

Structuring Senior Design for Entrepreneurs

Ken Ports
Florida Institute of Technology

Abstract

The Senior Design course taken near the end of an engineer's undergraduate tenure is increasingly recognized as a "capstone" activity, enabling these future professionals to apply their collegiate education and experience in a team environment to solving real world problems or to creating new capabilities. Ideally, Senior Design teams are also cross-functional, to broaden the projects and better replicate the professional world. In addition, there is a growing interest in linking Senior Design with entrepreneurial activities, even to the point of commercializing promising project results.

The Electrical and Computer Engineering (ECE) Department of Florida Tech has structured its senior design course sequence to replicate many of the activities that would be appropriate for a start-up venture, or a corporate product line introducing a new suite of products. In addition to the traditional preliminary and critical design reviews and a demonstration of the completed project, students learn about the industrial new product pipeline and generate feasibility studies, business plans, prototyping, validation reviews, and launch collateral to support a "market introduction" of their product, all in a "whole product" context. Senior Design culminates with a public "trade show" held as a feature of the University's spring Open House for the families of interested high school students. Most of the teams span multiple engineering departments. This year, there are teams also spanning schools and colleges within the university, and at least one team spanning two universities.

A few years ago, no ECE senior design teams intended to commercialize their projects. Since the course sequence was restructured, a steadily increasing number of teams have become entrepreneurial. This year, seven of the thirteen ECE department senior design teams are intending to go to market with their projects. This paper provides a brief overview of how senior design at Florida Tech has been structured to support both entrepreneurs and "standard" students, a description of the team and course sequence interaction with the Florida Tech business accelerator, Florida Tech*Start*, and other curricular support, and case studies of the entrepreneurial teams as they attempt to leverage their senior design projects into viable products and companies over the 18 month senior design cycle of courses.

Background

The Florida Institute of Technology (aka Florida Tech) is a private university of about 4500 students located in Melbourne, on the high technology "Space Coast" of Florida, about 30 miles south of Cape Canaveral. The principal component of the university is the College of Engineering (CoE), which harbors about half of the total enrollment. The CoE offers both undergraduate and graduate programs. Within the College of Engineering are seven departments: Chemical Engineering, Civil Engineering, Computer Science, Electrical and

Computer Engineering, Engineering Systems, Marine and Environmental Systems, and Mechanical and Aerospace Engineering. All of the departments except Engineering Systems, which currently only offers graduate programs, require their students to participate in Senior Design as part of their program core curricula. Historically, each department managed their own senior design courses, and there was no formal or systematic interaction between the departments in this regard.

The Electrical and Computer Engineering (ECE) Department senior design course sequence comprised two consecutive courses taken during the senior year, in which students formed teams and took on engineering projects designed to exercise their technical, practical and teamwork skills. Most of the project teams would contain a mix of electrical and computer engineering students. A few of the teams would span engineering departments at the university. For instance, there would always be a Mechanical Engineering vehicle team (formula race car, baja car, etc.) which needed electrical and computer engineering skills to develop gauge clusters, computer control systems, wiring harnesses, virtual dashboards, and so forth. There would always be an Aerospace Engineering plane or rocket project which needed electrical and computer engineering skills for data acquisition/analysis, communication, command and control systems.

Beginning in the Fall of 2002, several significant changes, decisions and events occurred in rapid succession and have had a dramatic positive impact on the nature and quality of the senior design program in the ECE Department and throughout the College of Engineering:

- The ECE senior design course context was changed to emulate a start-up enterprise
- Over \$40,000 in NCIIA funding was acquired to support certain types of senior design teams
- The senior design course instructors across the College of Engineering elected to self-organize to better coordinate their courses, forming the Senior Design Coordinating Committee (SDCC)
- The School of Management elected to actively participate and support the senior design experience in the College of Engineering
- The ECE Department senior design course sequence was extended by a semester, to be three semesters in length
- The SDCC sponsored the first Student Design Day, a “trade show” at which all CoE senior design projects were put on public display in the gymnasium
- The first multi-university ECE senior design team was formed
- The first ECE senior design team decided to commercialize its project results
- The College of Engineering and School of Management collaborated to set up Florida TechStart, a business accelerator for the university
- The School of Management established the first general ledger for all CoE senior design teams, greatly improving financial management in this area

