ASEE International Forum
Omni Hotel at CNN Center
Saturday June 22, 2013

Paper ID #8370

Invited Paper - Embracing complexity in engineering education: A way forward for developing intercultural competency

Mr. Thomas Lachlan Goldfinch, University of Wollongong

Tom Goldfinch is a lecturer in engineering education at the University of Wollongong. He has worked on engineering education research and development projects since 2006. His key research focus areas are engineering mechanics education, and the social and cultural aspects of engineering education and practice. Tom was recently project leader of an Australian Office for Learning and Teaching funded project Exploring Intercultural Competency in Engineering, which led to the development of a range of learning resources targeting students' development of intercultural competency (engineeringacrosscultures.org). Past projects also include: ALTC project A Pro-Active Approach to Addressing Student Learning Diversity in Engineering Mechanics; A graduate attribute led curriculum review for UTEM, Chile; and the implementation of UoW's University Learning and Teaching course at ImamU, Saudi Arabia. In 2009 he was awarded a vice-chancellors award for outstanding contribution to teaching and learning in the area of graduate attributes and has published numerous papers on engineering education research and practice.

Embracing complexity in engineering education: A way forward for developing intercultural competency

Abstract
Discourse surrounding the global nature of the engineering profession has fueled a push towards engineering education that prepares graduates to work effectively across foreign cultures and customs[1-3]. The author argues that while this outward focus is important and necessary, there is also a need to focus on preparing graduates for cultural issues that will arise much closer to home. Identifying, and working with subtle cultural differences that can occur in workplaces, organizations and the community, where the population may initially appear monocultural, presents unique challenges. The way in which one assumes cultural uniformity in a given situation can contribute to the oversimplification of a problem, and subsequently the pursuit of ineffective solutions. In a recent project, the author and colleagues sought to develop educational modules that introduced students, and staff, to strategies for identifying complexities arising from these subtle cultural contrasts and conflicts. In the process, a model for knowledge management by Kurtz and Snowden[4] has been identified that neatly frames the way we approach learning and decision making in engineering education and practice. The framework distinguishes the ways in which one perceives a problem in terms of its complexity and the strategies employed to solve it. This paper describes the applications of this framework to engineering education that focuses on developing students' intercultural competency. The way this framework has been used to design learning activities as well as its usefulness for staff training and development are outlined. The author proposes potential applications of this framework to other areas of engineering curricula as a way to embrace complexity in learning and teaching and avoid oversimplifying complicated problems.

Introduction

Globalisation, diversification, community engagement, socially responsible, these are all term that appear often when talking about modern engineering practice. Criteria set by professional bodies for accrediting engineering degree programs have set in stone the need for graduates to think well beyond the technical domains of engineering[5]. The cultural differences students are likely to encounter when working overseas or liaising with colleagues offshore has placed an emphasis on global competency and international aspects of intercultural competency. There is now a substantial body of work exploring this area[1-3].

Many of the considerations relating to working across national boundaries involve clearly identifiable, though not necessarily known, differences in cultural norms and work practices. This discussion paper looks at cross cultural interactions from a different perspective. It explores the question:

How can subtle cultural differences be managed in engineering education and practice?

These considerations stem from the authors experience contributing to an Australian Office for Learning and Teaching funded project, *Engineering Across Cultures*, abbreviated to EAC.

Intercultural competency

Intercultural competency (or cultural competence, intercultural competence, cross-cultural competence) has many definitions. Ang and Van Dyne[7] define cultural competence succinctly as *an individual's capability to function and manage effectively in culturally* *diverse settings*. Deardorff[8] defines it as *effective and appropriate behavior and communication in intercultural situations*. These definitions and many others refer to the term 'culture' in describing what it is to be interculturally competent[9]. The Author argues that this is where the challenge really begins. Definitions of culture range from those that are very detailed and specific to those that are more general and all encompassing. Hofstede's five dimensions of culture is one such definition that is quite specific[10]:

