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Entrepreneurship in Capstone Design: Has the Pendulum Swung Too Far?

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Entrepreneurship in Capstone Design: Has the Pendulum Swung Too Far?

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Abstract: The author supports entrepreneurial education for all interested students, but not at the expense of design education. He thinks we should develop business literacy among all of our students to prepare them for work in start-ups and established medical device companies, and provide opportunities for interested students to add entrepreneurial literacy to better prepare them to create new companies, either upon graduation or later in their careers. Capstone design courses should focus on helping students develop solid design skills and providing opportunities to apply the analytical tools learned in previous courses. Students should be encouraged, not required, to consider commercializing the results of their capstone projects, and interested students should be provided with support for doing so.

During the 2013 Biomedical Engineering Society meeting in Seattle, Washington, I spoke with a department chair about his program's capstone design course. He mentioned that he told his capstone design faculty that he wanted at least two of this year's capstone design projects to result in start-up companies. I nodded but wanted to ask: Why is this important for a design course?

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Approximately ten years ago, I began hearing predictions that start-up companies and small businesses would generate more new jobs than established companies. Engineering faculty recognized that engineering graduates would be well positioned to participate in and drive this new growth by creating new companies to commercialize new products designed and developed by graduate engineers. Many engineering programs encouraged their undergraduate students to become more entrepreneurial and to form companies based on devices and technologies developed as part of capstone design courses or extracurricular project activities. Design programs around the country began to measure the success of their programs by the number of start-up companies created, provisional patent applications filed, and other criteria. Engineering students were encouraged to collaborate with business students to develop business plans, and many business plan competitions were created.

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During the last 15 years, I attended all Biomedical Engineering Innovation, Design, and Entrepreneurship Alliance (BMEidea) meetings, 15 Biomedical Engineering Society meetings, four Capstone Design Conferences, and several American Society for Engineering Education meetings. I typically attend sessions dealing with design education, innovation, and entrepreneurship and have observed a shift among many biomedical and other engineering programs toward directing students down the start-up path instead of the path toward employment with established companies. I continue to hear students being encouraged to work for themselves and start new companies after graduation, implying that they are capable of running successful start-up companies with no business, management, or industry experience or expertise. I have heard many presentations that present tasks such as identifying problems, opportunities, and customer needs as requirements for engineers in start-up companies, with no recognition that these are also required of engineers in established companies. Recently, I heard anecdotal evidence of at least one biomedical engineering program adding courses on entrepreneurship at the expense of technical courses, resulting in a reduction of rigor of the engineering curricula.

Concerns

Prior to moving into academia 15 years ago, I spent 14 years developing and commercializing new medical and dental products for four medical device companies, including one start-up. Nine of these years were spent as an engineering manager. I have

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been an instructor for the multidisciplinary capstone design course at Marquette University for the last 14 years. My industry and academic experience provides me with a unique perspective on medical device design and design education. From that perspective, I am concerned with the current emphasis on entrepreneurship within some biomedical engineering programs and some senior capstone design courses.

First, in my opinion, the goal of the capstone design course is to allow students to apply what they have learned toward the solution of a real-world problem, through a team-based project experience. Students need to focus on developing their design skills and learning about the design process. This includes technical skills, such as analytical modeling and prototype testing, as well as a basic understanding of business concepts, such as cost, finance, and marketing, and a focus on the customer. As a licensed professional engineer, design instructor, and health care consumer, I feel that capstone design students need to first learn how to design products that perform as required and do not fail and injure patients. It is far more important that biomedical engineering graduates be capable of constructing free body diagrams, performing stress analyses, or analyzing circuits as part of the design process than it is for them to be able to start their own companies upon graduation. Teaching and nurturing entrepreneurship has value, and including a limited number of entrepreneurship topics to capstone design lectures is appropriate. However, the capstone design course should focus on developing design skills and should not be diluted by requirements or expectations for students to create companies based on their capstone design projects. Engineering curricula should provide opportunities for interested students to learn how to start companies, either through elective courses, workshops, or student clubs and organizations.

Second, there is no special design process for products developed by start-up companies. The same process is required of both start-ups and established companies and should be presented as such. Both must comply with the same International Organization for Standardization standard and other standards, meet the same regulatory and legal requirements, and deal with the same marketing issues and design constraints for a particular product or market segment. They both have to perform needs finding activities, protect intellectual property, and verify and validate their designs. Ethnographic observation methods and needs finding activities are not new, and they are not specific to start-up companies. They allow engineers to identify unmet needs and better understand the problems they are trying to solve, thus qualifying them as good design practices with which every design engineer (and industrial designer) should be familiar. Successful established medical device companies have been implementing these practices for years.

