that many of the best jobs of tomorrow do not even exist today. As advancements in areas like science, technology and engineering continue to be made at an ever increasing rate, new jobs will be created requiring skills that potential employers have not yet conceived of or developed yet. How then does one develop the skill of reinventing oneself so as not to become obsolete in the future?

This problem is not new as evidence shows that educators in the 1920s were already grappling with the issue. Over the years, educators have stressed the need to limit specialization, and focus on basic knowledge and skills which remain relevant regardless of the changing times. These usually include communication skills, critical thinking skills, creativity, and the ability for continuous learning even after graduating from college. Many of the today's problems and issues are complex and require the expertise of specialists from many and diverse disciplines. For this reason, I would like to add the ability to collaborate with professionals across varied disciplines to the list of skills a college education should strive to develop in students in order to prepare them for life beyond college. In this paper, I explain why this is best done within the context of a General Education (GE) Program.

General Education within the Engineering Curriculum

Much of the philosophy and framework for GE courses within the University of the Philippines (UP) engineering curriculum was set in place during the deanship of Dr. Vidal A. Tan from 1940 to 1949. Although educated as a mathematician and civil engineer, he was also known as a writer, poet, and playwright, having graduated from UP in 1913 with a degree in Liberal Arts. He warned against succumbing to the temptation to fill curricula with "a multiplicity of special courses designed to meet special needs." Rather, he emphasized the need to focus on the teaching of thinking skills, fundamental knowledge, and need to be well grounded in the liberal arts. In an article entitled "Engineering Education," Tan clearly explains:

> Under a fast changing world there is only one safe way of preparing the student for life: Teach him how to think. And let his thinking be built around an inner structure consisting of unchanging fundamental principles and sound methods of thought. This kind of training affords the student a better chance to survive in an ever shifting environment. (3)
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> Side by side with emphasis on fundamentals, the proposed curriculum will have more humanities. It must be recognized that the engineer cannot get along with only his technical training. It is clear that he is a part of the community and as such should know that community. The engineer lives in a world of human beings, works for men and under men; lives with men and depends on men for his success and happiness. His preparation would be one-sided and inadequate if he only learns how to deal with nature. (3)

Tan noted that a student of such a curriculum, in comparison with his peers with highly specialized training, would be at a disadvantage in topping the licensure examination or finding a job immediately upon graduation. Nonetheless, such a student will be well equipped to handle new issues and problems during his/her professional career.

It was during Tan's term as the 7th President of UP in 1953 when a new engineering curriculum requiring five instead four years of study was instituted. The additional year allowed for the inclusion of social science and humanities courses into the engineering curriculum, together with the legislated twelve units of Spanish.

Engineering GE Courses

Since the institution of the General Education Program in June 1958 during the term of President Vicente G. Sinco, it was only in June 2005 that the College of Engineering started offering general education courses. This was a result of the Revitalized General Education Program (RGEP) which was instituted in 2001 under the term of President Francisco Nemenzo Jr. Initially, all GE courses within the Math, Science and Technology (MST) domain were offered solely by the College of Science. This resulted in an acute shortage of general education courses in the MST domain, and the need to either open more sections or institute new MST general education courses. In November 2004, the College of Engineering given its significant undergraduate enrollment was asked to institute new MST GE courses to help address the demand. Although all academic units of the College of Engineering were initially asked to develop GE courses, only three departments eventually submitted curricular proposals. These were the Department of Geodetic Engineering; the Department of Electrical and Electronics Engineering, later named the Electrical and Electronic Engineering Institute in October 2008; and the Department of Engineering Sciences, which merged with the Department of Civil Engineering in October 2008 to become the Institute of Civil Engineering.

By June 2005, the College of Engineering was able to add three new courses to the pool of GE courses offered within the MST domain.

These included: EEE 1 Everyday EEE: Kuryente, Radyo, atbp—Electrical Engineering in everyday life; GE 1 Earth Trek—A guided exploration into the tools and techniques of earth observation and measurement; and ES 10 Forces @ Work—Principles of Engineering Mechanics and their relevance to everyday life. Due to logistical limitations, all courses had to be offered as large classes, often with more than 200 students per class. Majority of the courses were team taught in a relay manner.

