Successful S3 Design Projects

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Dr. William F. Pratt, Western Illinois University

Dr. Pratt was selected as the first Director of the new School of Engineering and tasked to start a new general engineering program at Western Illinois University in August of 2009. The first graduates received their diplomas in May of 2011 and the program was ABET accredited in August of 2012. The School will add a separate Mechanical Engineering Degree in 2017. He has experienced a varied career in government, academia, and industry and has six patents for advanced composite materials.

Dr. Il-Seop Shin, Western Illinois University

Il-Seop Shin received the B.S. degree in Electrical and Computer Engineering from California State University, Fresno in 1997, and M.S. and Ph.D. degrees in Electrical and Computer Engineering from the University of Massachusetts, Amherst in 1999 and 2007, respectively.

In 2007, he joined Biomedical Sensing and Signal Processing research center at the University of Massachusetts Amherst, as a postdoctoral research associate. He also worked as a mixed-signal CMOS Integrated Circuit designer and a system engineer at NewLANS, Inc. in Acton, Massachusetts until 2010. He became a Visiting Assistant Professor of Electrical Engineering at the University of North Florida in Jacksonville, Florida in 2010. Since August 2012, he has been with the School of Engineering at Western Illinois University, Quad Cities as an Assistant Professor of Engineering.

His current academic interests include project-based learning with real-world problems, training in critical thinking for students to improve efficient problem solving skills, and enhancement of interactive teaching/learning inside and outside classroom. His main research interests are integration of high performance sensors into mechatronic systems, development of mechatronic systems using biomechanics such as surface Electromyography, and implementation of intelligent microelectronic networks for multidisciplinary applications.

Dr. Khaled Zbeeb, Western Illinois University

Dr. Khaled Zbeeb received his PhD and Master's degree in Mechanical Engineering from the Florida Atlantic University (FAU) in 2011 and 2009 respectively. He also received his Bachelor degree in Aerospace Engineering from the University of Kansas in 1992. While pursuing his graduate degrees at FAU, Dr. Zbeeb taught various mechanical engineering classes including Dynamics, Thermodynamics, Fluid Mechanics and Engineering Graphics. In 2012, he joined Western Illinois University as an assistant professor, and he has been teaching there the following courses: • Thermodynamics • Heat Transfer • Thermo-Fluids • Dynamics • Engineering Graphics • Computational Methods in Fluid Dynamics (CFD) • Fluid Mechanics. • Finite Element Method

Dr. Zbeeb's research devotes itself to the theoretical and computational modeling of thermo fluid and energy systems. His interests span both low and high speed fluid mechanics, multiphase flows, hydrodynamic and acoustic instabilities, engine internal flow fields, vorticity dynamics, combustion, alternative fuels and CFD. His research activities since 2008 have materialized in over twenty publications in first-rate journals, book chapters, and conference proceedings. His work on flow modeling for two after-bodies trapped vortex combustion has led to the establishment for new design correlations for the TVC technology. His research interests focus on CFD, thermal fluids, heat transfer, energy and alternative fuel.

Successful S^3 Design Projects

Senior design projects are the final academic challenge that many engineering students must accomplish to graduate. Industry partners are heavily recruited by engineering programs nationwide to provide, and even fund, realistic projects that enable a meaningful senior design experience. A project with significant design content, where work is completed in a team environment, is universally desired. The following statement is from ABET's Engineering program accreditation requirements: "Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints."[1] What fits the bill better than having students work within industry, maybe even as paid interns, on an active company project? Nothing could be more real since the project *is* real. Such projects automatically include real schedules, deadlines, constraints, codes, standards, budgets, equipment allocations, contracts and an expected return on the company's investment or at least a clear demonstration of merit. These projects let students experience real workflow and work alongside professionals within industry.