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Third, not all of our students want to or are cut out to be entrepreneurs, at least not right away. The definition of entrepreneur is "one who organizes, manages, and assumes the risks of a business or enterprise".[1] Many of our engineering graduates are not willing to take on the risks of entrepreneurship nor do they have a problem with working for someone else. They have had and continue to have successful careers with established medical device companies with no desire to start their own companies. Entrepreneurial engineers working for established companies (also known as *intrapreneurs*) have plenty of opportunities to develop and apply their entrepreneurial skills as they identify problems and unmet needs and investigate new markets and opportunities for new product development within their organizations.

Fourth, we are misleading our students if we don't tell them about the very high failure rates and risks associated with start-up companies. We can all think of successful start-ups, but these are the exceptions. Depending upon how failure is defined, 75–95% of venture-backed start-up firms in the United States fail.[2] Most new graduates have very little or no business experience, and almost none have any managerial experience, especially with running successful start-up ventures. The problems associated with running any company, start-up or established, have more to do with human, not technical issues.[3] This is why venture capital firms often bring in experienced managers to run the new companies in which they invest. Would you invest in a company run by new graduates with no business or managerial experience? Experienced managers are able to create and manage high-performing technical teams, manage and motivate technical professionals such as engineers, scientists, and technicians (knowledge workers), create innovative climates, and manage the marketing/R&D interface. Having a good idea for a new product is not enough for successful commercialization; running a start-up company and getting a successful new product out the door requires skills, expertise, and experience not typically possessed by new engineering graduates, no matter what courses they have taken or internships they have completed. To suggest the opposite underestimates what it takes to start, grow, and maintain a successful medical device start-up company.

Fifth, the number of student start-up companies and provisional patent applications filed is not a good indicator of entrepreneurial success or good design and should not be used to measure the success of a capstone design course or engineering program. Anyone can start a company by filing the correct paperwork with his or her state government and paying the appropriate fee. Simply having a company is not a measure of entrepreneurial success. More impressive is how many products the start-up has actually successfully commercialized or licensed. I am most impressed by a new product that meets customer needs and is a commercial success—a better indication of good design and entrepreneurial

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success. Similarly, the number of provisional patent applications is not a good measure of success. There is no such thing as a provisional patent; there are only provisional patent applications. These applications are not reviewed or read; they reserve the applicants' place in line should they decide to proceed with a full patent application one year later. They do not imply that the applicants' ideas are novel, useful, or nonobvious, and they offer no guarantee of future issuance of a full patent.

Proposed Solutions

I agree that there are many opportunities for our students to use their design skills to create value, start new companies, and provide job growth for the economy, and I support entrepreneurship education. We should prepare interested students for these opportunities by providing resources to nurture and support any student who is interested in entrepreneurship and creating start-ups. We should let all students know that this is a potential career path for them (and fully inform them of the associated risks), but we should also discuss the benefits of working for an established company prior to starting a new company. These benefits include the opportunity to gain work experience, learn how companies are run, develop knowledge of a particular industry and market, and build a network of trusted mentors. In some start-ups, there may be only one engineer, with no mentor or anyone for a new engineer to learn from. In an established company, often there are many mentors for new engineers to learn from.

I have written previously about the differences between business and entrepreneurial literacy and the need to develop business literacy among all engineering students for successful careers in the medical device industry.[4] Business literacy includes an understanding of how a business functions (marketing/sales, accounting/finance, and operations) and familiarity with the legal, regulatory, and economic constraints affecting medical device design and development. As members and leaders of project teams, engineers need to understand the roles that team members from other functional areas within the organization play on the team and appreciate their contributions to the organization. Engineers do not need to be experts in these other areas, but they must be able to "speak the language" of their fellow team members. This is where knowledge of other business functions, such as accounting, finance, marketing, operations, supply chain, and regulatory affairs, can be beneficial.

The skills and knowledge needed to be a successful entrepreneur are in addition to the skills and knowledge needed to be a successful engineer in industry. For those students who are interested in someday starting a medical device company, their entrepreneurial

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interests should be nurtured by providing them with the opportunity to develop basic entrepreneurial literacy. This could include courses beyond those providing basic business literacy (described earlier) that address sources of venture funding, how to write a business plan, how to organize and structure a start-up venture, technology transfer (including intellectual property protection and licensing strategies), and management of technical personnel. Additional ideas and suggestions for finding ways to incorporate entrepreneurial topics in the engineering curriculum have been presented elsewhere.[4] Having students write business plans before teaching them something (formally or informally, through an entire course, seminar, or single lecture) about marketing and finance is putting the cart before the horse.

In summary, I support entrepreneurial education for all interested students, but not at the expense of design education. We should develop business literacy among all of our students to prepare them for work in start-ups and established medical device companies, and provide opportunities for interested students to add entrepreneurial literacy to better prepare them to create new companies, either upon graduation or later in their careers. Capstone design courses should focus on helping students develop solid design skills and providing opportunities to apply the analytical tools learned in previous courses. Students should be encouraged, not required, to consider commercializing the results of their capstone projects, and interested students should be provided with support for doing so.

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