

Using an Importance versus Practice Matrix to Understand How and Why Faculty Integrate Entrepreneurship into Capstone Design

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Capstone Design courses have traditionally provided students with a critical opportunity to apply what they have learned and to connect with industry. However, students' Capstone Design experiences might be further enhanced by incorporating entrepreneurial practices found to boost retention, job prospects, and workplace preparedness. Shartrand and Weilerstein identified various practices for incorporating entrepreneurship into Capstone design courses. However, it remains unclear how prevalent such entrepreneurial practices are. To better understand which entrepreneurial elements capstone practice, and how and why they practice them, a multiphase mixed-methods approach was employed. The authors expand on their preliminary analyses of Capstone design faculty survey responses by using the "importance" versus "practice" framework presented in ASEE's Innovation with Impact report, and incorporating findings obtained through follow-up interviews.

Keywords: Capstone, entrepreneurship, importance, practice

Introduction and Background

Capstone Design courses emerged out of a desire to provide students with real-world experience, connect them with industry and better prepare them to enter the workforce.^{1,2} In Capstone design, students typically apply what they have learned through an open-ended design project while industry provides viable projects and necessary funding.

While traditional Capstone Design courses play an important role, integrating entrepreneurship can elicit several additional advantages. Ohland et al. found that integrating entrepreneurship boosts retention and produces students that are more confident in their decision to pursue an engineering degree.³ Reasons provided for improved retention include the increased engagement and self-motivation students feel when working on projects they are passionate about.^{4,5}

Post-graduation, engineering graduates with entrepreneurship experience report improved job prospects.⁶ Graduates perceive the skills fostered by entrepreneurship—communication, multidisciplinary teamwork, an ability to see the big picture and understand business and market implications for a project—as highly relevant to their careers,⁶ and employers underscore the importance of these skills as well as the ability to understand contexts and constraints, and innovate.⁷⁻⁹ College entrepreneurship

experiences can also prepare students to start their own companies.¹⁰

Zappe's research notes that Capstone Design and some entrepreneurship courses share common characteristics: they are "less structured", "project-based", and teachers often play the role of "coach or a guide."¹¹ As such, Capstone Design is a good candidate for integrating entrepreneurial elements. Indeed, there are documented examples of entrepreneurial practices in Capstone Design.^{12,13} However, it remains unclear how and to what degree faculty are integrating various entrepreneurial elements. Thus, the two primary research questions for this study are: (RQ1) Which entrepreneurial elements do capstone faculty practice? (RQ2) How and why do they practice them?

Methods and Analysis

An explanatory sequential mixed methods design, paired with multiphase combination timing, was used for this study.¹⁴ This process involves the collection and analysis of quantitative data, concurrent with, and then followed by, the collection and/or analysis of qualitative data. Qualitative and quantitative analyses are weighted equally; therefore findings are combined in the results and discussion sections of the paper.

Quantitative

The survey questions were designed to capture elements of entrepreneurially focused Capstone courses identified by Shartrand and Weilerstein¹⁵ and drew from the “importance” versus “practice” framework described in ASEE’s Innovation with Impact report.¹⁶ Entrepreneurial practices are the extent to which faculty integrate entrepreneurial elements in their Capstone courses. Entrepreneurial importance is the degree to which faculty thought it was important to integrate entrepreneurial elements. The survey sample included attendees of the bi-annual Capstone Design Conference, VentureWell grantees, Epicenter Pathways to Innovation team members and Pathways referrals. Email invitations were sent to 225 faculty with a brief description of the study. After four reminders, an overall response rate of 55% was achieved. Close-ended survey responses were cleaned prior to analysis and items that aligned most closely to Capstone practice elements were used to categorize responses along importance and/or practice dimensions. Entrepreneurial practice and importance items were averaged separately and a median split used to categorize responses (Table 1). Remaining survey items were further subdivided by capstone element and averaged to provide element averages. Descriptive and inferential statistics were used to reveal differences between importance vs. practice quadrants.

Qualitative

Stratified purposeful sampling¹⁷ was used to identify post-survey interviewees. Samples were identified by selecting cases at the extremes of the practice and importance dimensions. Values for each dimension were recoded and rescaled (0 to 5) such that higher numbers suggested 1) the presence of entrepreneurial practices or 2) the importance of integrating entrepreneurship into Capstone Design. Average (unweighted) values determined the entrepreneurial importance and practice score of each survey respondent. Respondents with averages above 3.5 were included in the high practice and/or importance sample, and respondents with values below 2.5 were included in the low practice and/or importance sample. Subsequently, 18 survey respondents were asked to participate in a follow-up interview. After 1 week of reminders just 10 respondents agreed to participate: 6 in the Low practice / Low importance category (LO), 3 in the Low Practice / High Importance (LH) category and 1 in the High Importance / High Practice (HI) category. According to our interview sampling criteria, no respondents qualified for High practice / Low importance (HL) interviews. Protocols were aligned with the Capstone practice elements and interviews

lasted approximately 45 minutes. Detailed notes and recordings were used to analyze participant feedback. Data were then coded using thick descriptions along each element.¹⁷

Results

In our study, 33% of cases were classified as HI Capstones, followed by 31% in the LO quadrant.

Table 1. Practice and Importance

	Low Importance	High Importance	Total
Low Practice	LO: 31% (n=35)	LH: 20% (n=22)	57
High Practice	HL: 16% (n=18)	HI: 33% (n=37)	55
Total	53	59	112

Note. Includes data from one respondent that was not actively Teaching capstone design, but with significant prior Capstone teaching experience.