Importance of Teamwork

I have strongly believed that interpersonal skills, specifically leadership and teamwork, should be among the competencies a UP education should aim to strengthen. Interpersonal skills complement the intellectual skills the GE program seeks to inculcate in our students. An individual who is trained to think critically, independently, and creatively, and who is ethically and morally well-rooted, will also need to have complementary interpersonal skills to engage others so as not to be perceived as arrogant. Conversely, working in a multidisciplinary team requires both an understanding of and appreciation for the various disciplines comprising the course, as well as the ability to work in a team.

I define teamwork as the ability of individuals within a group to constructively engage each other and collectively work together towards the successful accomplishment of common goals. It is a necessary skill even more so today when most jobs require professionals to collaborate. It is a skill a potential employer looks for in its applicants. Accrediting agencies such as the Accreditation Board for Engineering and Technology, Inc. (ABET) expect students to gain proficiency in teamwork skills through experiential learning activities embedded in the engineering curriculum. However, these skills appear to be absent among the competencies the GE Program seeks to explicitly strengthen.

This current lack of emphasis on teamwork skills may be the underlying reason many employers have a poor impression of UP graduates when it comes to interpersonal skills. In the course of my work as a professional engineer, many of my clients have frequently told me that they generally do not hire engineers who are UP graduates because they are reputedly difficult to deal with and are not good team players. Conversely, many former students of mine who are now working as engineers often tell me that their biggest challenge lies not in the lack of technical preparation, but in the lack of preparation to engage and collaborate with graduates from other universities who do not have the same technical and analytical skills. They tell me they are often perceived as obstructionists and troublemakers when they critique the ideas of their peers and superiors.

My close involvement in the development and institution of ES 10 came as a result of my being, at that time, both the chairman of the Department of Engineering Sciences and a member of the University Curriculum Committee. In formulating the course, I believed that leadership and teamwork skills should be among the competencies this course should aim to strengthen despite these not being among the skills included in the RGEP framework. As a way of teaching leadership and teamwork skills, a set of group projects were included as part of the course requirements. Each project required a group to design and build a device aimed at performing a particular task within prescribed specifications. Examples of these projects are the bridge building challenge and the egg drop challenge. In the bridge building challenge shown in Figure 1, students build a bridge from a specified material (e.g., barbeque sticks, tooth picks, plastic sticks, fastened together with rubber bands or glue). The resulting bridge should satisfy prescribed requirements regarding its weight and length. The main challenge of this design problem is to maximize the load the bridge can carry. In the egg drop challenge shown in Figure 2, students design a cradle (again from a prescribe set of materials) in which a raw egg can be placed and dropped. The main challenge of this design problem is to maximize the height from which the cradle and egg can be dropped without cracking the egg. Teams had