1. *Power/Distance:* how inequalities in prestige, wealth and power are handled, within the family, education, work, politics, religion and ideas;
2. *Uncertainty Avoidance:* how uncertainty about the future is handled, with artifacts addressing the uncertainties of nature; laws (rules), the behaviour of others; and religion, what we do not know;
3. *Individualism/Collectivism:* what the relationship is between the individual and the collective;
4. *Masculinity/Femininity:* what gender role patterns are, and how highly differentiated the roles are;
5. *Long-term/Short-term Orientation:* whether the focus is on gratifying short-term needs or responding to longer term social and moral obligations.

Another more general definition states that culture encompasses 'socio-political factors (e.g. socio-cultural history, government and laws, religion, etc.) as well as familial and communal customs, norms, beliefs, opinions and rituals'[11]. The different definitions all highlight the complexity of culture as a concept. It involves deep-seated beliefs and practices that are largely shared with others within a cultural grouping. It is important to note that the literature around culture rarely associates culture with nationality. This is where intercultural competence is differentiated from global competence.

The EAC project explored academics' understanding of intercultural competence through a series of workshops with engineering educators in Australia. An outcome of these workshops was to develop a set of simple statements from participants own understandings about culture, drawing from the definitions above. These statements define culture in simple terms, and relate this to intercultural competency, and then on to the challenges that will be faced by engineering graduates. It was clear from this process that engineering educators also saw the distinction between culture and nationality, and the result was the following three statements:

> ***Culture:*** *Values, beliefs and behaviors*
>
> ***Intercultural Competency:*** *Appreciating, respecting and adapting to other values, beliefs and behaviors and working with differences*
>
> ***Challenges faced by graduates:*** *Identifying and understanding values, beliefs, and behaviors of one's self and others*

An educational approach

The educational approach developed in the EAC project focused on the third of the statements above, the challenges faced by graduates. Identifying and understanding culture is enormously challenging. Equating culture with nationality certainly makes the process of identifying cultural differences simpler. Other research has indicated that students are more confident in judging their own levels of cultural competence (their perceived level of knowledge and skill about other cultures) when cultural differences can be aligned with differences in nationality[12].

The learning modules developed within the Engineering Across Cultures project sought to take students beyond the culture as nationality paradigm. The modules address the issue of identifying cultural differences within one's own country, and in some cases, within a workplace. Variation theory in learning suggests that development of new understandings is dependent on observing differences between what is known and what is new[13-14]. For example, understanding the concept of color requires the observation of many different colours. When differences in culture are subtle, that is, there is limited variation, understanding the attributes of culture that contribute to behavior and actions is difficult. Hence, understanding culture and its impact on behavior and other outcomes when a student may be overly familiar with, or even embedded within that culture presents some interesting challenges.

To help identify cultural issues and their impacts, the EAC approach breaks down discussions about cultural issues in engineering into cultural contexts. The materials developed by the project cover five cultural context found in engineering education and practice identified by the project team:

1. Living culture – Developing awareness and understanding of how engineering fits into social contexts
2. Workplace culture – Seeing how workplace cultures evolve and their effect on work practices
3. Community culture – Engaging with community issues that engineers often encounter
4. Technical/cultural demands – Exploring links between technical and cultural requirements in design and practice
5. Culture in the classroom – Identifying students' priorities and cultivating a classroom learning culture that is open and accepting of new ways of thinking (for the educator).

In many of the case studies and scenarios presented in the EAC modules, few have a 'correct' or 'best' solution. The modules do not attempt to guide students towards what the resource developers believed is an optimum solution. Rather, the modules instead aim to structure learning to encourage students to identify unknowns, in terms of cultural differences, and develop strategies for dealing with them. The approach takes a distinct departure from content focus and instead seeks to guide students towards a level of comfort with uncertainty and complexity.