When student design projects involve proprietary information, they require a higher level of academic management. They may even become "Super-Secret." A Super-Secret Senior Design Project or S^3 Design Project has more at stake than a run of the mill project. It might be the next version of software or development of a revolutionary product. The concept, progress, results and any work completed by students must be kept from public disclosure and competitors; therefore, the work, reports, discussions and presentations must be accomplished behind closed doors and privy only to a select group.

Management of the S^3 Design Project necessitates involving legal counsel and entering into non-disclosure agreements, a memorandum of understanding, contracts, agreements on intellectual property rights, patents, royalties and so on. Even when everyone on both sides wants to jump start an S^3 Design Project, it can take months to organize, lay the ground rules and get the final permission to proceed. The experience gained by students completing this category of project can be valuable and highly rewarding; however, these projects may also have unexpected implications related to assessing and evaluating learning outcomes, course objectives and program accreditation.

Projects that involve an industrial partner will usually involve some form of contract to define the scope of work and the intellectual property rights of each entity participating in the project. Herein lies a problem, the school's academic mission to disseminate knowledge conflicts with industries concern for exclusive privilege and trade secrecy. So, while a project with industry may provide a major design experience and realistic constraints, the students and faculty advisors involved may not be able to say anything about it. This obviously curtails the ability to publish findings in journals and/or conferences or even project presentations in class. Faculty and students involved in such projects may not be able to discuss their contributions for years in the case of companies seeking patents; and in the event of trade secrets not protected by patents or proprietary information they may never be able to talk or write about their findings.

When engineering schools solicit industry for student projects or industry approaches an engineering program with a student project, the industrial partner knows (maybe even hopes) that there will be some level of publicity and public disclosure associated with the project. In this situation, industry does not knowingly offer projects that involve company secrets because of the understood publicity. Contracts for these projects may be straight forward and relatively easy.

However, when a company employee that is working on a proprietary industrial problem is also an engineering student nearing graduation (and therefore in need of a design project) the company might be persuaded to allow the employee/student to use the company project in part or in its entirety. Typically, the student's initial request to the company is soon followed by negotiations between the company and school to clarify what can be used, openly discussed, published and shared and ultimately results in a legal agreement. Reaching an agreement may take several iterations and many months. In fact, the negotiations may take longer than the project! When approaching a project of this nature, one that is to be 'Super-Secret,' expect some delays and setbacks. S^3 Design Projects are often new territory for the student, the company and the university.

In discussing projects, the following legal instruments will be referred to.

Memorandum of Intent, MOI: "Also a letter of intent. A letter of intent is generally an agreement to agree. It outlines the terms between parties who have not formalized an agreement into a contract. Letters of intent are generally not binding and unenforceable."[2]

Memorandum of Understanding, MOU: "A memorandum of understanding (MOU) may be used as a confirmation of agreed upon terms when an oral agreement has not been reduced to a formal contract. It may also be a contract used to set forth the basic principles and guidelines under which the parties will work together to accomplish their goals."[3]

Non-disclosure Agreement: "Non-disclosure agreement is a legally binding contract between two or more persons, in which a person or business promises to treat specific information as a trade secret and not disclose it to others without proper authorization. Usually, non-disclosure agreements are used when a business discloses a trade secret to another person or business for such purposes as development, marketing, evaluation or securing financial backing. Information known to the parties with regard to their transactions should not be disclosed to a third party."[4]

Non-compete Statement: "Non-competition agreements are restrictive contracts between employers and employees that 1) prohibit workers from revealing proprietary information about the company to competitors or other outsiders, or 2) forbid workers from themselves competing with their ex-employer for a certain period of time after leaving the company. Non-competition agreements often appear as clauses within a larger employment agreement. Such agreements are a tool that small business owners may use to try and ensure that key personnel do not walk off with company secrets or clients in order to start their own competing business or join an existing competitor in the area. Non-competition agreements have significant deterrent value in many situations, but they may also alienate some potential employees. It is important that their application within a firm is seen to be fair and equitable. Most firms that employ non-competition agreements do so to safeguard sensitive proprietary company information. Sensitive proprietary company information may cover any aspect of a business's operation, including

production formulas, processes, and methods; business and marketing plans; pricing strategies; salary structure; customer lists, contracts; intellectual property; and computer systems.