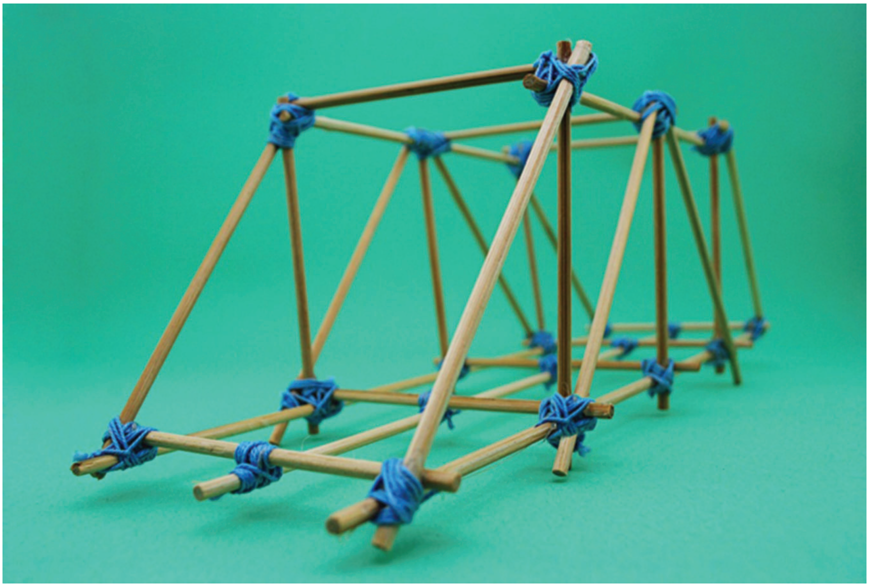

Figure 1. Bridge building challenge

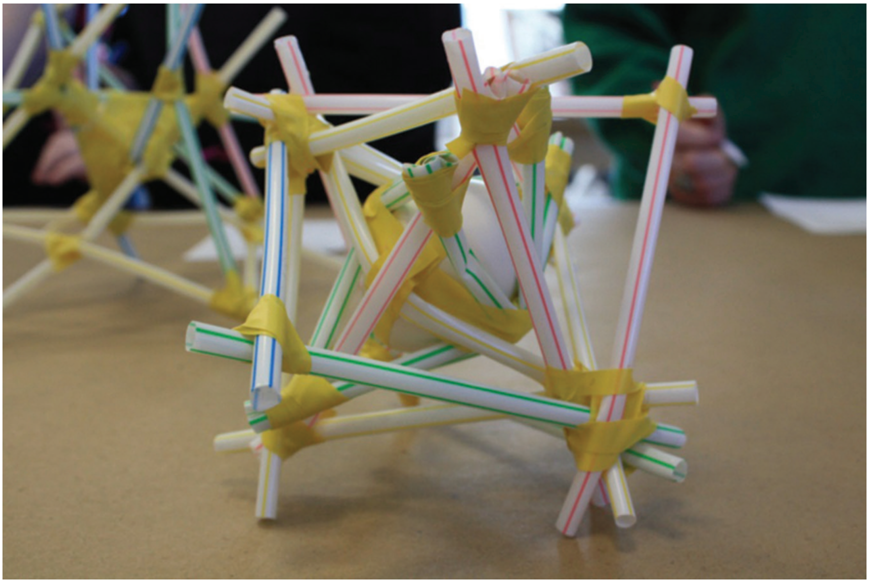

Figure 2. Egg drop challenge

four to five students. Initially, the students were allowed to pick their teammates. In subsequent semesters, teams were formed to ensure a greater variety of academic backgrounds among students.

Important Observations from ES 10

Although fraught with logistical challenges, the implementation of the group project over the course of eight semesters gave me valuable experience and insights regarding how students work together as well as how teams should be formed. On the average 40% of students who enrolled in ES 10 were engineering students. As expected, Engineering students generally performed better than non-Engineering students on written conceptual examinations. This could be attributed to their familiarity with the material since they took several engineering science courses prior to taking ES 10. However, there was no significant difference between engineering and non-engineering students when it came to how well they performed in the design projects. Very rarely did projects perform below par (e.g., the bridge failing to carry minimum load). This normally occurred when there was a failure of the team to work together. Teams consisting entirely of males from varied backgrounds generally did not work well together. Also, teams of students with high scores in the conceptual examinations did not always produce outstanding solutions to the design problems.

In general, most teams were at least able to design projects that met the minimum levels of performance, and in most cases surpassed them. It was noted that successful teams took the initiative to consult either the faculty handling the course, students who had taken the course, or an outside expert, or teams searched for ideas and/or solutions on the internet. This necessitated periodic modification of the design problem in terms of materials and specifications to discourage students from simply copying solutions from previous semesters. Teams composed of members coming from different academic clusters generally found it more difficult to work together as compared to teams consisting entirely of engineering students. But in cases where such teams effectively worked together, the results were generally better and more original compared to those of teams consisting entirely of engineering students. This observation supports the general notion that engineering design teams benefit from the insights of non-engineers.

It is interesting to note that some of the most successful (e.g., cradle that could protect an egg dropped from a height of three meters) and novel designs originated from team members in non-engineering courses such as Creative Writing, Fine Arts, Journalism, History, and Philosophy. This seems to suggest that critical and creative thinking obtained through the study of the Arts and Humanities can be used to some extent for solving engineering problems.

Cross-disciplinary GE: CE 10 D*MAPS

As in most professions, the vast majority of engineering problems are multidisciplinary in nature. As a professional consulting engineer, I always found working with professionals and experts outside my general area of purview intellectually stimulating. Taking from Edward de Bono's concept of the six thinking hats,[1] I have always believed that real-life engineering problems should be analyzed from a variety of perspectives in order to gain deeper insight. For this reason, I felt there was a need for GE courses in which multidisciplinary topics and issues can be discussed in an integrative manner considering the different perspectives of the various relevant disciplines.