Minimal differences were found between HI, LH and LO capstones for 1) sources of project funding, 2) project duration, or 3) how often IP is included in the Capstone curriculum. However, significant differences were found along other element practices. Some of the results are listed below.

Skills emphasized

HI courses emphasize skills pertaining to creativity and problem solving. LH capstones on the other hand, promote student versatility: “...I think even if they are not going to start a company, having an entrepreneurial spirit or being an intrapreneur is valuable and would help them move forward in their careers.” LO faculty are primarily concerned with preparing students for employment:

“My experience having students work for big companies that may come back and support us, is the best strategy so far.”

Idea/Problem

In HI and LH institutions capstone project ideas are student or industry initiated. Faculty in LO institutions rarely use student-initiated projects, most come from industry or the course instructor. This finding was validated by quantitative results. Chi-square analyses revealed statistically significant differences between HI and LH or LO institutions. Students are more likely to initiate capstone design project ideas more frequently at HI than LH or LO institutions (χ^2 (2, N = 105) = 7.029, $p = .030$). Students also tend to define the problem scope of capstone design projects more frequently at HI than at LH or LO institutions (χ^2 (2, N = 105) = 7.029, $p = .030$).

Criteria for Success

In HI institutions, project teams are evaluated according to the process (problem identification, potential solutions and possibly monetization) used to come up with their solution.

"[It matters]...how well they have done in the context of their problem [and that] they have done the process and demonstrated that they have gone through the thinking."

Prototype functionality is important, and projects are validated and/or tested for user/commercial viability through participation in competitions. LH institutions similarly participate in competitions, emphasize process over product, but also emphasize soft skills such as time management and oral/written communication skills. In LO institutions, success depends on meeting user needs and successful demonstration of the final product.

Project Funding

No statistically significant differences were found between the HI, LH or LO institutions in terms of how often industry sponsors provide unrestricted gifts to support the entire course, as opposed to a specific student project, or in terms of how often students are required to sign an exclusive license agreement with the sponsor.

Duration

Year-long capstones are the norm at HI institutions as compared to semester-long courses at LH and LO institutions. Projects at HI schools sometimes extend beyond the course, but rarely do so at LH and LO institutions.

Intellectual Property

No significant differences were observed between HI, LH and LO institutions on how often IP protection is included in capstone curriculum. However, significant differences were observed between how important it is to increase the degree to which the understanding of IP is supported in capstone courses, $F(3,107) = 4.862$, $p < .003$. A post hoc Tukey HSD test revealed that HI institutions tend to value the importance of increasing the understanding of IP in courses more than LO institutions. However, HI faculty expressed concern that when students bring in pre-existing projects and are assigned teammates, it becomes unclear who owns the IP. LH/LO faculty also stated that they lack expertise in IP or their institution lacks student IP policies and procedures.

Commercial and/or Societal Project Impacts

Faculty noted that students sometimes end up with patents at HI institutions, but that this is not common. LH and LO respondents noted that projects rarely make

an impact, because the duration of the class is often too short, and students rarely want to continue with their ideas beyond the course.

In addition to the analyses above, we also examined the data for differences by Carnegie Classification and found no significant difference. Due to the small number of *non-mechanical* engineering respondents, no statistical tests were employed to identify differences by engineering discipline.

Discussion

Shartrand and Weilerstein¹⁵ indicate faculty might incorporate a myriad of potential entrepreneurial elements into Capstone Design. Results illustrate that practices adopted vary depending upon where faculty reside in the importance versus practice matrix:

Low practice / Low importance (LO) respondents adopt a more traditional approach, emphasizing industry or faculty-initiated projects. Projects are evaluated based on the ability of a functioning prototype to meet sponsor needs. Job preparation is the ultimate goal.

Low practice / High Importance (LH) respondents depart from this approach by 1) integrating student initiated projects; 2) encouraging participation in competitions where students likely communicate how their project meets a customer need; 3) emphasizing additional soft skills like written communication and time management; and 4) highlighting the importance of the process used to come up with their solution as opposed to the prototype itself. The perceived value of this approach is its ability to equip students with the skills needed to innovate within an existing organization.

High Practice / High Importance (HI) respondents: emphasize student-initiated projects, and amplify the sense of student ownership by having students develop their own problem scope. Students are evaluated based on their process, as well as the degree to which their prototype meets a customer need and is commercially viable. Increased understanding of student IP is fostered, and in a limited number of cases, patents are awarded.

Through the process of placing faculty respondents into the importance versus practice matrix, we are also better able to understand why faculty do or do not integrate different entrepreneurial elements. While the authors' earlier analysis of this data indicated that the availability of funding for student-driven projects impacts the integration of such entrepreneurial projects¹⁸, this study illustrates no significant difference by matrix quadrant. Rather we see that institutional support and better preparation of faculty, specifically around the topic of IP, impact a faculty member's ability to integrate entrepreneurship.

However the integration of different entrepreneurial elements appears to be predominantly driven by respondents' own definitions of entrepreneurship. In the context of this study, participants were not provided with a definition of entrepreneurship; they were free to adopt their own definition. This study illustrates that the definition adopted impacts whether faculty deem entrepreneurship important enough to integrate into Capstone, and which specific Capstone elements are integrated. This aligns with the authors' earlier analysis, which found that some faculty do not consider the integration of entrepreneurship important because of the perceived focus on venture creation, a topic not considered relevant for the vast majority of students. For other faculty, the development of an entrepreneurial mindset is considered critical to students post-graduation; consequently those skills are emphasized. Thus if entrepreneurial practices are to be further adopted in Capstone, and faculty are to move into the HI quadrant, it is critical that faculty understand the breadth of what the discipline entails, the potential outcomes and applicability to different students.¹⁹

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