These agreements are also called confidentiality or nondisclosure agreements or, simply, non-compete agreements, and they typically define confidential information, identify ownership rights, and detail employee obligations to ensure that confidentiality is maintained. But there are definite limits on the scope and duration of such covenants. Employers generally cannot use non-compete agreements to keep employees from practicing their trade or profession indefinitely. This is particularly true if the former employees were experienced in the specified occupation before they were hired. But while employees generally have every right to make use of skills and experiences gained in one company when they set off on the next stage of their lives, it is illegal for them to make off with trade secrets of their former place of employment."[5]

Contract: "A contract is an agreement between two parties that creates an obligation to do or refrain from doing a particular thing. The purpose of a contract is to establish the terms of the agreement by which the parties have fixed their rights and duties. Courts must enforce valid contracts, unless one party has legal grounds to bar enforcement.

For a contract to be legally binding it has to have all six of the following elements: (i) an agreement; (ii) between competent parties; (iii) based upon the genuine assent of the parties; (iv) supported by consideration; (v) made for a lawful objective; and (vi) in the form required by law."[6]

A contract may include several agreements such as non-disclosure agreements, non-compete agreements, intellectual property ownership including possibly new discoveries, publication agreements, and many others. Item (iii) above can be a particular issue since all of the parties to the agreement including those faculty and students who will work on the contract, must assent (usually separately) to the restrictions these agreements impose.

One of the stickiest S^3 Design Project problems involves passing on the restrictions of a contract to students and members of the university. As is often said, "Everyone is happy with the agreement until real money is involved". Naturally people who work on the contract will gain knowledge that gives them an edge in subsequent employment and they will want to use that knowledge. If that knowledge was acquired in a contract with a non-compete agreement, use of the information may be restricted for significant periods of time. Here's a good quote to consider when passing down restrictions:

"Courts have traditionally frowned upon restrictions placed by employers on their employees' right to find and make a living. The longer the non-compete time period, the closer scrutiny the court will give the agreement. The length of time that an agreement not to compete can be enforced depends on the facts and circumstances of the individual case. However, courts will enforce non-competition agreements if:

- the employer proves that it has a legitimate business interest to protect by restricting its employees' right to compete against it;
- the restriction on the employee's right to compete is no greater than that necessary to protect the employer's business interest; and

- the covenant not to compete is supported by consideration, meaning that the employee received something in exchange for it."[7]

The fictitious Project X discussion that follows is based on actual situations, behaviors and events gleaned from several S^3 Design Projects.

Project X: In August a senior engineering student, working for a local manufacturer, is assigned to a design team that is given a new project. They are to design, build and test a stand to evaluate the performance and estimate the life cycle status of a critical component in a machine the manufacturer produces. The duration of the project is anticipated to be six months. When school starts, later that month, the Student asks the senior design project Advisor about using the project at work for the two-semester project requirement. The Advisor is ecstatic! As explained by the Student, the project includes all of the major components required by the school but with a professional team, real deadlines and actual consequences; and, the student will be paid. The Advisor instructs the Student to have the Supervisor at the plant contact the school to work out the details.

When the Student approaches the project Supervisor at the plant, the Supervisor recognizes that the plant Manager will have to authorize any interaction with the School. Initially, the plant Manager is furious! Although the Student had not entered into any formal agreement preventing disclosure of what was being done at work, the Manager felt it should have been understood that details of the project were proprietary to the company and should never be discussed with anyone outside of work. The plant Manager calls the engineering department Chairman to straighten the mess out and do damage control.

The Chairman receives the plant Manager's call without having any prior knowledge of the classroom conversation between the Student and Advisor. The Chairman assures the Manager that a resolution can be found that protects the company and arranges for a meeting the following week at the plant between the Manager, the Chairman and the Advisor. Then the Chairman goes to find the Advisor to figure out how this all got started.

