Exploring Sources and Skill levels of Accidental Competencies for an Engineering Capstone Project

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Abstract

Capstone courses provide students the opportunity to work on real-world engineering projects. Usually, these design projects are multidisciplinary, open ended and tackled in student teams. To perform well, seniors require a broader set of competencies beyond the academic competencies taught in a linear and sequential process in the classroom or laboratory. In previous semesters, students who acquire accidental competencies (i.e. *competencies not directly linked to targeted instruction of stated learning outcomes in the curriculum*) have been observed to perform better than their peers in these capstone projects. This paper reports preliminary findings from a pre-survey of 70 Aerospace Engineering seniors that explored the skill level and sources of competencies acquired prior to their capstone senior design course. Approximately half of respondents say they are at least very skilled in some academic or workplace competence. In addition, they perceive that they acquire a greater portion of the relevant competencies for their capstone project from accidental competency sources.

Keywords

Accidental Competencies, Multidisciplinary Project, Capstone Senior Design

Introduction

The modern engineering curriculum should accomplish two major tasks; first is analytical, computational and technical skills development, which may be taught in a sequential and linear process in the classroom or laboratory[1]. The other is design practice where students rehearse most workplace competencies. The latter task addresses real-life problems with open-ended answers and needs to be developed using holistic and adaptive methods not easily taught in the classroom[1]. There has always been a call for design practice to be more incorporated into the engineering curriculum[1,2,3] and not only in the senior capstone project as is currently done. This disconnect is known as the competence dilemma[3]. This is because, with a few exceptions, students are not introduced early to the fundamentals of design practice in the curriculum and are tasked with a capstone design project that they are unprepared to handle. However, some students acquire accidental competencies from sources such as hands-on club activities, co-ops and internships etc[3]. *Accidental competencies are competencies acquired by students that are not directly linked to targeted instruction of stated learning outcomes in the curriculum*[3]. Previously, these students have performed better than those who do not participate in these activities. The design task cannot be fully disaggregated, broken up, or reduced to subtasks that can be independently pursued[2]; therefore, students have to work on the projects in teams. Workplace competencies like teamwork, planning, organizing, leadership and interpersonal skills essential for the workforce are better practiced in team-based projects such as the capstone. Honor Passow studied the relative importance of ABET competencies in professional practice and found these workplace competencies to be as important as the technical skills the students learn in the eight semesters in college[4]. Specialized projects are no longer a viable option, because the modern workforce requires considerable familiarity with several disciplines. Therefore, engaging in multidisciplinary capstone projects is fundamental to the professional formation of the modern engineering graduate. Therefore, Aerospace Engineering graduates require other engineering competencies outside the traditional Aerospace Engineering domain.

The Aerospace Engineering (AE) senior design capstone course is a two-semester project course. It centers on the design, build and fly of an aerospace vehicle, which is by nature multidisciplinary. The design synthesis phase is in the fall semester where students define the project objectives, define functional and design requirements, generate concepts, select the concepts and go through a detailed design to obtain a detailed design solution. In the spring semester, students build and test their prototype. The capstone project is an exciting and revealing activity for seniors. They will use these previously acquired skills in the project and acquire a few while navigating the project life cycle. This exploratory study seeks to reveal a better understanding of students' perceptions of a capstone project and clarify specific constructs and factors that affect their performance in a multidisciplinary capstone project.

Methods

Using Qualtrics, a pre-enrollment survey was sent to seniors about to enroll in the Aerospace Engineering capstone senior design course. Eighty-three self-assessment surveys were sent to the students with 70 completed surveys, an 84% response rate. In collaboration with the Aerospace Industries Association (AIA) and the National Defense Industrial Association (NDIA), the Employment and Training Administration (ETA) has worked with industry leaders to develop a comprehensive competency model for the aerospace industry[5]. This Aerospace Competency Model from the Competency Model Clearinghouse was adapted to categorize and define the relevant competencies. Table 1 shows the survey question of interest. Data collected were analyzed using SPSS to post process the perceived skill level and sources of these competencies.