Context for the ECE Senior Design Sequence of Courses

Florida Tech was formed entrepreneurially in 1958 to provide much needed continuing education opportunities for the engineers working at NASA and related space companies at Cape Canaveral. The entrepreneurial spirit and culture at Florida Tech has continued up to the present. When a new professor took over the senior design course sequence, after spending a quarter of a

century in industry, the architecture of the courses immediately took on a “new look”. At the first class, the students are told that they have been recruited from college into a new start-up (a fictitious, “Florida Tech Ventures, LLC”), and that they have until the following April to form teams and conceive, define, design, develop, prototype, build, characterize, validate and prepare to launch a suite of new products, to be displayed at an all-important trade show. The students learn about the new product pipeline, technology roadmapping, business planning, the product-to-market cycle, design-for-X, project planning, management, execution and closure, and the whole product concept, including the development of launch collateral and participation in trade show and related events.

As part of the venture ambiance, “Classes” were replaced with “all hands meetings”. “Lectures” were replaced with OJT (On the Job Training). The “instructor” became the start-up’s President, CEO, CTO and CSO. The “graduate teaching assistant” assigned to the course became the COO, CFO, Chief Scientist and Lab Director. A simple management hierarchy was installed, and there were meetings with the project leaders to discuss management as well as project and technical topics.

The goal of putting the course sequence into this context has been to make our graduates as “plug ‘n play” as possible. The value proposition slogan for Florida Tech engineering has evolved to be that “you can learn engineering at a number of places; you do engineering at Florida Tech”. (For example, our ECE students design and build their own computers as freshmen.) We routinely survey recent graduates and also their employers, and over the next few years will determine if this strong industrial, entrepreneurial flavor to senior design does shorten the time for new college grad employees to become productive in their careers.

Senior Design Course Content

It became apparent that in this context, the amount of technical and programmatic material handled in the senior design sequence was so great that it was adding technical and schedule risk to the successful completion of many of the projects. Project teams which needed to secure external funding to support the materials and services needed to be purchased for their projects were even more pressed for time. The current run rate for project expenses across the College of Engineering is about \$100,000 per year. Most of this money comes from grants and external sponsors and donors for the projects, and most of the sponsors and donors must be discovered or cultivated annually by the teams needing the funding.

On this basis, it was decided to add a semester to the ECE senior design sequence of courses. The sequence now begins in the spring semester of the junior year and proceeds through both semesters of the senior year. The junior design course is a one credit course, and the two senior design courses are three credits each. Junior design includes project and team selection and culminates with a preliminary business plan and a display of the emerging project at the Student Design Day trade show.

The first semester senior design course is the semester for design, ending approximately with the Critical Design Review (CDR). The second semester senior design course is the semester for building, validating the product, preparations for a launch, and a display of the finished product at the Student Design Day trade show.

New high tech start-ups often have the attributes of a skunkworks, with virtually no structure or documented systems for getting things done. On the other hand, an expanding product line in a corporate setting often has a surplus of structure and documented systems and procedures to follow. The ECE senior design course sequence emulates a hybrid of these two environments, to prepare the students for participation in either. More succinctly put, we expose the students to detailed systems, then relax them in practice somewhat to encourage creativity and also to account for the fact that this experience is superimposed on typically four or five other courses the students are taking, plus all of the other senior year activities and events. Even with this, many of the students become enthusiastically involved and may average 20-40 hours a week or more working on some stages of their projects.

Below is a summary of the senior design course sequence content, expressed as the topics covered and course deliverables required of the students and teams:

Junior Design Topics –

- Team Formation and Project Selection
- Project and Product Development Basics
- Feasibility Studies
- Project Funding and Finances
- Business Planning
- Trade Show Preparation

Junior Design Deliverables –

- Project Feasibility Study
- Preliminary Business Plan
- Trade Show Booth
- Project Website
- Weekly Individual Activity Reports, once teams are formed

The feasibility study touches on technical, schedule, financial and “marketing” feasibility. The business plan is not complex; it has minimal financial content, focusing on top level specs, the product value proposition, competitive analysis and risk awareness.