During the week, the plant Manager considers the value of the project in terms of the Student's academic progress and career, but is still concerned about being able to insure protection of the company's intellectual property and trade secrets. The student is a good employee, and is being groomed by the Company for an engineering position. Working on this project is the final stage in the Student's informal internship with the Company and they are highly interested in helping the Student succeed and graduate. At school, the Advisor and Chairman have discussed the merits of the project and an association with the Company. They are hopeful that this could be the start of a long relationship with the Company and the first of many projects.

Next week the meeting at the plant goes splendidly. The Company and School agree that the project is feasible academically and will provide the Student a unique and valuable experience. They draft a Letter of Intent during the meeting and agree to work out a Memorandum of Understanding and a Confidentiality Agreement to protect the Company.

Following the meeting at the plant, the plant Manager contacts the Company's legal counsel and the Chairman contacts the Schools contracting agents, asking them to work together to draft an

agreement and/or contract. Over the course of the next four months, numerous drafts are exchanged and revised before an acceptable final contract is signed.

While the legal documents are being developed, the Design Team at the plant (including the Student) continues to work and make good progress on the project. During this time, the Student is unable to participate in any of the classroom project presentation components of the course because no one is quite sure what information can and cannot be presented in a classroom setting. During this period, the student reports project progress in private to the Advisor who has signed a non-disclosure agreement with the company. Shortly thereafter, two additional professors who will be part of the project review team on the academic side and the Chairman, sign non-disclosures with the company and make arrangements to protect the company's intellectual property.

Within the contract, the limitations of what the Student can present, report and publish are clearly defined. The Student finishes the course making general presentations of progress to the class. The presentations do not include any specific details of the test stand design or configuration. In accordance with the agreement, the student gives a Final Project Presentation to the Company's Executive Board and the faculty and Chairman but does not participate in any public presentations or poster sessions and does not include an abstract of the project in the Senior Design Project Proceedings for that year.

<u>Project X Considerations:</u>

1. The benefit to the Student makes this project worthwhile even though project details cannot be disclosed in the classroom or a public forum.
2. The tradeoff between not being able to fully present the project to other students and participating in designing and building an innovative, expensive, state-of-the-art, one-of-a-kind machine must be weighed for each situation and evaluated.
3. No one foresaw the time required to iron out an agreement acceptable to both the School and the Company; however, the Student was able to continue participating on the Company's design team and report progress to the School's Advisor in private.
4. The existence of a secret project will probably be well known to other students taking the course. Students and faculty not covered by non-disclosures and who are not privy to the details will be naturally curious and in some cases resentful. The very real danger is inadvertent disclosure to colleagues who have no imposed restrictions and may even have their own industrial partners but with less restrictive agreements. Fortunately, after some instruction, the students only initiate some good natured ribbing.
5. A Super-Secret project provides the course instructor with a unique opportunity to discuss and demonstrate common professional ethical and legal situations.
6. Without signing non-disclosure agreements, members of a program accreditation review team may not be able to review the full details of this project.

Our experience has been with two general types of S^3 Design Projects which are distinguished by the facilities used. Some projects use university facilities exclusively and a team of students. Others are worked on by one or more students working with an industrial team using industry or a combination of industry and university facilities. Both are valuable. Both come with advantages and disadvantages. Our discussion will exclude R-1 universities that work on developing new technologies and restrict the discussion to senior design projects.

Projects done on university property.

In general terms, the company will contract with the university to develop a process, machine, or design that is usually not in the "critical path," it has lower priority in the company, and is unlikely to result in a break through development. Typically, publication is not an issue, and neither is inadvertent disclosure. The contractual arrangements may be relatively easy and involve a grant or gift to cover expenses. These projects are easy to accommodate and supervise but may not be very exciting. The students are able to work alongside other design teams and share their experiences.

