AC 2008-278: SENIOR DESIGN COURSE DELIVERY MODEL USING AN INDUSTRY COORDINATOR

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Senior Design Delivery Model using an Industry Coordinator

Purpose of Senior Design Course

A Senior Design Course has long been a standard component in the engineering curriculum. It serves as a capstone as well as a bridge from classroom work to industrial application. As a capstone, Senior Design pulls together the prior engineering course work. It may blend several courses together requiring students to select the needed information from each course. It also helps students realize when to use materials and when it is not appropriate for a given situation.

The course provides a bridge to full time industrial experience. Responsibility for project execution provides deeper appreciation for what they will experience. Allowing mistakes provides a low risk learning environment so the lessons learned can stick.

By its nature as a bridge, the senior design course offers unique delivery challenges. At the University of St Thomas, a variety of delivery approaches have been attempted over the last 9 years to overcome these challenges.

Historic Structure of Senior Design Courses

Senior design courses are often structured as a collection of independent student team projects with a faculty coordinator responsible for scheduling presentations and lining up projects[1]. There are several aspects of this structure that hamper the potential learning opportunity[2]. Some of these areas have been addressed in other programs[3,4], but we have found that a structure that replaces the faculty coordinator with an industry coordinator has been particularly effective in serving our students and local industries basic needs. A few of the critical aspects are briefly described below.

Traditionally at our university, all faculty were involved in recruiting corporate sponsors for senior design projects and needed to find projects and groom companies as time allowed. Creating a comprehensive portfolio of projects is difficult if this task is entirely decentralized to the individual faculty member. It is also difficult to have a consistent message to the potential sponsors. A company can also be confused if they have multiple communication paths into the university system.

The internal battle for resources at the university can consume energy for the faculty and can put the students in the middle of resolving it. This includes distribution of students to projects, lab space assignments, faculty project assignment and several other areas of interest to the students.

In a traditional framework, the class does not have “togetherness” or a strong group connection. All work is done between the students and the client. Presentations do not include the entire class, if they exist at all. Any lectures are not presented to the entire class at one time. Guidance on design process or expectations can vary greatly between faculty and clients. The experiences are naturally going to be different for each project, but opportunities to share the experiences do not exist. Because of the lack of lectures, learning about the design process is ad hoc. However,

industry will require new engineers to work within their system from day one. Students are forced to use only what they have learned in other courses working on projects with much smaller scope.

Senior design courses are often only one semester long. This does not allow for lecture time on the design process, for gathering requirements or for build and test. Focus is thus on completion of the project. Any "extraneous" activities are eliminated to have as much project engineering time as possible. Courses also are restricted to one discipline (mechanical, electrical, civil, or chemical). A systems perspective is difficult to achieve if the scope is limited to one area. This compressed academic schedule can result in compressed learning opportunities[5].

Our Solution to the Challenges

Several of our program characteristics address these issues to build a capstone class which bridges to industry. After several years of experimentation, the University of St Thomas has converged on a model of using multidisciplinary student teams working on industrial projects with faculty advisor/ consultants and a non-faculty industry coordinator acting as director of engineering. The industry coordinator is seen as a credible authority to the students with respect to real world employer expectations. The industry coordinator provides outside mediation of faculty differences, assignment of resources and a normalizing factor for lectures and grading. Most importantly, they can provide the close, ongoing relationship with local industry that is needed to provide a wealth of appropriate industrial projects.

The industry coordinator role is filled using a portion of a Thwaits endowed chair from 3M Corporation. Our department has multiple people using a portion of the chair for special department needs. This provides a limited teaching load but does create a strong connection with the school and department as this is a visible position. This position creates a bridge between industry and the school.

We offer a two-semester, multi-disciplined (mechanical and electrical engineers) Senior Design course. We provide a structure to support learning and ensure delivery of value to our industry customer. This structure is shown in Figure 1 below. In each graphic, the top portion of the label gives the academic terminology while the equivalent industrial term is given below.