Getting comfortable with complexity

The EAC resources were structured around a theoretical framework originally designed as a knowledge management concept. The Cynefin Domains of Knowledge[4], originated from organizational research at IBM and is presented in Figure 1. The model, as used in this engineering education context, clarifies the way in which people seek out and deal with knowledge in different situations. While the Authors understanding and explanation of the model may differ slightly from that of the original authors, it is considered in this paper only as it relates to engineering education. The model uses the idea of cause and effect relationships to explore five different conditions that may be found at different times in during the learning process. These conditions have informed the structure of activities for each of the EAC teaching modules.

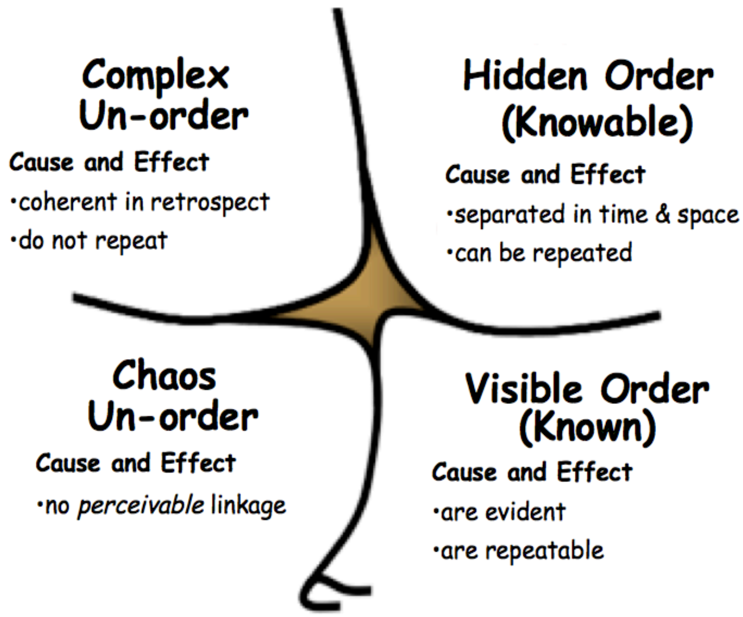

Figure 1 The Cynefin Domains of Knowledge (Kurtz & Snowden, 2003)

Traditional education mainly focuses on the 'ordered' domains on the right. The 'visible order' exists where there are known cause and effect relationships that can be used to easily predict an outcome. One such example is the layout of a traditional tiered lecture theatre. Students walk in to the room with the understanding that the lecturer will present from the front, and that there is a good chance that their role in the class will be that of a passive learner. They are there to listen, take notes, or alternatively, spend some time on facebook.

The 'hidden order' exists when causes and effects are not known initially, but can be identified, understood and repeated. This condition may exist in that same lecture theatre where the lecturer effectively utilizes active lecturing strategies. In this scenario students walk into the room with a certain expectation of their role in the class that is subsequently upset by the teaching approach of the lecturer. Never the less, this new approach can be understood over the course of the first class. This means that the order is knowable, and will be anticipated in the next class taught by that lecturer. Other examples of the 'hidden order' include the introduction of technical engineering concepts in a tutorial class. The causes and effects in this case are concepts, procedures and correct solutions that are discovered under the guidance of a teacher (i.e. lab classes, simple engineering mechanics problems).

The two 'un-ordered' (an interesting word play on the paranormal idea of the 'un-dead' – not alive, not dead but somewhere in between) domains are where the approach used in the EAC modules on intercultural competence are targeted. The 'complex' domain describes conditions where the relationship between cause and effect is difficult to predict, and may only make sense after an event has occurred. These situations are common in engineering education and practice, where events occur that have not, and could not be perfectly planned for from the outset. Effectively dealing with this complexity requires continual observation of the progress of a project or educational activity and appropriate readjustments to the approaches used to ensure the desired outcome. Competence in this domain is particularly important for anticipating challenges, and putting in place strategies for dealing with issues as they arise. In terms of the lecture theatre scenario, imagine a class of students who are anticipating an active lecturing approach and met with a very passive chalk and talk style. This is likely to lead to unrest among students and without anticipating this scenario and having strategies for dealing with it on hand, the lecturer may lose control of the class. The EAC modules encourage students to become comfortable in the complex domain by providing case studies or scenarios of events that have already occurred in engineering projects. In these case studies, subsequent investigations have identified workplace cultures or other cultural practices as having led to the event. Students are required to analyze the factors at play and develop possibilities for how a workplace or community culture has evolved and contributed to the event, and then propose strategies for managing these possibilities in future scenarios.