Fall semester Senior Design Topics –

- Product to Market System Details
- Project Planning, Management, Execution and Closure
- Product Design
- Design-for-X
- Manufacturing Readiness
- Risk Management and Mitigation
- Engineering Ethics

Fall semester Senior Design Deliverables –

- Final Business Plans

- Detailed Gantt chart
- Preliminary Design Review (PDR) and Documentation Package
- Successful Manufacturing Readiness Reviews
- Critical Design Review (CDR) and Documentation Package
- Project Website
- Individual Project Journals
- Weekly individual Activity Reports

The fall semester is heavy in documentation, as it should be. All the content is lifted directly from industry best practices (the instructor is also an industrial consultant in these areas). The deliverable due dates are set by the project Gantt chart plans, and not by a rigid class “schedule”. Projects completing their CDR before the end of the semester proceed to the build stage of their projects during the fall semester.

Spring semester Senior Design Topics –

- Proof-of-Concept Prototyping
- Building and Validating the Product
- Whole Product Concept and Launch Collateral
- Trade Show Preparation

Spring semester Senior Design Deliverables –

- Detailed Gantt chart
- Proof-of-Concept System Level Prototype
- A Product that Works to Spec
- Validation Review and Documentation Package
- Launch Collateral
- Trade Show Booth
- Team Web Site
- Individual Project Journals
- Weekly individual Activity Reports

The spring semester is heavy in building and testing. The validation review is simple in concept, but not necessarily easy. It answers the questions “what did you say it was going to do?”, “what does it do?”, and “how do you account for the difference?”. For launch collateral, teams develop and deliver their choices from a list of possibilities. The choices range from applications notes and instruction manuals to marketing brochures and websites, journal and magazine articles, to patent disclosures and site sellers. The trade show booths are displayed at Student Design Days, which this year will be held on a Friday and Saturday in April. The Friday “trade show” is for grading, judging, and exposure to students, faculty, the public, and various departmental and college level advisory boards that purposely schedule events for that day. The Saturday event is part of the university spring Open House, with approximately 1000 high school students and families from all over the country attending the trade show, plus the general public. The last week of the semester is spent doing informal lessons-learned discussions, covering the trade show, the projects and the course in general.

Coordination with Other Departments, Schools and Universities

The ECE senior design course sequence does not exist in a vacuum. There is heavy coordination in several dimensions. The instructors of all the senior design courses meet regularly as the Student Design Coordination Committee (SDCC) to collaborate and coordinate the courses, to address common opportunities and issues, to set CoE policy regarding senior design, and to cross-pollinate and share best practices. The electrical engineering, computer engineering, mechanical engineering and aerospace engineering programs are completely coordinated, having the same three course schedule. The other programs have one- or two-semester programs which also are synchronized with the flow. There are several common sessions where all classes meet in the same auditorium. These meetings are held particularly at the beginning of junior design, to encourage and facilitate the formation of true cross-functional teams, and again periodically throughout the senior year, typically for invited internal or external speakers delivering information and wisdom on topics of common interest, such as project finance, engineering ethics, available university project resources, project planning and management, team behavior and communications and presentation skills.

The SDCC plans and coordinates (with much help from volunteering student honor societies) the Student Design Day event, and works many common issues, often relating to finance and fund raising. It sets policy, such as requiring all CoE teams to get access to and learn Microsoft Project as our standard software for project planning. Since the advent of the SDCC, the fraction of multi-departmental ECE project teams has more than doubled.

The School of Management (SoM) also participates in the SDCC. In addition to the traditional high level of cooperation between the College of Engineering and the School of Management, the School of Management has three specific interest areas regarding CoE senior design. First, several senior design projects are used for case study and market study purposes by some SoM courses. The marketing students work with the teams, do their study, and share the results with both the team and the senior design instructor.

Second, there is a decided entrepreneurial spirit in our School of Management, and there is engagement with senior design teams desiring to commercialize their products through Florida TechStart, our university business accelerator, which was founded and is managed collaboratively by the SoM and the CoE. Finally, a senior design course financial system has been developed and installed by a series of accounting students who have set up a general ledger system used by the project teams and course instructors to manage senior design finance. The financial system is linked to the finance and development areas of the university, so contributions in kind, general and specific cash donations and contributed endowment moneys can be properly acknowledged, tracked and applied to the proper projects.