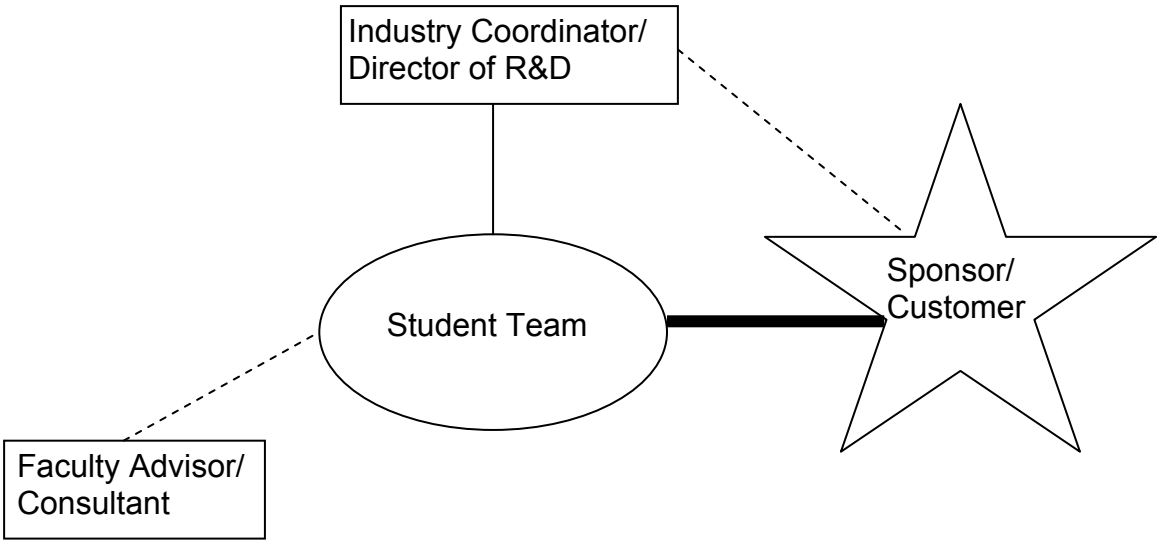


Figure 1 – Structure of Senior Design Course

The student team is at the center of the structure to emphasize that they are the focus of the learning experience. On the lower left is the faculty advisor. The faculty advisor serves primarily as a consultant for the student team, but their consistent attention can help keep a team on task. The industry coordinator, the topic of this paper, ensures a fresh and varied project portfolio with active company sponsors. The industry coordinator also provides oversight and balances competing needs. The sponsor is the primary focus for the student team. Having an active sponsor ensures we understand their process and their expectations. They attend periodic status/ project meetings with the student teams and typically attend the design reviews.

The solid line indicates the student team is focused on delivering to the customer expectations which dictates templates and expectations. The industry coordinator is a dotted line to the customer and on an "as needed basis" after the semester begins. The faculty advisor role is dotted line to the student team as they are not directing the project or setting expectations. They are part of the student led team, but not the driving force. While we have clear expectations for the learning objectives, the students are to fit within the company environment – instead of the company trying to fit within the school.

Table 1 shows a summary of the challenges of a Senior Design course, our specific steps for resolving them (solutions), and the observed results.

Challenges	**Solution**	**Result**
Finding projects	Industry coordinator provides consistent effort all year long.	Proposals groomed and pipeline continually in motion. Use survey of student interest in spring to direct priority proposals.
Resources	Industry coordinator facilitates the process for labs and people assignment.	Close knowledge of projects and clients allows a balanced assessment and decision.
Design Process	Industry coordinator provides	Best practices are identified and yet

learning	general lectures to all project teams in one lecture session. Also meets with all teams independently to discuss "deviations" to the norm.	flexibility exists to adapt to company expectations. Coordinator "staff meetings" monitor execution during the semester.
Learn from build and test	2 semester course, hardware build expectation given to clients up front.	Time is available for lectures. Time is available for build and test iterations.
Systems approach	Multi-disciplined teams with ME and EE students. Students create own requirements for project.	Discuss issues and trends with need for systems perspective. Students "naturally" think about needs that can be filled in other departments (chemistry for example) builder bigger bridges. Active industry sponsor.
Motivation	Industry coordinator works with student group leads and provides a fresh perspective to push student activity.	Focus on value to customer.

