Academic Versus Industrial Senior Design Projects

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For the past seven years, the Department of Chemical Engineering at the University of Minnesota-Duluth has used industrially supplied projects in its senior capstone design sequence. The change was implemented from academic to industrial projects as a result of an ABET recommendation to increase the multidisciplinary experiences of the students. By ABET definition, an industrially supplied project is considered multidisciplinary. The department does not charge companies for the student work. Instead, companies are solicited to provide projects voluntarily. Of the forty industrial projects completed, all have been obtained through departmental contacts, alumni or current students with coop or internship experience. Table 1 summarizes the raw data since the change to industrial projects.

Academic Year: 2004-5							
Group No.	1	2	3	4	5	6	7
Company	Windswept	WLSSD	MPCA	WLSSD	Sappi	Cargill	WLSSD
Topic	Al_2O_3	Bio H_2	Waste H_2O	Bio H_2	Black Liq.	Energy Int.	CH_4 prod.
Source	Student	Dept.	Alumnus	Dept.	Dept.	Student	Dept.
Implemented?	No	No	Yes	No	Yes	Yes	No

Academic Year: 2005-6						
Group No.	1	2	3	4	5	6
Company	Dul. Steam	Sappi	Faculty	Wasau Paper	CHS Oilsd.	Sappi
Topic	H_2O Pretreat.	Sludge Disp.	Orphan Drugs	Waste H_2O	Energy Int.	ClO_2 Prod.
Source	Alumnus	Dept.	Dept.	Student	Alumnus	Dept.
Implemented?	Yes	No	No	Yes	Yes	No

Academic Year: 2006-7						
Group No.	1	2	3	4	5	6
Company	MN Power	SSOE, Inc.	(Verso/NRRI)	Dul. Steam	Sappi	WLSSD
Topic	Hg Reduction	Biodiesel	Wood to EtOH	Hotel Heat	Anaerobic Dig.	CH_4 Fuel Cell
Source	Alumnus	Student	Dept./Alum.	Alumnus	Dept.	Dept.
Implemented?	Yes	No	No	Yes	No	No

Academic Year: 2007-8				
Group No.	1	2	3	4
Company	EcoLab	Dave Stark (Local Consultant)	CHS Oilseed	Sappi
Topic	Tank Design	House Design	Miscella Solvent Extraction	Hemicellulose to Ethanal
Source	Dept.	Dept.	Dept./Alum.	Dept.
Implemented?	No	No	No	No

Academic Year: 2008-9						
Group No.	1	2	3	4	5	6
Company	MN Power	CB&I	LSB Brewery	PolyMet	Arkema	Sappi
Topic	Fugitive Dust	Gas Plant	Carbonation/En. Integration	Acid Capture	Reactor Column	Digester Scrubber
Source	Alumnus	Student	Student	Dept./Alum.	Student	Student
Implemented?	Yes	No	No	Yes	Yes	No

Academic Year: 2009-10							
Group No.	1	2	3	4	5	6	7
Company	Fond du Lac	Verso	Cargill	N/A	Sappi	Barr	MPCA
Topic	Biomass Gasifier	Energy Integration	Optimization Corn Germ Dewater.	DME Production	Recovery Bolier	Zero Liq. Disch.	Phos. Removal
Source	Dept.	Student	Student	Student	Alumnus	Alumnus	Alumnus
Implemented?	Yes	No	Yes	N/A	No	Yes	No

Academic Year: 2010-11						
Group No.	1	2	3	4	5	6
Company	Fond du Lac	Fond du Lac	N/A	Sappi	Graymont	Barr
Topic	Biomass Gasifier	Wood Pellet Plant	Wood Torrefaction	Tall Oil Prod.	Energy Integration	Tank Design Permitting
Source	Dept.	Dept.	Student	Student	Student	Alumnus
Implemented?	No	Yes	N/A	No	No	No

Table 1: Summary of senior design projects over the last seven years.

