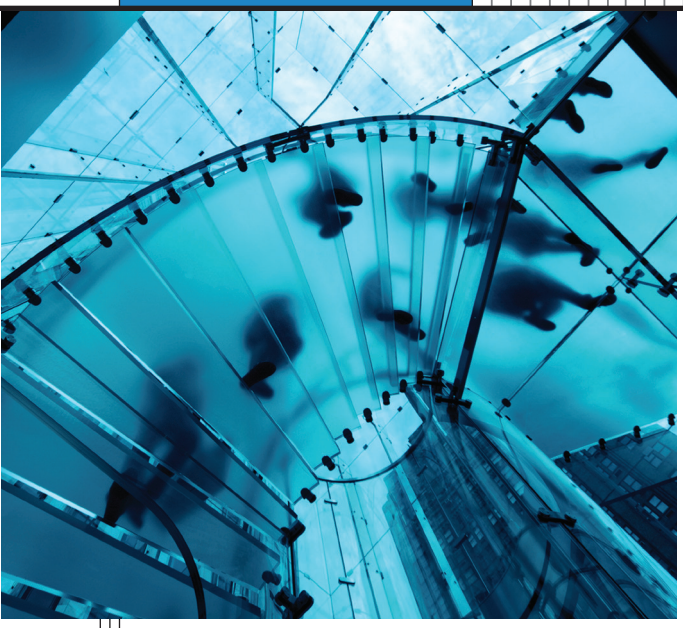

Cultivating Entrepreneurial Thinking through IEEE-CS Student Chapters

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A proposed IEEE Computer Society student chapter model is designed to immerse students in activities that expose them to entrepreneurial thinking, with guidance from faculty and community members who are entrepreneurs.

Thinking and acting as an entrepreneur includes the ability to be creative, propose innovative solutions, gather data to make informed decisions, evaluate options from different perspectives, work in collaborative teams, and take risks.[1-3] While developing a technology workforce whose members are entrepreneurial thinkers is desirable, higher education curricula often fail to foster innovation and prepare students to become entrepreneurs or intrapreneurs—persons who possess the skills of entrepreneurs but work within an organization.

In today's tough economic climate, it is critical that computing graduates, whether they are starting a business or working for a corporation, understand customer needs from a global perspective and know how to rapidly adapt to changing priorities. Some new computing curricula prepare graduates for the rigors and vicissitudes of new business ownership and present opportunities for discovery, innovation, and creativity. Unfortunately, this preparation is not typically part of most undergraduate programs, especially at engineering institutions.

Cultivating entrepreneurial thinking requires going beyond teaching business fundamentals and reviewing case studies; it requires learning through practice.[2] To support active student engagement in entrepreneurial activities outside the classroom, the IEEE Computer Society, through its Educational Activity Board's Committee of Diversity and External Activities (CDEA), has proposed a Leadership, Entrepreneurship, and Professional Development (LEAD) student chapter model. The goal of IEEE-CS LEAD student chapters is to introduce students to activities that promote entrepreneurial thinking and facilitate critical hands-on experiences that can induce the excitement of discovery and develop the professional skills needed for successful computing careers. Another distinguishing characteristic is their emphasis on solving societal problems.

ENTREPRENEURSHIP IN UNIVERSITY CURRICULA

Nearly four years ago, the Ewing Marion Kauffman Foundation commissioned a panel of distinguished scholars to investigate entrepreneurship in higher education curricula.[4] Among the panelists were Rodney Brooks, director of the MIT Computer Science and Artificial Intelligence Laboratory; William Green, senior vice provost and dean of undergraduate education at the University of

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Miami; and the late Richard Newton, dean of the College of Engineering at the University of California, Berkeley. Noting that "entrepreneurship is critical to understanding and succeeding in the contemporary global economy," the group emphasized the value to students of developing and practicing the skills needed to become an entrepreneur, rather than merely studying entrepreneurship.