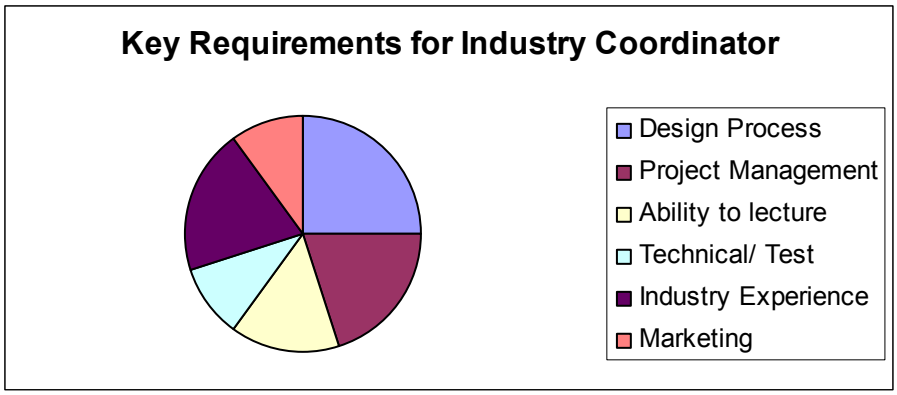
Table 1 – Key Concerns and Resolutions for Senior Design Course

Role of the Industry Coordinator

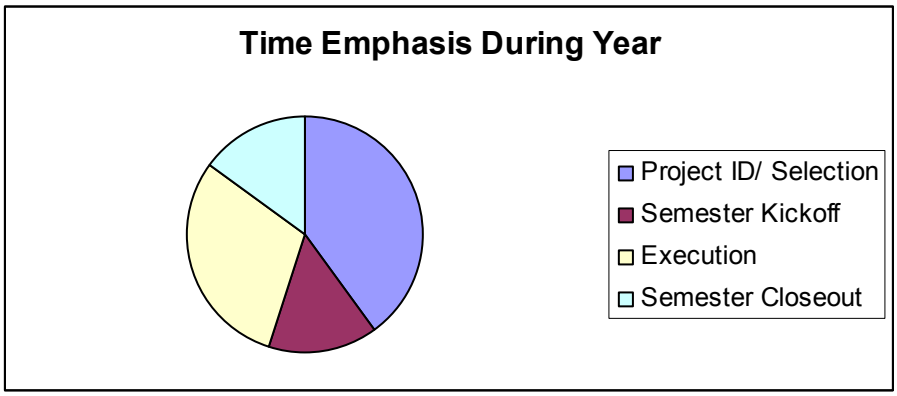
The various phases of the Senior Design course have a range of responsibilities required for the Industry Coordinator. The principle assignment is to be the lead instructor responsible for the Senior Design Course, including providing industrial perspective, negotiating industry projects and coordinating course resources.

More specifically, the role includes identifying projects, distributing lab space assignments, assigning projects to students, ensuring appropriate faculty assignment to projects to match their skills and interests, organizing all presentations and project reviews, clarifying expectations for students and for grading, and defining expectations on how to identify appropriate projects for our industry customers. This works best when the coordinator reviews and understands progress of all projects, deals with team issues and balances these competing concerns in an unbiased manner.

Characteristics of a successful industry coordinator are an understanding of the design process and system engineering, proven project management skills, ability to lecture on the above topics, a technical background, marketing perspective and industry experience. It is also beneficial to have industry connections and experimental knowledge.



Overall, the industry coordinator role works through the following phases – project identification, project selection, semester kickoff, semester/ project execution and end of semester close out. In the following sections, we will expand on each of the phases. The skills required by an industry coordinator change as we progress from phase to phase. A discussion about the criteria for the phase and the process we use will be included.



Project Identification

While there is a focused effort during the summer, the actual activity is throughout the year. This is what makes it tough for faculty to adequately address this phase. It usually takes a year for a new organization to get on board and sponsor a project. Companies need time to get budget in place. They need time to understand the expectations for a good project. And finally, they need time to "shake the bushes" to get the project options and then select the best one to present to the selection committee. We have also found that companies understand the program better after the Spring Design Show, which will be described in the description of that phase. The Industry Coordinator visits companies and answers their questions offline as they go through the proposal development process.