In industry, it is common practice for product development teams and their supporting functions to be scattered across several company sites. It is also a common practice for some new products to be developed in collaboration with the early adopting customers, in different companies at different locations and perhaps even in other countries. A grant was secured from NCIIA to support providing this type of experience to selected senior design teams. Our partner in the grant is the Rose-Hulman Institute of Technology, in Terre Haute, Indiana, about 1000 miles from Florida. For each of the past two years we have had a collaborative team, of approximately

20 students, with team members split between the two universities. Per the terms of the grant, each team has been working on wireless-based projects, specifically related to the tracking of materials, information and people. A university in Switzerland has indicated an interest in a similar arrangement. An Aerospace Engineering team is currently collaborating with a team from the Indiana Institute of Technology, and there is consideration of doing a three-university senior design team in the future.

How do Entrepreneurs fit into this System?

What if a senior design team wants to go from emulating being part of a start-up to actually starting up a company to take its senior design “product” to market? Florida Tech is prepared to support this type of activity, and as of this writing, seven current projects are in some stage of being productized for commercialization. Available to support this aspect of senior design is Florida TechStart, the university business accelerator for high tech ventures.

Florida TechStart was opened in October, 2003, as a joint venture of the College of Engineering and the School of Management, and is housed in the engineering building. Student teams interested in an entrepreneurial path work directly with Florida TechStart staff to make the necessary connections to help make their dreams a reality.

An additional resource is the array of entrepreneurial courses offered by the School of Management and by the Engineering Systems Department in Engineering. These courses cover the range from entrepreneurial finance to tactical and strategic marketing to business planning and even to how to secure SBIR and other seed money grants. Entrepreneurial certificate curricula are being developed, and graduate and undergraduate degree programs are in the planning stage. Further, an NCIIA grant has been received which provides funding to senior design course projects taking this exciting path.

The Products We Develop

There are approximately 40 senior design projects in the College of Engineering every year. Of these 40, the typically 70 – 80 ECE senior design students are team members of about 12-14 teams. The demographics of nearly all of these teams span departments or universities. This year’s ECE projects are listed below.

The entrepreneurial projects:

- Interactive Guest Paging System (IGPS)
 - Guests at restaurants or other facilities are given dedicated PDAs with games, information, wait-time updates, even interactive ordering capability to use while waiting for seating
- Off-road Autonomous Sensory Intelligent System (OASIS)
 - The first phase of entering the DARPA Grand Challenge, developing hardware and software for making full size automobiles run autonomously
- Optical Identification System (OIS)

- Augmenting the standard bar code technology with the use of color for security and high density information storage
- Optical Navigation Protection System (ONPS)
 - Combination “black box” and integrated entertainment system for automobiles and other vehicles
- Remote Computer Administrative Device (RCAD)
 - Improved system for linking local computers with remote servers
- Wireless Interstate Information Network (WIIN)
 - System provides real-time traffic and environmental information to vehicle operators. Could be linked with GPS systems to improve their performance and usefulness
 - This project spans two universities.
- Wireless Real-Time Networking Solutions (WRNS)
 - Wireless real-time tracking, monitoring and communications capability for employees at a work site.
 - This project spans two universities, and will be the second company started by the project leader.

The conventional projects:

- Automated Greenhouse (AG)
 - An autonomous, closed-system greenhouse environment for plants
- Electrochemical Deposition Experiment (EDEP)
 - Improved solar cell growth in a microgravity environment
 - A funded undergraduate research project being done in concert with the Department of Physics and Space Sciences in the College of Science.
- Formula Race Car
 - A formula race car for intercollegiate competitions
 - The team is large and spans several Engineering departments
- Sub-Orbital Amateur Rocket (SOAR)
 - A rocket designed for launch to 80 miles altitude
 - Candidate for Guinness Book of Records if successful – highest amateur rocket launch and first successful suborbital rocket constructed and launched in less than 2 years
 - The team is large and spans several Engineering departments
- Versatile Exploratory Robotic Tilt-rotor for Information Gathering Operations (Vertigo)
 - Vertical take-off and landing airplane with cameras
 - Team spans ECE and MAE departments