In addition to understanding the benefits and risks of being an entrepreneur, it is important to consider the perspectives of other stakeholders, including those who support entrepreneurial development and the general public. Topics related to globalization and technological innovations are especially critical. The commissioned report concluded that entrepreneurship was essential to students' undergraduate education.

Arguments for introducing entrepreneurship in engineering education specifically refer to enhancing next-generation engineers' ability to succeed in a knowledge-based economy.[5] Although engineers often have experience working with teams, most lack entrepreneurial skills, which can be acquired through education and training.[2]

At the 2008 Kauffman-Planck Summit on Entrepreneurship Research and Policy, William Wulf, past president of the National Academy of Engineering and a leading computer scientist, described the central role that universities and research laboratories have played in many revolutionary technological innovations.[6] Although innovation is not discipline specific, it is often rooted in multidisciplinary and interdisciplinary fundamentals. Stanford University's Entrepreneurial Design for Extreme Affordability graduate course is an example of cocurricula various universities are developing to design innovative products;[7] the uniqueness of this course is its focus on the challenges people face in developing countries.

The number of US colleges and universities offering at least one course in entrepreneurship more than tripled from approximately 425 in 1994 to more than 1,500 in 2004, and currently more than 2,000 higher education institutions, about two out of three, do so.[8,9] In addition, the number of campus entrepreneurship centers that support technology transfer and, in some cases, student startups, has increased.[8] In fall 2009, a three-day conference sponsored by the Global Consortium of Entrepreneurship Centers drew representatives from 240 entrepreneurship programs in 42 states and 15 countries.[4] The notable growth in the number of students entering business competitions also reflects the rising interest in entrepreneurship. While becoming an entrepreneur was once considered risky, in today's uncertain job market, students seem to be more willing to take that risk.

CHALLENGES

Today, being able to design software is only one necessary skill for computing professionals; business-related skills are also needed.[10,11] The ability to offer innovative, integrated, and strategic services as a computing professional requires knowledge that is different from any of the techniques or conceptual frameworks historically taught in computing curricula.[12-14] Because business decisions are not based purely on technical solutions, it is essential to provide a path for understanding the financial implications of possible solutions to a given problem.

The nature of the computing discipline itself, namely the rapid pace of innovation, poses unique challenges that other programs do not have with respect to expanding the curriculum to include entrepreneurship. For example, to keep aligned with the state of the art, computing faculty must constantly revise content and update the curriculum. This typically results in undergraduate computing programs that contain a wide variety of courses to provide students with a relevant and topical education. With all of the curricular requirements and electives for students in science, technology, engineering, and mathematics (STEM) majors, especially in computing, it is difficult for traditional, four-year baccalaureate programs to fit in entrepreneurship.

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Another challenge is the dearth of computing faculty with the background and qualifications to teach entrepreneurship.[9] Developing and introducing sound entrepreneurship curricula into computing programs likewise requires teachers who understand how businesses work. The strong experiential, learn-by-doing component of entrepreneurship education provides an opportunity for computing and entrepreneurship faculty to work together.[15]

Entrepreneurship courses in engineering and computing programs are mostly theoretical in nature and often lack the practical insights that can only be achieved through extracurricular opportunities to develop and implement ideas in actual situations.[13,16] Institutions must therefore commit to offering a campus environment that supports entrepreneurial activities. Such activities let students experience the full innovation process, empower them with the excitement of discovery, and educate them in entrepreneurship fundamentals.[6] Several studies have documented the concrete benefits of university-based entrepreneurship programs.[16-18] In addition, successful entrepreneurial alumni are often willing to help prepare and present educational materials for dissemination.[16]

IEEE-CS LEAD STUDENT CHAPTER MODEL

The proposed IEEE-CS LEAD student chapter model supports the development of students' entrepreneurial thinking while addressing some of the aforementioned challenges. It aims to create a network of students, faculty, and experts in entrepreneurship who work on solutions to real-life technological problems. The core purpose of a LEAD chapter is twofold: to foster an environment in which students, with expert guidance, learn about relevant social issues and design innovative computer-based solutions; and to provide students with opportunities to develop leadership, professional, and entrepreneurial skills.