The fourth domain is 'chaos'. Conditions of chaos exist where there are so many factors at play that the relationship between cause and effect is impossible to determine with any certainty. Effectively managing chaos requires one to first recognize that conditions of chaos exist. Then, using the best judgment available, one must simply take action and observe the outcome. While the EAC modules deal mostly with the complex domain, students are encouraged at certain points, where the best course of action for dealing with a scenario is unclear, to simply discuss the situation with their peers and make a decision.

Overall, the EAC approach keeps students within the un-ordered domains by posing engineering challenges involving intercultural interactions and using a simulation style. The challenges simulate those encountered in engineering practice where students need to work with incomplete information. Activities in each module encourage them to work just sufficiently beyond current levels of knowledge so as to stretch their capabilities for absorbing, managing and responding to new information - and develop their self-confidence while doing so.

The fifth and very important domain is the shaded area in the middle of figure one. This region is referred to by Kurtz and Snowden as 'Disorder'. It is often the starting point at which the relationship between cause and effect is not known to the student. It is important that students recognize when they are in this situation, not knowing whether the way forward is ordered or un-ordered. Failing to move from this region of the model to the appropriate domain can lead to distress and a retreat to inappropriate or ineffective strategies for dealing with the situation. To illustrate, this is similar to what can be observed in complex political debates where participants create an overly simplistic understanding of cause and effect in the ordered domains as opposed to the more appropriate, but less comfortable 'un-ordered' domains. The result is ineffective policy decisions. In the EAC materials, this reaction is avoided by providing students with just enough guidance to recognize complexity or chaos in the scenarios and identify patterns. These patterns help students to understand the underlying culture that may be contributing to the outcome of the scenario.

The Cynefin Domains as a staff development tool

In developing the EAC materials, exploring the Cynefin Domains model and running workshops with engineering academics, the author noted other potential applications of the model. Complexities in large engineering projects, academic research and even the organizational structures within which academics operate are commonly recognized and accepted. However, the same is not always true of students and academics views on engineering education. Views on the learning and teaching process often involve fault projected on others, oversimplification of the responsibilities of students and educators, and approaches to teaching and study that do not respond to the complicated and inconsistent nature of learning needs[15-16]. In the world of business administration, there is a growing understanding of the need for business models to be flexible and responsive to market demands in increasingly complex environments. Kelly and Alison[17] propose an approach to managing business that embraces complexity, rather than trying to predict and meet market demands. The outcomes of such approaches can be seen in the runaway success of new types of consumer products such as smart phones that allow users to customize the functions of the device to meet their needs. Businesses operating successfully in this domain are clearly comfortable in the un-ordered domains.

Many of the more traditional approaches that are common in engineering education encourage students to remain in the ordered domains of knowledge through textbook style problems and 'correct' solutions to design scenarios. These approaches most certainly have their place in engineering education, the fundamentals are important, and there is often a right and wrong answer. However, in implementing the EAC modules, the project team frequently encountered academics seeking to impose these types of approaches when dealing with intercultural competency. It was also evident from early staff reactions that the staff themselves did not view the educational process as existing within the un-ordered domains. Embracing complexity is not only an issue for students, it is of key importance for staff.