Table 1: Survey Question of Interest for this Study

Question:
[1] Rate your skill level in each of the following competencies you will apply in the Aerospace Engineering capstone senior design project.
[2] In the right column (Table 2), select how you acquired this competence from the drop down list.
Responses:
Not Skilled, Somewhat Skilled, Moderately Skilled, Very Skilled, Extremely Skilled

To perform well in the capstone project, seniors require a broader set of competencies beyond the academic competencies taught in the classroom or laboratory. Table 2 shows the clusters of relevant competencies. Academic competencies are those skills aligned with targeted learning outcomes in the Aerospace Engineering curriculum. Workplace competencies are mainly skills practiced in team-based design projects and other engineering competencies are required because of the multidisciplinary nature of AE projects. Table 3 shows the cluster of sources under Aerospace Engineering curriculum and accidental competencies.

Table 2: Relevant AE Capstone Project Competencies

Academic Competencies	Workplace Competencies	Other Engineering Competencies
• Problem Solving/Calculations	• Planning and Organizing	• Mechanical Hardware Fabrication
• Writing/Preparing Documents	• Teamwork	• Electronics/Instrumentation
• Speaking/Making Presentations	• Leadership	• Micro-controllers/Embedded systems
• CAD/Animation	• Creative Thinking	
• Computer Programming/Coding	• System Thinking	
• Numerical Analysis/Simulation	• Interpersonal Skill	
• Research/Literature Review		
• Testing/Experimental Design		

Table 3: Sources of AE Capstone Competencies

AE Curriculum	Accidental Competencies
• Classroom Lecture Courses	• College Club Activities
• Laboratory Activities	• Internship/Co-op/Work
• Undergraduate Research	• Self-Trained
	• Non-College Courses/Trainings

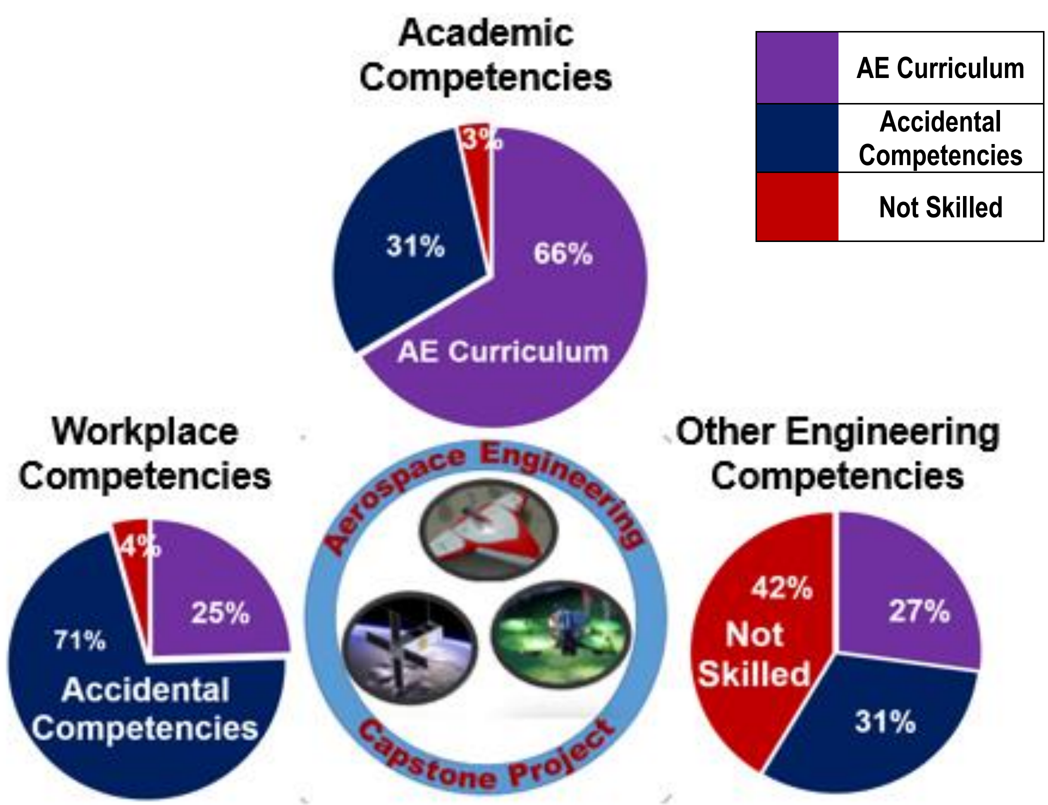

Figure 1: Perceived Sources of Skill

Key Findings

Figure 1 describes the distribution of sources from which students perceive they acquired the relevant competencies for their capstone project. Students perceive they acquired most of their workplace competencies from accidental competencies sources. As expected a majority of academic competencies were acquired from the stated instruction of learning outcomes in the Aerospace Engineering curriculum; however, roughly one-third were from accidental competencies sources, which is very significant. Approximately 40% AE seniors say they are not skilled in other Engineering competencies outside traditional Aerospace Engineering competencies. However, with students who have some of these other Engineering skills, their responses show that they acquired it evenly from the AE curriculum as well as accidental competencies sources.