- Wake-Up Word (WUW)
 - Voice recognition and artificial intelligence for homeland security applications
 - A funded undergraduate research project spanning engineering departments, two universities and a community college

Senior Design Execution for Conventional and Entrepreneurial Teams

During the three-semester senior design sequence of courses, the entrepreneurial and conventional teams form and work alongside one another, and there is no segregation or special treatment of one set versus the other during class hours. There is also no way to identify either type of team through course grades or the level of effort expended by the team members during the courses, due to a large overlap of all team and project metrics. Yet there are several significant differences in how the senior design projects are executed by the respective types of teams:

1. **Senior Design Deliverables Scheduling** – We recognize the fact that market windows feel no obligation to coincide with the academic calendar. Entrepreneurial teams develop their project schedule to meet their needs as a potential start-up company, not to meet the instructor needs for a certain set of team and individual deliverables. The instructor takes this into account when assigning course grades throughout the senior design course sequence.

To a lesser extent, this also applies to the conventional teams as well. Some conventional projects are heavy on design and light on build and others are the other way around, and this too is taken into account.

2. **Additional Academic Training** – Several courses are offered by the Engineering Systems Department at the graduate level, though senior design students are eligible to enroll in them if they meet a minimum gradepoint requirement (2.75 / 4.0). These courses cover whole product development, strategic and tactical marketing, business planning and securing start-up funding. Entrepreneurial team members are strongly encouraged to take one or more of these courses, and several do, sometimes even over the summer term.
3. **Institutional and Peer Support** – Florida Tech is fortunate to have a dedicated business accelerator, Florida TechStart, which supports faculty, students and citizens in any quest to develop a successful, high tech start up, or to extend the product line offerings of a local high tech business. Entrepreneurial team members are encouraged to make use of its services, which include mentoring, networking, and training events such as workshops and boot camps. Several do.

In addition, Florida Tech has a very active student entrepreneurs' organization, the e-club, which has weekly meetings and programs. Again, the entrepreneurial students are encouraged to join and several do.

4. **Offline Instructor Support** – To support the need for individualized schedules for senior design deliverables, the course instructor works offline with entrepreneurial teams to ensure that they have the deliverables information and techniques they will need when they need to have them. This typically involves having the team come to the office to review and discuss future classroom material that they will need to apply long before it is appropriate to review with the conventional teams.
5. **Proprietary Team Information** – Most entrepreneurial teams develop trade secret or patent pending ideas and information as part of the differentiation of their product or technology. Documentation of this material is necessary for the deliverables, and the deliverables are required to be posted on all team websites within a week of their completion. Entrepreneurial teams are encouraged to develop secure areas within their websites for storing proprietary information. The passwords are provided to the instructor privately for access and grading purposes, etc.

Current Status of Entrepreneurial Teams in Senior Design

At the point of this writing, the senior design course sequence has just completed the design cycle and is poised for project build and prototyping activities. In some cases, long lead materials have already been ordered, and other material has been acquired in anticipation of the product fabrication activities. Overall, the entrepreneurial teams are pretty much still synchronized with the conventional teams in terms of their location in the new product pipeline. Below is a brief assessment of the entrepreneurial teams. A subsequent update will be provided at the conference. The teams are arranged in descending order of my assessment of their probability of success, where success is defined as attaining an initial revenue stream.

Each of the teams below appears to be driven by one or two students with entrepreneurial vision, commitment and enthusiasm. Most of the team members are committed to at least project success, if not entrepreneurial success. Most of the teams also have one or two relatively weak team members, in the sense of no particular commitment to success and/or weaker technical team skills. Note that senior design is a required course sequence which all students must take, strong or weak, and all students are required to be on teams. Members of at least one team have indicated that forming teams with friends is not necessarily good, as sometimes survival of the project conflicts with survival of the friendship.