For this reason, in preparation for the implementation of the EAC modules in a first year (freshmen) design subject, the Cynefin Domains have been utilized to great effect as a staff development tool. Staff were encouraged to consider the classroom as a complex system, where it is possible to anticipate cause and effect (teaching an learning) but that it is not possible to predict outcomes absolutely. This approach has led to a greater level of acceptance of the need for flexibility in teaching approaches and to plan alternative strategies for explaining ideas and facilitating learning activities. The effect of this approach in staff development has not been evaluated externally. However, the invitation extended to the author from the design subject lecturer and tutors to redevelop the entire subject around this approach gives some cause for optimism about its usefulness as both an educational design and staff development tool.

Where to next?

This discussion paper has presented some of the author's experiences in addressing the challenging area of Intercultural Competency in engineering education. In the process of addressing this challenge, an educational model has been identified that is rarely seen in engineering education research and development. The usefulness and alternative applications of the Cynefin Domains model have been discussed in the interest of sparking wider interest in the model among engineering educators. It is hoped that this framework, used as an educational design and staff development tool to help engineering education continue to break away from traditional approaches to embrace complexity in the classroom.

References

1. Thomas, D.C. and K. Inkson, *Cultural Intelligence: People Skills for Global Business*. 2004, San Francisco, CA: Berrett-Koehler.
2. Lohmann, J.R., H.A. Rollins, and J.J. Hoey, *Defining, developing and assessing global competence in engineers.* European Journal of Engineering Education, 2006. **31**(1).
3. Becker, F.S., *Globalization, curricula reform and the consequences for engineers working in an international company.* European Journal of Engineering Education, 2006. **31**(3).
4. Kurtz, C.F. and D.J. Snowden, *The new dynamics of strategy: Sense-making in a compex and complicated world.* IBM Systems Journal, 2003. **42**(3).
5. Australia, E., *Stage 1 Competency Standard for Professional Engineer*. 2011: Melbourne, VIC.
6. Commission, A.E.A., *Criteria for Accrediting Engineering Programs*. 2011, Accreditation Board for Engineering and Technology: Baltimore, MD.
7. Ang, S. and L. Van Dyne, *Handbook of Cultural Intelligence: Theory, measurement and applications.* 2008, Sharpe, M.E.: Armonk, NY. p. 391.

8. Deardorff, D.K., *Assessing Intercultural Competence.* New Directions for Institutional Research, 2011. **149**.
9. Spitzberg, B.H. and G. Changnon, *Conceptualizing Intercultural Competence*, in *The SAGE Handbook of Intercultural Competence*, D.K. Deardorff, Editor. 2010, SAGE: Thousand Oaks, CA.
10. Hofstede, G., *Culture's Consequences (2nd edn.)*. 2001: Thousand Oaks: Sage Publications.
11. Matsumoto, D., *Reflections on culture and competence*, in *Culture and competence: contexts of life success*, R.J. Sterberg and E.L. Grigorenko, Editors. 2004, American Psychological Association: Washington, DC.
12. Goldfinch, T., et al., *Intercultural competence in engineering education: who are we teaching?*, in *Australasian Association of Engineering Education Annual Conference*. 2012: Melbourne, VIC.
13. Marton, F. and S.A. Booth, *Learning and Awareness*. 1997, Mahwah, NJ: Lawrence Erlbaum Associates.
14. Thune, M. and A. Eckerdal, *Variation theory applied to students' conceptions of computer programming.* European Journal of Engineering Education, 2009. **34**(4).
15. Goldfinch, T., A. Carew, and G. Thomas, *Students Views on Engineering Mechaincs Education and the Implications for Educators*, in *Engineering Education: an Australian Perspective*, S. Grainger and C. Kestell, Editors. 2011, Multi-science Publishing: Brentwood, UK.
16. Pomales-Garcia, C. and Y. Liu, *Excellence in Engineering Education: Views of Undergraduate Engineering Students.* Journal of Engineering Education, 2007. **96**(3).
17. Kelly, S. and M.A. Allison, *The Complexity Advantage*. 1999, New York: McGraw-Hill.