A LEAD chapter will immerse students in entrepreneurship experiences through virtual and face-to-face interactions with highly recognized and qualified experts.

IEEE-CS student chapters will bring together groups of students with an interest in computing and help prepare them to be professionals. The difference between a traditional and a LEAD student chapter is the latter's focus on leadership, entrepreneurship, and professional development in line with the following guiding principles:

- Each chapter will have a faculty advisor and an external advisor with expertise in entrepreneurship.
- Chapter activities will center on designing solutions to problems that impact the university, community, and society in general.
- Students will be motivated to develop their entrepreneurial thinking and "business sense."
- Professional and cooperative team skills will be deliberately taught and practiced.
- Students will have access to resources to deepen their technical knowledge and understanding of entrepreneurship.
- Chapters will strive to protect intellectual property (IP) rights of all members.

A LEAD chapter will immerse students in entrepreneurship experiences through virtual and face-to-face interactions with highly recognized and qualified experts. Students will engage in problem- and experience-based learning that includes observing and collaborating with peers and professionals. These cocurriculum experiences will supplement students' coursework and, in many cases, will be their only exposure to entrepreneurship.

To address computing faculty's lack of entrepreneurial experience, the IEEE-CS Educational Activity Board's Committee of Diversity and External Activities will work to create shared resources, such as self-study learning modules and webinars, for the LEAD chapters. The CDEA will engage the IEEE-CS's interdisciplinary network, which provides access to

- 287,000 IEEE members and 74,000 IEEE-CS members with diverse backgrounds and perspectives;
- 150 student chapters with 7,600 students;
- recognition through technical, educational, and service awards; and
- professional speakers through the IEEE-CS Distinguished Visitors Program.

By becoming part of the one of the world's largest societies for computing professionals, students will be able to network with members of other chapters around the world and take full advantage of these resources. LEAD chapters will be especially helpful to students in developing countries with limited economic infrastructure.

LEAD CHAPTER ORGANIZATIONAL STRUCTURE

Figure 1 shows the LEAD student chapter structure. The key to success is active participation by and a sense of ownership among all members—not only students, but faculty and other stakeholders as well. This is in sharp contrast to the traditional IEEE-CS student chapter, in which only the student officers are responsible for the chapter's activities.

CDEA

The CDEA will serve as the foundation of all LEAD chapters and will provide a roadmap for their efforts. It will maintain a portal for members who wish to deepen their knowledge with webinars on entrepreneurship and development materials from experts including succinct descriptions of essential elements for various topics and activities that can facilitate learning and applying these topics to a project. The knowledge base will include other resources such as a start-up kit with guidance on starting a LEAD chapter, tutorials, a list of chapters interested in collaboration, a directory of regional experts in entrepreneurship, and links to local, state, national, and international resources.

In addition, the CDEA will recognize LEAD chapters that have excelled and advisors who have made extraordinary contributions to a LEAD chapter, in accordance with appropriate IEEE-CS criteria. Acknowledging exceptional student chapters and individual contributors with awards is important in keeping members engaged.

Student executive committee

Each LEAD chapter will have a student executive committee—consisting of a chair, a vice chair, a secretary, and at most three student-at-large members—to oversee opera-