Industry coordinator skills that are useful during this phase include marketing and systems engineering skills. Identification of company needs uses both of these skill areas. High level project concerns are important to discover early on. A systems perspective helps uncover these issues. Creating a conceptual high level approach to solve the situation helps ensure the potential execution by the student teams.

Relationship building is a huge part of this phase since it is vital to creating trust within the potential sponsor companies. Visiting the companies is an important step toward this goal. This can include looking at potential projects, discussing needs, discussing what opportunities we have to offer them, and finally seeing the company capabilities.

By understanding student interests from spring semester, we can leverage our contacts in those areas. A contact tracking system is used to know our working history with each individual and corporation. Returning companies receive high priority but strong consideration is given to organizations that match student interest. During the academic year, companies that express interest to the school are visited and encouraged to submit but are only pursued strongly if students are interested. Overall, we are looking to develop a project portfolio. For example, we want a technical mix of projects. We want to have large and small companies represented. We want manufacturing and design related topics. There must be a variety of industries included. While we want companies in our area, we also desire "remote" projects.

Project Selection

A process has been created for performing project selection including the faculty in the process. Criteria for selection of projects have been created and are now stable. The industry coordinator mediates the session. The results of the screening allow us to focus only on the student interest once the semester starts.

We want projects that are "requirementable" (ones for which it is possible to generate a set of requirements) – neither a vague project where you will only know you got there when you see it, nor a project with an already identified set of requirements. The work needs to be capable of being divided up among the student, even though the actual split will be accomplished by the student team. The project needs to have some clear value to the company and the marketplace, but should not be critical for the company. The project must have a definitive end product, so the students have some to test their knowledge. Paper studies are not desired. Finally, company support is a key. Beyond financial considerations, the sponsor is important. Do they value the learning aspect, are they timely in their dealings, do they expect to attend the reviews, can they allow space to the students to do the work, and do they have the potential or history of hiring our students for internships or full time positions.

Faculty is involved during the identification process. Early in the summer, they will indicate any questions, issues, or concerns regarding the projects being pursued. A few weeks before classes start, the projects are screened or prioritized with faculty input following our selection criteria. More projects than desired are presented to students. Seeing this additional information provides greater insight by the faculty – and the student interest does not necessarily match the survey inputs from the spring semester. The faculty has stated that it is smoother to have an outsider mediate this process. A single point of contact helps avoid over-promising to the clients, ensures fair treatment of each company involved, and allows areas of improvement to be visible and resolved.

Final selection and assignment is performed after the students express their interest in the projects. Selection is done by the faculty team, and mediated by the industry coordinator. Each project selected should positively address the industry criteria, match the faculty interest and abilities, and address student interest. Additionally, we need to make sure that the projects meet the needs of the class learning objectives. We also try to ensure the project portfolio is balanced. with respect to company sizes, types of companies/ organizations/ industries, and design versus manufacturing orientation.[6]

Semester Kickoff

We want the projects and the companies to get started on the right foot. We want to quickly get the projects selected and the teams rolling. On one hand, the students need to understand the course expectations. On the other hand, the students need to begin determining their customer and the project. This requires simultaneous planning, defining requirements, and overall project organization. Providing quick suggestions or asking key questions to open up the options available to the students is valuable so they can get moving. We work to create a sense of urgency. By having the Industry Coordinator kick off the class with a business focus and serious intent, the students have the right attitude to move quickly in the beginning.

At the start of the semester, Systems engineering skills and Industry Coordinator accessibility are important. As the students begin the official project work, they will be identifying company needs. Then they will word these as requirements which need to be translated into engineering specifications.

At the beginning of the semester, students need to plan out the project over the entire school year. An Industry Coordinator with project management skills can greatly help ensure that the student plans are executable. Students also need to understand budgets (project and product) with limited initial information. Finally, each project needs to identify and understand the project risks. This topic is difficult to perform well in industry, so getting a first attempt with a student group is a worthwhile activity.

The Industry Coordinator needs to be comfortable with the “fuzzy front end” of product development. Projects can get stagnant at this stage, so assistance for getting through it is critical. Iterations between the above generated requirements and potential concepts consume the final piece of the first semester. To wrap up the kickoff, we hold a concept review. The concept development and selection is the most challenging of the design reviews and is held midway through the first semester.