1. Obtaining Projects

In mid-summer, as the instructor, I contact a variety of alumni and company representatives recommended to me by other faculty members about the possibility of sponsoring a design project in the coming year. The email contains a brief description of project requirements and the obligations of the industrial liaisons, as well as a disclaimer about student work being free of charge. In addition, the message informs potential sponsors that the demand on the contact person will be less than an hour a week, with the students asking most of their questions either at the beginning or toward the end of the spring semester. In general, the response to this first solicitation is weak - and understandably so, since engineers are busy and not looking for added responsibility with little obvious benefit. By the beginning of the fall semester, one or two projects may be lined up. Often, these are projects left over from the previous year.

Typically, once a company has supplied a project, it is willing to participate again. For example, I generally count on Sappi and Duluth Steam (see Fig. 1), which are both within driving distance of campus, to supply some work for the students, and both companies often have several project options. In October, the Industrial Advisory Committee (IAC) meeting takes place. Since the IAC consists predominantly of alumni, I make a public request for projects and then poll individual members as opportunity allows. By the end of November, when students are presented the available projects, the required number of alternatives has been obtained. However, it is not unusual for me to be working out details the week of Thanksgiving on one or more projects.

Figure 1: Sappi Fine Paper of Cloquet, MN (left) and Duluth Steam Cooperative (right) have provided 10 of 42 total projects in the last seven years.

One important source of projects is the students themselves. By their senior year, most of the students have completed an internship or coop and have good industrial contacts. At the beginning of fall semester and several times thereafter, I mention to the class the advantages of obtaining their own projects. As Table 1 shows, about 33% of the projects over the last seven years were arranged by the students. The CHS Oilseed project in 2005-6 (see Table 1) could perhaps be added to that number, since a student solicited an alumnus for the work. The student-obtained projects can work out very well, since at least one student is well versed in the topic. On the other hand, that one student often dominates the group.

As a point of information, it should be mentioned that students are not forced to take one of the projects on the list presented to them. They may try to obtain one on their own, if they are strongly opposed to their choices. However, I give them a limited amount of time to make their contacts after November, since they have already been given ample opportunity. Their other option is to do an academic project with at least one reactor and two separation steps. In the first five years, no group chose an academic project, although the Verso/NRRI project in 2006-7 (see Table 1) amounted to an academic project when the group and company made the mutual decision to stop the originally suggested work on bleach-water treatment. In the last two years, two groups did academic projects, both of which worked out very well.

The issue of why it is difficult to get new industrial sponsors remains – and whether a better solicitation method exists. As discussed above, the difficulty seems to reflect an attitude on the part of industry that the company liaisons will have to do a lot of work for little or no benefit. Another concern which potential sponsors often express is that much of the material in any project offered would be proprietary. Since the final design reports are in the public domain, many times companies decline to participate on this basis alone. To get around this obstacle, I generally point out that we can change specific numbers in the reports, so that there would be two versions, one for the company and one for the university. In several of the projects which have been completed in the last seven years, some process information has been omitted to satisfy industrial interests.

2. Characterizing Projects

Granted that the sample is relatively small, with seven years of experience it is now possible to make some observations about the switchover to industrial projects. First, as mentioned above, we note almost all projects come from departmental, alumni and/or student

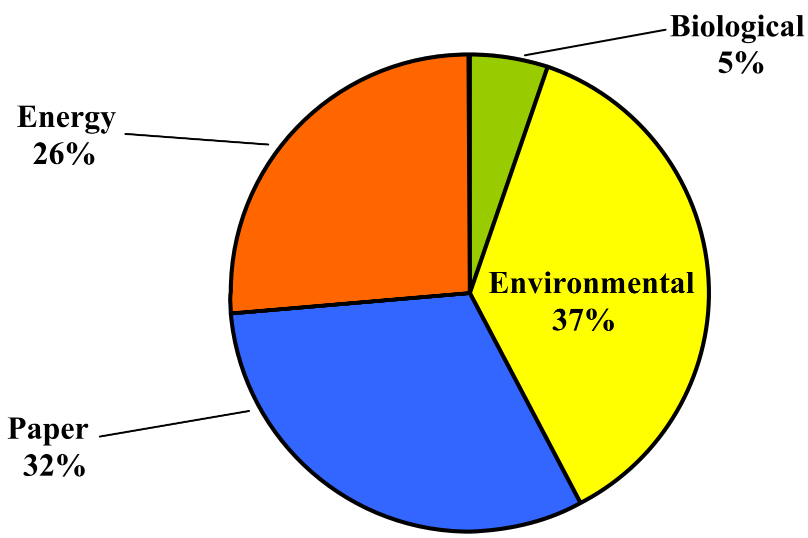

Figure 2: Breakdown of projects by area.