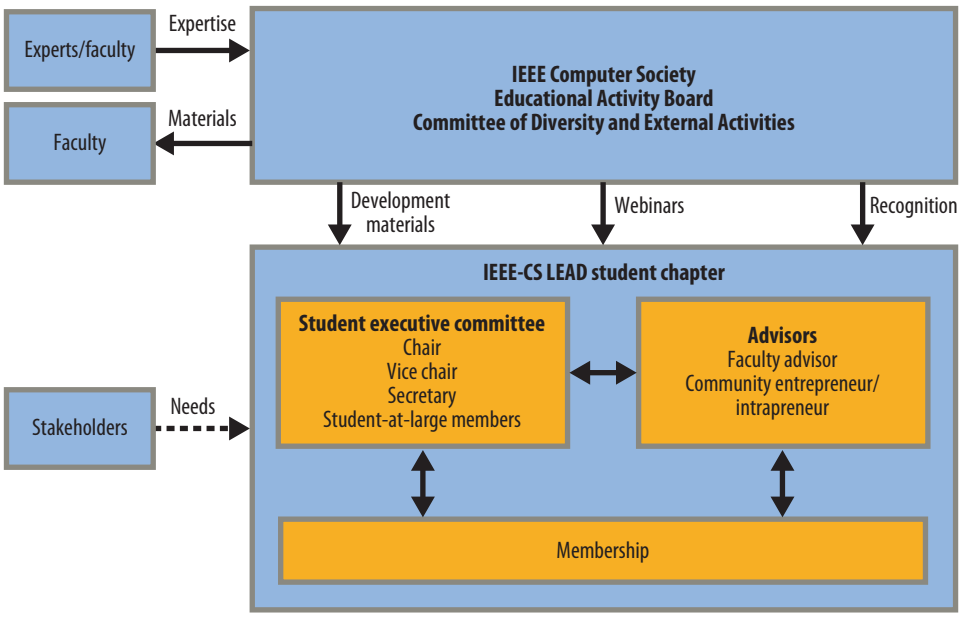

Figure 1. IEEE-CS LEAD student chapter organization. In contrast to the traditional IEEE-CS student chapter, all members including faculty and other stakeholders—not just student officers—will be responsible for chapter activities.

tions. The officers' primary responsibility will be to lay out the chapter's direction and activities. In coordination with the advisors, they will work to create a fertile environment for student members to develop leadership and entrepreneurship skills, using established best practices to run meetings and cooperative teams to create a sense of community among members.

Advisors

The LEAD chapter will have at least two volunteer advisors: a faculty advisor and a professional or business advisor with experience in entrepreneurship. They will invest their time—typically a semester or an academic year—to serve student members in a mentoring capacity. The motivation for a nonfaculty advisor is to give back to the community by sharing expertise with members of the future workforce and helping them develop an entrepreneurial approach to problem solving, with the possibility of some students seeking employment with the advisor's organization after graduation. The CDEA recommends that advisors sign a nondisclosure agreement with the chapter to guarantee the protection of IP rights of all parties involved.

Student members

To encourage their active participation, student members will have responsibility for multiple activities based on chapter and project size, allowing them to obtain depth of knowledge in a particular area or benefit from involvement in interrelated areas. For example, a large project may give students the opportunity to focus on marketing, while on a small project they may learn all aspects of product development.

LEAD CHAPTER OPERATIONS

Each LEAD chapter will be run as a business by students and for the benefit of students. It can operate in various ways—for example, it could focus on the value proposition, conception, and design of innovative solutions, or it could host a regional or national business plan competition or an international design competition such as the Imagine Cup. The chapter's nimble structure enables it to support a wide spectrum of students: from those taking courses on entrepreneurship to those with little exposure to entrepreneurial concepts.

If a chapter's membership chooses to work on one or more projects, they will develop ideas up to the design or prototype phase. The goal is not to create a product but to learn the business aspects of innovation: identifying a need, generating ideas, creating a business plan, locating and securing resources, protecting IP, and funding the process.

Because a sound business plan is a key building block of any systematic effort to launch a business, various competitions at the regional, national, and international level either focus on business plan development or include a business plan as a requirement for participation in the competition. LEAD chapter student leadership can work with their business schools or colleges to identify possible business plan competitions.