Semester/ Project Execution

We primarily cover two areas during execution - working through issues and performing design reviews. This is primarily covered during the last 2/3 of the first semester and all of the second semester.

Issues can be technical challenges, changing requirements, budget and schedule concerns or team dynamics. The coordinator’s first role is helping the students realize that there is no right answer.

The Industry Coordinator will help the student team understand options, relate to the various perspectives and provide a framework for moving forward. This does not resolve the issue for the students, but instead equips the team to work through the issue and then live with the consequences of the answer they select.

Our design reviews include concept, detailed design, test readiness, and project conclusion. These are equally spaced through the academic calendar. Each faculty member and all customers in attendance provide anonymous feedback in prescribed areas for each team presentation. These are provided to the Industry Coordinator, faculty advisor, department chair and to the student teams. We provide video feedback to each team, so they can verify the written comments themselves. While the feedback tends to have a range of assessment levels, the students can see first hand the different perceptions of their presentations. The Industry Coordinator can provide students guidance in how to prepare for these reviews.

The technical skills of the Industry Coordinator are useful for addressing technical concerns identified by the students. Another perspective can be provided to assist the students in rounding out their approach.

The ability to link analysis and test is essential as the second semester progresses. It is not unusual for there to be a conflict between the detailed analysis and the first test. Trouble shooting the root cause is important. Was it a test issue? Was it an incorrect analysis assumption?

The beginning of the first semester is when lectures on special topics occur. We cover requirements, project management, test strategy, common tools (FMEA, SPC, gage R&R, etc), and concept generation and selection. We also discuss team dynamics as part of the lectures, but it also is part of the discussion during the industry coordinator meetings. Questions come up regarding how to be “a group lead”, motivation for the team, how to follow a lead, and how to address competing needs. For instance, there could be a conflict between objectives or a schedule and budget mismatch.

Coordinator meetings are held every other week with the Industry Coordinator for each team. These are brief meetings to understand status, areas of concern, and clarification of expectations. If all is well, the meeting ends promptly. If something important comes up, the questions can be handled off line or through an email to the entire class. Some topics are also shared with only the group leads, and they are expected to communicate it to the rest of the team.

Grading is another area that is performed as a faculty team. The faculty advisor brings in a recommended grade based on the learning objectives. Reasons for grade deviations are provided and compared between groups. The Industry Coordinator helps ensure a balanced opinion between skill areas and between projects.

End of Semester Close Out

We want to close out the year on a positive note and take credit for our accomplishments in as visible of a manner as possible. This initiates the momentum for the next cycle.

We hold a trade show style event, called the Spring Design Show. This is for the students to present their results to a larger audience so we invite our Project Sponsors, Industrial Advisory Board, other University of St Thomas departments, parents, and prospective sponsors. The display for each project typically consists of a poster summary, prototype parts, demonstration units, video clips of experiments and similar items that could exist at a trade show. The posters created by the students are used for other purposes as well. We put them on display in the engineering hallway and at the engineering reception prior to graduation.

As a department, we create hand out materials to the guests of the Spring Design Show. One document is the biographies of the faculty. This is of most interest to prospective companies. Another document is the project summary document for that particular Design Show. These are popular for many people – company sponsors, prospective companies, parents, and students. Finally, we have an overview document for the Senior Design program that is of most interest to the prospective companies.

Thanks and recognition is a big part of the year end activities. We want to ensure the client companies are invited to the Senior Design Show. A poster to recognize other organizations who contributed to the projects is created and those individuals are invited to the Spring Design Show to build as much of a relationship as possible.

Results Using an Industry Coordinator

Our students are able to obtain an outside perspective and real time stories about engineering issues and trends in the work place. The Industry Coordinator provides a focal point for the school to develop a deeper Industry relationship. Our structure has improved the level of project ownership by students. We are able to connect with industry on a different and deeper level. Faculty has the ability to interact with students at a unique level and thus strengthen their connection with students. Representative industrial experience is obtained for the students. And finally, we have created value to organizations.