contacts. In other words, no projects have come from cold calling. Second, given the location of the university in northern Minnesota, most of the projects have been either environmental or paper-related. Figure 2 provides a rough breakdown of the projects. Some of the projects could be classified under more than one area, since the divisions are not mutually exclusive. For example, the Wasau Paper project from 2005-6 and several of the Sappi projects could be categorized as both paper-related and environmental or even biological in nature. Moreover, some of the Western Lake Superior Sanitary District (WLSSD) projects are both environmental and energy-related.

The relevant point, however, is that the vast majority of the projects do not involve making a final chemical product. The Orphan Drug project involved pharmaceuticals on a batch scale, so it was essentially specialty chemicals. The Windswept Energy project concerned production of alumina from anorthosite but developed into a study of the feasibility of wind energy. One of the Sappi projects investigated alternatives for production of chlorine dioxide (ClO_2). However, the chlorine dioxide is an intermediate used in the bleaching process and is not sold. Several of the WLSSD projects dealt with hydrogen or methane production, but the goal was to feed the gas into a fuel cell to produce energy for use on site or sale to the grid. The Verso/NRRI project involved batch-scale production of ethanol from wood for use in fuel. The ethanol production was driven by concern for renewable resources in energy and had mixed economic results. Only the SSOE, Inc. project to make biodiesel (and possibly the wood-to-ethanol project) was a true continuous process to make large quantities of a chemical product. Although biodiesel may turn out to be an important gasoline alternative, the project was clearly driven by Minnesota law and subsidy. In other words, biodiesel is not yet a commodity product in the traditional chemical engineering sense, such as petroleum products or polymers.

The types of projects which have been completed to date may reflect the changing nature of chemical engineering itself or the location of UMD, as mentioned above. However, an attempt to obtain a wider variety of projects may be in order.

3. Evaluating Projects

Experience with the industrial projects has been mixed. The previous academic projects were rigorous and provided a true capstone experience incorporating knowledge gained in many of the undergraduate courses. Design of a novel process involving one reaction and two separation steps was required. The industrial projects are typically not as demanding or as broad in scope. In fact, less than of the forty industrial projects could be considered to satisfy the previous academic requirements. Moreover, two of those projects, the Orphan Drug and Verso/NRRI projects, were quasi-academic anyway. That is, the Orphan Drug project was sponsored by a faculty member and the Verso/NRRI project turned into a student-driven study on production of ethanol from wood on a batch scale.

A Block Flow Diagram from one of the industrial projects is provided in Figure 3. Although the example is an extreme one, it does illustrate some of the problems that can be encountered. The scope of the project involved switching over from a solid nutrient feed system to a liquid one for a rotating biological contactor wastewater treatment system at Wasau Paper. Essentially, the students needed to get some vendor quotes for the appropriate liquid nutrients design some tanks with piping, and do the economics. I asked the group to do some work on the necessary control system, which was an interesting problem. However, Wasau Paper was satisfied with their existing controls, so it was difficult to motivate the students. The project was not a capstone experience.