However, if the project involves proprietary information or the anticipation of generating new technology and/or intellectual property, you can expect the contract(s) to be more involved, include restrictions, and significant penalties. There is a real danger of inadvertent disclosure and access to project information must be controlled. Most tier 2+ schools are not initially prepared to accommodate the restrictions and provide the security required. The only way these can be safely done is at a separately controlled area. Additionally, there are usually restrictions on presentation, publication and review.

Projects done at the sponsoring company's facilities.

These projects can range from the benign to the really cool high tech. If benign, contracts can be similar to a university sited project. A general project agreement may even be employed. If the student(s) are company employees most companies will restrict disclosure, ownership of intellectual property, and other issues with an employment agreement. The main disadvantage of this type of project is that the University may not receive any benefit other than a good project for one student.

If, however, it is an S^3 Design Project, the pros and cons vary depending on a number of issues.

Pros:

1. The company becomes responsible for protecting proprietary information. This can be done with employment agreements with the students, and/or non-disclosure agreements with students and supervising faculty.
2. The university does not have to provide special facilities or tooling.
3. The student gets to work on a real-world problem, gain reputation, and in our experience ends up with a job offer before graduation. As one manager stated after the final briefing, "Why wouldn't we hire this person? They've been with us for two years, they at least know where the water fountain and toilets are, and they are already better with new technology than some of our engineers!"

Cons:

1. Classroom and other presentations in a school setting can be severely restricted. Project advisors must guard against inadvertent disclosure during discussions and briefings, and access to senior design reports (which ABET teams may want to inspect) must be controlled.
2. The university may not accrue any monetary benefit. For example, our university can apply a much higher overhead rate for any contracts performed on university property,

but only a very nominal overhead rate on contracts performed "offsite." This disadvantage can be offset by grants or equipment donations from the company to the university, especially if they see a tremendous benefit to the relationship and want to make sure it is continued in the future.

3. The payment of wages to students can be more complicated. In one case, a student was not paid until several months after the completion of a project because of contract complications.
4. You may never be able tell the world what great things your students do for these companies, and publication of new technologies may wait for years, or forever. The formula for Coca Cola is illustrative.

In our experience, faculty and universities generally don't want to touch S^3 Design Projects, especially if they cannot benefit monetarily or may not be able to publish the findings in journals, conferences or even school poster competitions. The authors have advised numerous student design projects at six different engineering schools and have had to work through contractual issues at every school. Admittedly, senior design projects of this nature do not fit the mold of R-1 research. However, for a mid-size school in the midst of hundreds of companies and manufacturers, S^3 Design Projects can be the life blood of a senior design program and create a tremendous amount of good will. As a result of our efforts, industrial donors have been very generous to our program, and we now find ourselves actively participating in a manufacturing revival.

After working through several S^3 Design Projects, the first thing we learned was that no two projects use the exact same legal documents. Therefore, having a master contract does not eliminate the need to negotiate the terms and conditions associated with each project. However, the existence of a set of master documents may accelerate the negotiations.

The second thing we learned was that trade secrets are secrets! Companies are not interested in letting the world know how they make the world's best _____ . Academics that desire to assist companies in developing their trade secrets must be willing to leave the secrets with the company. Even when the individuals doing the work are agreeable to this concept, there are frequently conflicts between the organizations or within organizations that prevent agreement and those projects should not be pursued.

But… if you can establish a reputation of excellence, helpfulness, and become a source of technology development, the benefits far outweigh any angst or difficulties. As for us, we love "Super-Secret Senior Design Projects and they have paid off handsomely!

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[1] ABET 2017, "Accreditation Policy and Procedure Manual, 2017-2018", Accreditation Board for Engineering and Technology, 2017; available as a pdf at ABET.org.
[2] https://definitions.uslegal.com/l/letter-of-intent/
[3] https://definitions.uslegal.com/m/memorandum-of-understanding/
[4] https://definitions.uslegal.com/n/non-disclosure-agreement/
[5] https://definitions.uslegal.com/n/non-competition-agreements/
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