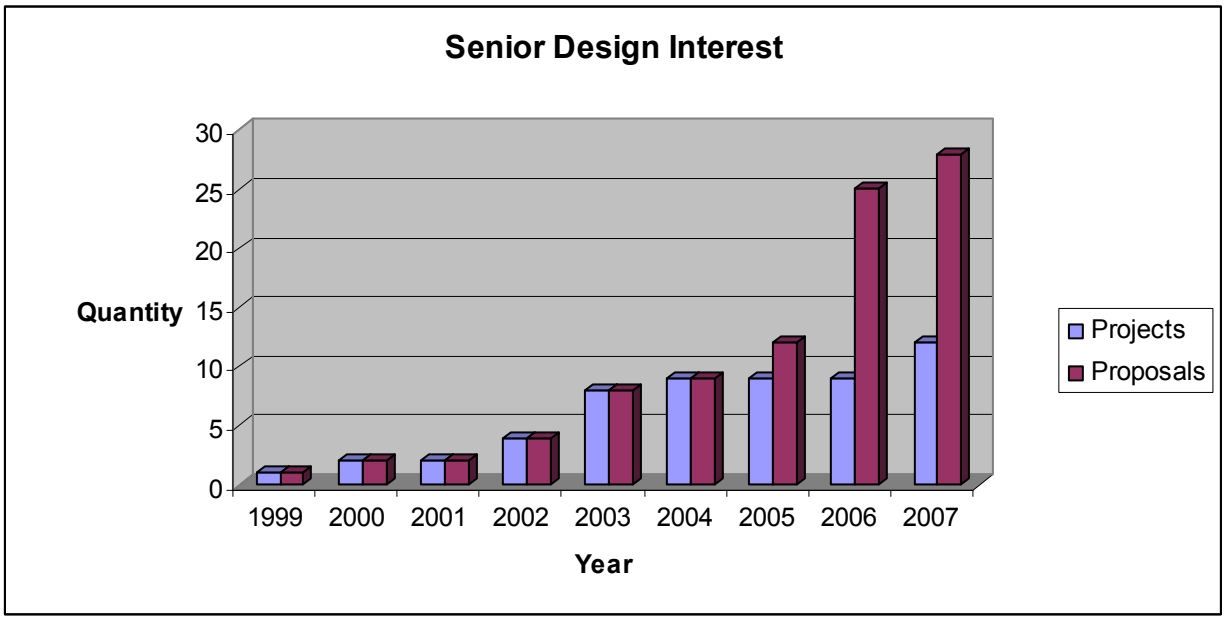
How do we know this model is generating greater value? Faculty members who have worked through the different models have witnessed the improvement and encouraged continued use of this model. In fact, they encouraged writing this paper to share our success with other engineering schools.

Sponsor feedback consistently shows that it works. The majority of projects are implemented by the sponsoring companies. We also have a high return rate (nearly 50%) of companies with projects in future years. Not all organizations get selected to return or they may not have the appropriate timing for another project, thus the percent of interested companies is even higher than this level.

Student feedback from the course evaluations also shows an improvement in overall satisfaction with the course. Prior to the Industry Coordinator, about 25% of the time the surveys indicated acceptable levels. After introduction of this model, our data shows that acceptable rating occur roughly 75% of the time.

Other groups have also indicated a positive response to this model. Our Industrial Advisory Board members who have watched the evolution of the delivery models indicate a preference for the current model. These are also the people who hire our graduates, so they have an interest in methods that provide valued employees. Prospective sponsors are drawn to the program at a higher level than before. After seeing the Spring Design Show, they understand the program better and then follow up with a proposal for a project the following year. We had a unique feedback opportunity this year as we searched for a new dean. Several of the Dean candidate finalists expressed how they were impressed by the unique model and the success that they can see from it. We have also had external reviewers from other engineering programs who see our process closer than most, and they also express how well it works.

Prior to instituting use of this model in 2003, obtaining company proposals for projects was a challenge. Teams were large due to lack of projects and no project proposals were rejected. Now the proposals exceed the number of projects needed, even as program has grown from 3 projects to 12 projects over the last 5 years. This past year, we had over 25 proposals for the 12 available spots. All indicators point to a successful educational model.



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