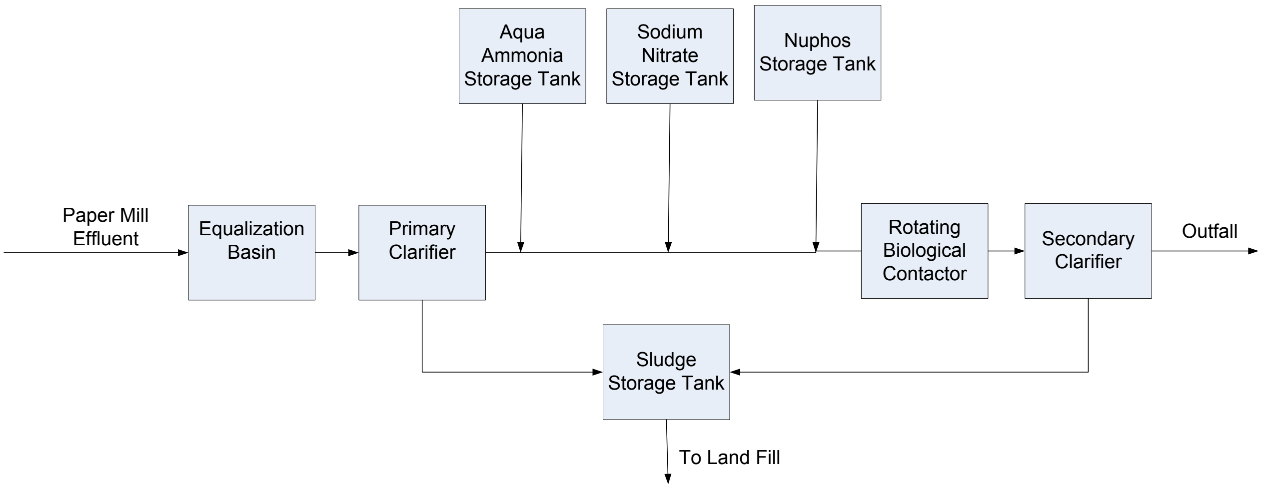

Figure 3: Block Flow Diagram from Wasau Paper project (See Table 1, 2005-6).

With the industrial projects, the students do gain practical experience dealing with vendors and contacts from the sponsoring company. Because the students do not actually work for the sponsors, vendors are sometimes unwilling to provide quotes, since they expect no purchase to occur. I tell the students to obtain permission from their industrial liaisons to say they represent the company or ask the liaison to obtain the quote him/herself. One problem that sometimes occurs is that students rely too heavily on vendor quotes. They are told to size and cost equipment themselves, as well, to check the vendor numbers.

The difficulties students encounter are often similar to ones they will meet as they enter the workplace. Moreover, over one third of the projects end up being implemented in some form, so that the students get the satisfaction of seeing their work in action. (Depending on how 'implementation' is defined, in 15 of the 40 projects, changes were made in existing processes along the lines of student recommendations.) In the case of the MN Power project, the students researched a technology (SAMMS) the sponsor had not considered. After testing, it was found that mercury levels were successfully lowered below 1.3 parts per trillion.

4. Improving Projects

To counter the academic shortcoming, the department sometimes supplements a project with an academic component. For example, the Duluth Steam project from 2006-7 was a feasibility study of adding some downtown hotels to the heating loop. Some heat exchangers needed to be designed, an energy balance performed and economics evaluated. However, the scope of the project was far from the traditional academic projects. After some discussion, several of the faculty decided to add a problem on optimum insulation thickness for piping to the project. Although the project was still not as rigorous as some former capstone experiences, it was improved. At our last ABET meeting in May, we agreed as a faculty to meet in October or November, when the projects are lined up, to discuss which topics need strengthening and how to make them more academically rigorous. An alternative which has been discussed but left on the table is to have the students do the AIChE Design Competition project in the fall as an additional individual project. One difficulty with this idea is that there really is not enough time in the semester for more work.

5. Conclusions

In moving from academic to industrial projects, we have found that departmental contacts are most helpful initially. Local industry provides the vast majority of the projects through alumni and current students, and companies are often willing to offer projects again after they have gone through the experience once. Patience is required since many new contacts may result in only one or two projects. For a relatively small department, such as chemical engineering at UMD, the types of projects obtained are generally dictated by the nature of local industry.

The change to industrially supplied senior design projects has been beneficial for the department. It has helped satisfy ABET requirements for multidisciplinary activities and gives the graduating seniors a practical experience as they prepare to enter the job market. It is true that academic rigor can sometimes suffer, but with careful monitoring it is hoped that a true capstone experience can be achieved together with real-life problem-solving.

Biographical Information

MIKE ROTHER is Associate Professor of Chemical Engineering at the University of Minnesota-Duluth. He received his Ph.D. from the University of Colorado at Boulder in 1999, and his research area is transport phenomena in the study of drops and bubbles. He teaches fluid mechanics, transport phenomena and senior design.