Societal impact theme

A common theme of LEAD chapter operations is exposure to problems that impact the university, community, or society in general. Such problems can be identified by working with business community leaders, not-for-profit organizations, and nongovernmental organizations. Another resource is the CDEA knowledge base, which will maintain pointers to grand challenges and initiatives targeting problems in developing countries and impoverished areas, such as the United Nations Millennium Development Goals (www.un.org/millenniumgoals).

Cooperative teams

To achieve their goals, LEAD chapters will function as cooperative teams with five basic characteristics.[19]

Positive interdependence. Each chapter member has a personal stake in the chapter's success and believes that the others value his or her contributions. Everyone recognizes that all members bring special skills to the group.

A common theme of LEAD chapter operations is exposure to problems that impact the university, community, or society in general.

Promotive interaction. All members feel comfortable exchanging ideas and sharing resources. Members help one another succeed and thereby help the chapter reach its goals. Members acknowledge and recognize each person's contribution.

Team skills training. Student members will receive explicit instruction in and practice team skills while carrying out chapter activities. Basic skills relate to team functioning, information formulation, and conflict resolution. Students will learn to generate ideas, construct critiques, and integrate perspectives.

Individual accountability. Each chapter member is responsible for tangibly contributing his or her fair share to the group. Members are collectively responsible for the chapter's smooth functioning and for achieving its goals.

Process improvement. Chapter members regularly reflect on chapter operations and success in attaining goals. After reviewing results, the executive leadership with input from membership determines how to improve the process.

Entrepreneurial skills development

Idea generation is an important aspect of entrepeneurship that can facilitate innovative solutions. In addition to brainstorming, a LEAD chapter can easily incorporate intuitive team-based techniques such as the 6-3-5 method and collaborative sketching (C-Sketch)[20] into their activities.

The 6-3-5 method involves six participants. In the first round of idea generation, each person writes down three ideas using keywords or phrases. Participants then pass their idea to the person to the right. After reviewing the idea for a set amount of time and without discussion, each person passes the idea to the right. After the first rotation, the group generates a new set of three ideas, which may be original ideas or modifications or enhancements of ideas from the previous round. The rotation continues for five rounds, during which each member of the group views each set of ideas. In C-Sketch, which uses fewer participants, each person generates one concept as a sketch and the others make modifications directly to the sketch.

It is also critical for LEAD student members to learn about and practice developing a value proposition, selling an idea, and creating a business plan; they must also understand IP and associated legal processes. A typical LEAD chapter will schedule an orientation at the beginning of the academic year that includes discussion of IP and nondisclosure agreements. The chapter will then choose a problem to tackle during the upcoming semester and participate in idea generation. Once it defines a potential solution, the chapter will focus on articulating the value proposition, selling the idea, and creating a business plan for the remainder of the semester.

SUPPORTING ORGANIZATIONS AND INITIATIVES

The formula for entrepreneurial success requires three main ingredients: a burning desire to launch a successful business, focused tenacity, and finely tuned entrepreneurial skills. Multiple organizations and initiatives promote the acquisition and honing of entrepreneurial skills and are excellent resources for coordinating LEAD chapter activities.

The National Collegiate Inventors and Innovators Alliance (http://nciia.org) offers grants, competitions, venture development resources, and great opportunities for networking with a large community interested in innovation and entrepreneurship. The NCIIA grants funds to college faculty and students working on innovations with a social impact and fosters the creation and enhancement of educational programs promoting invention and entrepreneurship.

The Consortium for Entrepreneurship Education (www.entre-ed.org) organizes the annual National Entrepreneurship Week, which aims to train future business leaders by bringing together faculty and students at all levels with members of the business community at large including entrepreneurs, chambers of commerce, and policymakers.

Microsoft and NCIIA sponsor the annual Imagine Cup Software Design Invitational, which rewards innovative student projects with a substantial software component fo-

Table 1. Benefits of LEAD student chapter membership.