1. **Wireless Real-Time Networking Solutions (WRNS)**
 - Wireless real-time tracking, monitoring and communications capability for employees at a work site.
 - This project spans two universities, and will be the second company started by the project leader
 - The project leader is slightly older (mid twenties) and superb at enthusiastic leadership. He has already started and remains involved with a company in a different field. All on the team seem bought into the goal of commercial realization
 - The team has sought and obtained private investors, delivers very professional output, seems to “have its act together”, and is on track to a successful product

demonstration. Team members have been enrolled in the entrepreneurial engineering management courses.

2. Interactive Guest Paging System (IGPS)

- Guests at restaurants or other facilities are given dedicated PDAs with games, information, wait-time updates, even interactive ordering capability to use while waiting for seating
- This is a very well thought-out project. The design is detailed and thorough. The entrepreneur has given project leadership responsibility to another team member and has taken the “project engineer” role for himself, freeing up his time to focus on technical issues.
- This entrepreneur has been the most active in participating in the entrepreneurial engineering management courses, Florida TechStart workshops and boot camps, and even entrepreneurial events put on by the University of Central Florida in Orlando.
- The entrepreneur is older (late twenties), has a busy life (parent and manager of a foster home plus a part time job), and the project has slipped from its original, highly ambitious schedule. Their initial product was to have been in the sampling stage by now, with second generation design getting underway. Part of the delay has been due to underestimating levels of effort and part due to feature creep, but the principal issue has been whether or not to actually follow through and start a company (high risk/reward versus family security). The answer is still uncertain but seems to be leaning towards going for it.

3. Remote Computer Administrative Device (RCAD)

- Improved system for linking local computers with remote servers
- This is a very competent team, overall, led by a quiet but extremely technically bright entrepreneur. The team has researched the market and designed an integrated system which will replace the collage of piece-parts currently available
- For ultimate success, in my opinion, this team would benefit by pairing up with a savvy, business/marketing team. Though quiet, the entrepreneur has a strong personality which would nicely complement the marketing capability. To his credit, the entrepreneur has been taking all of the entrepreneurial engineering management courses.
- The system design was thorough and excellent, but not much has been done to acquire funding partners or to set up for product sampling or introduction to this point

4. Optical Navigation Protection System (ONPS)

- Combination “black box” and integrated entertainment system for automobiles and other vehicles
- This project has a large team, with most of it abounding in energy. Their business model is to work the medium tech “black box” (most of the functionality for it already exists off the shelf. Their value-add is packaging it for automotive applications and making it cheaply customizable.) and open a shop designing and installing the system in automobiles.

- The entrepreneur is energetic, always in “sell” mode, has an excellent marketing sense, and is coming up the project management learning curve rapidly. He has a good practical sense of computing systems (he has a nearly-full-time job as a tech at a computer store). How many of his team are committed is not known, but I expect most of them are more “along for the ride” at this point. The quality of work from the team has been good but not exceptional, except for the graphics and presentations. No one on this team is taking any entrepreneurial academic courses.
5. Wireless Interstate Information Network (WIIN)
- System provides real-time traffic and environmental information to vehicle operators. Could be linked with GPS systems to improve their performance and usefulness
 - This project spans two universities.
 - The principals on this team are exceptionally bright and dedicated entrepreneurs, but they are ranked at this level due to their team size versus the level of effort I perceive is needed to take a venture of this magnitude to market.
6. Optical Identification System (OIS)
- Augmenting standard bar code technology with the use of color for security and high density information storage
 - This team has high aspirations on paper, but its senior design goals are to do a relatively elementary demonstration of the capabilities of its technology concept. The team is keeping busy, but there has been little evidence that it has the resolve, commitment or ability to actually take the concept to market.
 - The team has not been leveraging either the available academic coursework or Florida TechStart, at least to date.
7. Off-road Autonomous Sensory Intelligent System (OASIS)
- The first phase of entering the DARPA Grand Challenge, developing hardware and software for making full size automobiles run autonomously
 - This project is our dark horse candidate. The team formed in the wake of the publicity surrounding the initial DARPA Grand Challenge, and at one point had nearly 50 team members from several departments and at all undergraduate levels. The team was enthusiastic and generated excitement throughout the campus and beyond. It was even featured in national news articles as a contender.
 - Over last summer, the financial realities of participating in the Grand Challenge were recognized, and in fall of 2004, most of the team quietly disbanded. The current team, of about 6-10 students, is centered in Electrical and Computer Engineering and wants to prepare to enter the competition by outfitting a car for autonomous control. In fact, the team plans to open a shop and sell their expertise at modifying automobiles in this regard, to at least other Grand Challenge competitors and perhaps to the automotive industry.
 - This is the team I am least confident will succeed at setting up a business, but it has done nearly the best at clearing all the hurdles I have set up for teams to