Figure 2 shows the perceived skill level of AE seniors prior to enrolling the capstone course. More of the responding seniors perceive they are at least very skilled in workplace competencies than academic competencies. About half of responding AE seniors say they are at least very skilled in some academic competence and about two-thirds say the same for workplace competencies. Only around 10% of the seniors say they are at least very skilled in other Engineering competencies.

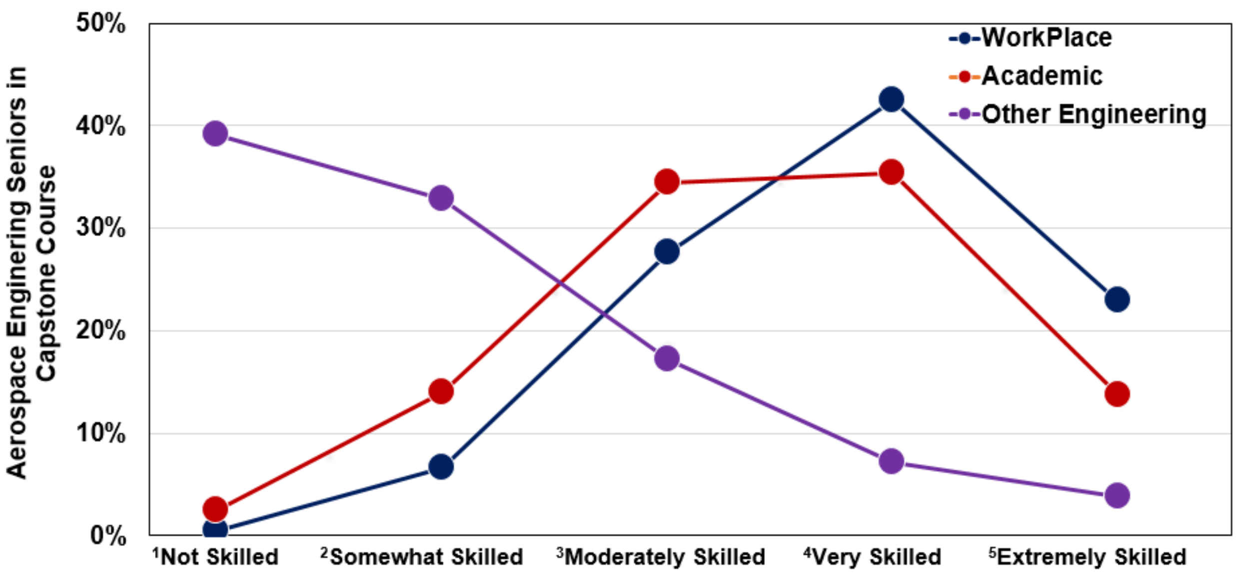

Figure 2: Perceived Skill Level

Conclusion and Future Work

Overall, responding seniors perceive they acquire most of the relevant competencies for their capstone project from accidental competencies sources. Despite being preliminary results, these findings indicate that accidental competencies cannot be considered auxiliary anymore. Currently, engineering curricula nationwide is less than 130 credit hours. This can limit the incorporation of merged learning outcomes in a four-year plan i.e. *to embed the technical content in the context of professional practice*[4]. However, there will be some benefit, if a few of the identified sources of accidental competencies' were required in the curriculum.

Since accidental competencies are very relevant to Aerospace Engineering students' performance in the capstone course, it is important to continue these investigations because of the benefits to the professional formation of engineers. More data will be collected and further analysis done to ascertain repeatability and validate these responses. Furthermore, at the end of the project, the same group will relate their experiences in a post project survey. Future research will focus on how accidental competencies affect students' performance in multidisciplinary capstone project. How to bridge these observed gaps in competencies will also be explored.

References

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