The concept of a GE course that is transdisciplinary is not new. The GE Program of Harvard University includes courses that inherently cut across disciplinal boundaries. Examples include courses entitled Science and Cooking: From Haute Cuisine to Soft Matter Science which

[1] De Bono, Edward. 1985. Six Thinking Hats: An Essential Approach to Business Management Little, Brown, & Company.

combines the expertise of food scientists, chemists, and chefs; and The Toll of Infection: Understanding Disease in Scientific, Social and Cultural Contexts which discusses the impact of infectious diseases on wars, politics, economics, religion, public health, and society as reflected in history, literature, and the arts.[2]

This idea of a transdisciplinary GE course saw fruition when the Institute of Civil Engineering instituted in June 2013 the course entitled CE 10 D*MAPS: Disaster Mitigation, Adaptation and Preparedness Strategies. From its inception in October 2009, the course was designed to be a transdisciplinary course on disaster risk management synthesizing the inputs of experts across disciplines. Because of the collaborative/cooperative and interdisciplinary nature of disaster risk management, the course designers sought to operationalize a number of pedagogic strategies aimed at teaching collaboration and cooperation within an interdisciplinary framework. To my knowledge, this is among the very first undergraduate GE courses on disaster risk management that is transdisciplinary; the course on natural disasters offered by Harvard University explores this topic solely from the perspective of earth sciences.[3]

CE 10 was handled by a multi-disciplinary teaching team from five colleges: namely, the College Engineering, College of Arts and Letters, College of Fine Arts, College of Social Science and Philosophy, and the College of Education. Members of the team took turns lecturing, but with the other members of the team present during each lecture and ready to provide supplementary insights on the topic. In subsequent semesters, members of the teaching team made a conscious effort to include/connect topics and concepts to the lecture that were outside their general area of expertise (e.g., connecting various cross sections

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2 http://www.generaleducation.fas.harvard.edu/icb/icb.do

3 Ibid.

that make a building layout vulnerable to earthquakes within a lecture on frameworks of aesthetics).

The course was initially offered using a model similar to STS in which experts are invited as guest lecturers. However, this mode of delivery had two major disadvantages. First, some lecturers included too much material or presented materials that were too technical for students to understand. As a result, students suffered from cognitive overload. Also, the suspension of classes due to inclement weather, or the guest lecturer becoming suddenly unavailable severely disrupted the schedule. To address these problems, the method of course delivery was modified to a blended learning environment based on the Flipped Classroom Model.[4] In this model, instructional materials and activities were delivered online using the University Virtual Learning Environment (UVLE). Students studied the materials before coming to class. The regular class period was then used for activities aimed at both reinforcing and integrating concepts, or activities that allowed the students to apply the concepts learned.

Very much like ES 10, students were organized into teams of five members. Enrollment in the course was controlled through the Computerized Registration System (CRS) to ensure that every team had members coming from each of the four academic clusters. Each team was tasked to choose a specific concept related to disaster risk management and develop a video based on that concept. The group presentation project was aimed at providing students with an authentic learning environment[5] that both was collaborative and cross-disciplinary

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4 Lage, Maureen J., Platt, Glenn J. and Michael Treglia. 2000. "Inverting the Classroom: A Gateway to Creating an Inclusive Learning Environment." Journal of Economic Instruction. 30–43.

5 Donovan, S., Bransford, J., & Pellegrino. 1999. How People Learn: Bridging Research and Practice. Washington D.C.: National Academy of Science.

in nature. Also by grouping students of different academic disciplines in a team, it was hoped that students would learn from each other based on an informal version of the Peer Instruction model.[6] Teams were assigned a mentor from among the members of the faculty teaching team. The mentor guided the student teams through the conceptualization and production of the video presentation.

The fact that this was the very first time members of the teaching team had worked together provided valuable learning experience in cross-disciplinary collaboration, and helped the teaching team more effectively mentor the groups.

It should be noted that while pedagogical strategies such the Flipped Classroom, Authentic Learning, and Peer instruction have been in existence in the last ten years and are widely used today, to my knowledge this is the first time in UP that such strategies have been applied within a context that is both cross-disciplinary and collaborative.

Conclusion

The main objective of a GE program should be to give students a broad perspective on knowledge and an awareness of diverse human experiences and cultures. In this paper, I highlighted the need for GE courses where both faculty and students collaborate across disciplines, learn from one another, and grow intellectually beyond disciplinal boundaries. It is hoped that my experiences will encourage others to institute similar GE courses.

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[6] Couch, H. Catherine, and Eric Mazur. 2001. "Peer Instruction: Ten Years of Experience and Results." American Journal of Physics, vol. 69, 970–977.

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