qualify for entrepreneurial funding. Team members are also taking the entrepreneurial engineering management courses.

What Happens Next?

Most of the senior design course system attributes described in this paper are new, have only happened once or twice, and generally have not yet been in existence long enough for their impact on student post-graduate performance and success to be meaningfully measured. Anecdotal data has begun to appear, such as recent graduates stopping by to visit and relating that their management was amazed at their understanding of the product to market system. Other graduates have reported that they felt well prepared for technology and product development as a result of their senior design experience. The anecdote we continue to await is a recent grad who has become a successful entrepreneur and attributes it to senior design and the other support received from Florida Tech.

The only measured data so far has been the student surveys given in each course at the end of every semester. Since the inception of the changes catalogued in this paper beginning in the fall of 2002, the student evaluation of the ECE senior design courses has steadily improved from an already high rating, indicating that the students at least perceive continual improvement of the course context, content, delivery and results.

Some elements of the overall program are expected to grow, such as multi-university teaming. A person in the Development organization of the university is now assigned nearly full time to support senior design funding acquisition, and an endowment for the projects is being developed, all of which should dramatically reduce funding issues. Other elements of senior design, such as the Student Design Day event and the application of the financial general ledger, are expected to continually improve as we add to our experience and lessons learned.

Conclusion

Over a short period of time, the ECE senior design course sequence has been transformed from a traditional, one year course to a three semester, high tech start-up emulator with significant external funding and an abundance of true cross-functional teams spanning departments, schools and universities. An entrepreneurial spirit pervades the culture of the course, and this year, more than half of the teams are working towards becoming true start-ups, up from zero a few years ago. Improvements in student satisfaction with the course sequence have been quantitatively measured and are significant.

We have found that entrepreneurial and conventional senior design teams can coexist very successfully in the same course infrastructure, though some flexibility and special attention must be built into that infrastructure to support the special needs of the entrepreneurial teams.

In addition, all the departmental senior design course operations of the Florida Tech College of Engineering have been transformed from a set of fairly independent, autonomous courses to an integrated, cross-coordinated organic shared curricular experience, complete with large public events and shared policies and course management systems.

The circumstances driving these changes are a synergistic confluence of independent decisions to shift faculty assignments, seek senior design funding, coordinate senior design courses, start a business accelerator, encourage entrepreneurial behavior by engineering students and, on the part of the School of Management, to get involved with engineering senior design. The net result is as outlined in this paper.

Though it is too early to quantitatively assess the bottom line of the effects of these changes (student career satisfaction and success), such measurements will be done. In the meantime, there is general agreement of the course instructors, and also departmental and CoE administrators, that all of the changes have been beneficial and are already driving the right results.

Bibliographic Information

As the ECE senior design course sequence is a “doing” experience, information needed by the teams and projects is transmitted by means of meeting notes, much as in industry. There is no textbook assigned for any of the courses. However, typical of the texts which provide good reference information for the purposes of the instructor are:

1. Barry Hyman, *Fundamentals of Engineering Design* (Upper Saddle River, N.J.: Prentice Hall, 2003)
2. Daniel L. Babcock and Lucy C. Morse, *Managing Engineering and Technology* (Upper Saddle River, N.J.: Prentice Hall, 2002)

Biographical Information

KEN PORTS is a Professor in the Electrical and Computer Engineering Department of the College of Engineering at Florida Tech and the Engineering Director of Florida Tech*Start*, the Florida Institute of Technology’s business accelerator. Prior to joining the university, he spent 25 years in the microelectronics industry in technical, management, staff and internal consulting roles.