LEAD promotes …	Students …
involvement in an organization that uses interdisciplinary cooperative teams to create innovations that positively impact society.	learn the value of social service by working with others to solve problems.
involvement in cross-cultural activities through interaction with chapters located in different countries.	are exposed to cultural differences and a global perspective.
participation in projects that promote entrepreneurial thinking, project planning, and decision making.	actively engage in applying learned concepts and mastering skills through personal experience.
connection with professional entrepreneurs using business models.	develop business acumen and professional skills, learn new concepts, and appreciate the value of networking.
the institutionalization of best practices among students over time.	practice and understand the importance of meeting, planning, communicating, and other skills.

cused on satisfying world needs. The competition consists of a series of rounds in which participants roughly follow the steps involved in developing and commercializing a new product.[21]

IBM has created INNOV8 (www-01.ibm.com/software/solutions/soa/innov8/index.html), a business process management simulation game that demonstrates the impact of effective process management on an entire business ecosystem. Players learn how an organization can improve business processes by using instrumentation and forming intelligent internal and external connections.

The Kauffman Foundation's FastTrac programs (www.fasttrac.org) provide aspiring entrepreneurs with networking and mentoring opportunities that can lead to the development of business skills as well as shared insights and leadership experiences. The FastTrac NewVenture College Edition program includes business planning templates, action steps, activities, videos, and other excellent informational resources for educators and students.

Global Entrepreneurship Week (GEW; www.unleashingideas.org) is a well-established effort sponsored by the Kauffman Foundation and Enterprise UK's Make Your Mark in the Markets campaign that aims to promote innovation, imagination, and creativity among students. GEW includes activities that are planned across the world during a designated week in the fall and focuses on encouraging youth to brainstorm better ways to do things.

LEAD STUDENT CHAPTER BENEFITS

Table 1 summarizes the main benefits of membership in a LEAD student chapter. In particular, students learn the value of social service and, in the process, acquire both business acumen and entrepreneurial thinking skills.

Computing programs that are unable to integrate entrepreneurship into the curriculum can introduce it through a LEAD student chapter, which supports active student involvement in practical activities that develop their entrepreneurial thinking. Practical experience leads to skill mastery, and skills such as interdisciplinary collaboration are hard to grasp without application and personal involvement. LEAD students will enter the workforce with a better understanding of how businesses function and grow, will be better prepared to become managers and business owners, and will learn the value of IP and how to protect it through legal means, including patents.

Faculty mentors can work with academic units to offer credit to students who invest time in the LEAD chapter. The chapter could serve as a recruiting tool by offering participation in program-specific and university-wide activities that extend student involvement outside the classroom, an important element in student retention.

Entrepreneurship, in particular social entrepreneurship, requires the ability to identify innovative business opportunities that also benefit society. A thread of entrepreneurship in a computing program, or through cocurricular activities, can provide students with access to local, national, and international networks that assist entrepreneurs and present unique opportunities for continuous professional development.

As one of the world's largest organizations for computing professionals, the IEEE-CS is uniquely positioned to promote and support activities that benefit society as well as its members. Based on the extremely popular student chapter model, the proposed LEAD chapter will motivate next-generation computer scientists to develop entrepreneurship skills that they can use to help them launch their careers as well as make the world a better place.

The University of Texas at El Paso has piloted a LEAD chapter, and Miami Dade College is in the process of initiating pilot chapters. In addition, Rochester Institute of Technology has mature entrepreneurship organizations that can support the implementation of LEAD chapters. The lessons learned from the pilot chapters will help the CDEA to create a LEAD start-up kit. The CDEA is currently working to populate the knowledge base.

To start a LEAD chapter, a faculty advisor who is a member of the IEEE-CS and at least 12 student members must petition the IEEE-CS, with formal approval provided by the regional director, the regional Student Activities Committee chair, and the Computer Society president. IEEE-CS members interested in contributing to the LEAD effort or starting a chapter should contact one of the authors.

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