Using STUDENT TECHNICAL CONFERENCES To Build Multidisciplinary Teamwork Skills

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Accredited chemical engineering programs in the United States continue to face the issue of how to assess "soft skill" outcomes in their curriculum, including the ability to function on multidisciplinary teams, communicate effectively, and engage in lifelong learning.[1] Of these three, perhaps the most obvious to address is the communication outcome. The other two require a little more effort, not only to achieve the outcome but to define what it means. The lifelong-learning criterion seems most often interpreted to mean "give students the ability to learn independently," meaning make them go to the library and teach themselves.[2] Others extend this concept, suggesting that not only should they be able to locate information, but they should be able to learn from their peers. Supporters of collaborative learning strongly endorse this concept.[3]

Programs also need to address the "multidisciplinary teams" criterion, which first requires a definition of what a multidisciplinary team is supposed to be. In some programs, multidisciplinary refers to students with different degree majors collaborating on a single project. This requires a course involving such students, or some other method of bringing this diverse group together.[4-7] Obviously, this can be challenging at most institutions, since the requirement must be fulfilled in a required course in the chemical engineering curriculum. Others consider a team project that gives each student a distinct role, function, or discipline to apply as fulfilling requirements for the outcome.[8] This is more readily accomplished and is the method that appears to be most commonly adopted. In both cases, teamwork training is recommended. Not only is this outcome important for ABET purposes, but industry also considers teaming skills as critical.[9, 10]

Additionally, the AIChE Annual Meeting often causes cancellation of a week's worth of chemical engineering classes during the fall term. Many students will also participate in the National Student Conference the weekend before, missing another day or two of classes. Instructors, already under time constraints in most courses, often attempt to redeem the otherwise lost time by assigning extra homework, reading, or short-term projects to keep students engaged during the week.

With both the need to address difficult ABET Engineering Criteria outcomes and lost class time in mind, a novel student project was created to develop student skills while taking advantage of student participation in conferences. The task also engages those who do not attend such conferences. Chemical engineering students at the University of Kentucky Extended Campus Program in Paducah, Ky.,[11] were assigned this project in the fall semesters of 2003 and 2004.[12]

PROJECT DESCRIPTION

The key feature of this project is that students are placed in teams that span courses across years of the curriculum. In other words, sophomores, juniors, and seniors are placed on

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a single team. This team structure assures a multidisciplinary functionality since the capabilities of team members to contribute to a technical project vary distinctly from class to class. The teams are formed to be balanced according to class standing, and then according to academic ability. Since the classes engaged in this project are small, no formal method for dividing teams was required. A more promising approach to grouping students in larger programs is proposed by Newell, *et al.*[13]

The premise of the project is that each team consists of new hires in a startup company conducting business in an emerging area of chemical engineering. The first two years, the fictional companies were involved in biotech and nanotech enterprises. There is, however, one problem. Despite a wealth of venture capital and high salaries, management is fatally confused. They are not certain exactly what product or service they are offering. The team is charged with the task of defining that

UK CME

Cross-Curricular Assignment

Fall 2004

Student Research Project

Due: 5PM Monday, November 15, 2004

You've Got Work To Do

Congratulations! You have your first job after completing your decades of formal education. Unfortunately, you have landed that job with a startup company which does not have a firm sense of what it does to make money. You do know that it is focused on nanotechnology, dealing with things like carbon nanotubes, MEMs, nanoparticles, nanosensors, or other things nano-.

As part of a multidisciplinary project team, you are going to collect information required to move your company forward and make it a competitive force in its field-- whatever that specifically may be. Those of you attending the conference will gather information from exhibitors and from technical sessions that are tied to your specialization. Those remaining home will obtain similar information via the web and from the technical literature.

You team will prepare a **summary report** for your chief executive officer which will contain a recommendation for a nano-related product to produce including **objectives** identified for obtaining information; identification of key elements in current knowledge on the cutting-edge substance or process; and identification of equipment, software, or other items which will contribute to your company's efforts. Specific requirements for the report are included in the rubric on the last page. Your role (or roles) is (are) based on the classes you are enrolled in and are summarized below. If you are enrolled in multiple classes listed below, your responsibilities will increase.

Due to the size of the teams, each report can contain up to 12 paper summaries, so staying organized as a group is important. Those attending the conference should use the online program to plan their strategy ahead of time and establish their company objectives prior to departure. Those not attending the conference should be able to collect their data during the conference. Upon return, all team members should finalize their summaries and work together to compile a single report. Make certain you **reference** all summaries of presentations or journal articles using end notes.

Be creative, and have some fun with the project, but do keep within the scope of the project. You are actually supposed to learn something valuable!

Deliverables: Your team will turn in four copies of a single report with the names of all team members. One copy will go to each CME faculty member. Grading will be performed by the instructor(s) of the class(es) for which you receive a grade. Grading criteria may vary somewhat from class to class. The instructor of your class retains the final authority to determine how a grade for this assignment will apply to your class.

Peer evaluation surveys of team participation will be submitted individually and used to assign individual grades based on the team grade. Failure to contribute adequately to the team report will result in significant reduction of individual grades.

Figure 1a. *Page one of the project assignment from the second offering.*

product or service, and then to:

Prepare a summary report for your chief executive officer that will contain a recommendation for a nano-related (or bio-related) product to produce or service to offer, including: objectives identified for obtaining information; identification of key elements in current knowledge on the cutting-edge product or process; and identification of equipment, software, or other items that will contribute to your company's efforts.

The concise version of the assignment is that the team identifies a fictional objective, each team member contributes a very brief summary of two journal articles or conference papers related to the objective in some way, and each member identifies a vendor that provides a product or service that would also contribute to the company's objectives. The topics summarized and vendors identified should be tied to students' current courses in some way. The complete assignment is given in Figures 1a and 1b.

Participating Courses:

CME 200- As a person currently focussed on fundamentals, you will need to identify products and processes of interest. General summaries of research involving phase equilibria, or mass & energy balances are a plus. Identify resources which may be of general assistance in developing a top notch nano-engineering department for your company. You may not understand much of what you see, but a brief overview or description should be enough.

CME 470- As a safety expert, you need to be knowledgeable of all aspects of your company's technology. Identify nano-topics that provide a basis to conduct risk analysis to ethically protect the safety of your company's professionals. Since you have additional expertise in separations, fluid mechanics, and reactor design, you may also identify information useful when considering those areas of responsibility.

Team Assignments:

Team 1	Team 2
Michael [redacted]	Alicia [redacted]
Kelly [redacted]	Ben [redacted]
Brent [redacted]	Todd [redacted]
Elizabeth [redacted]	Lindsey [redacted]
Chris [redacted]	Jacob [redacted]
Jessica [redacted]*	Drew [redacted]*

* Indicates Project Leader. The project leader will coordinate efforts among teams, maintain the common report file, and arrange necessary team meetings. Successful execution of this role will increase the individual grade for this person.

Suggestions:

Meet as a group to select your scenario well in advance of the conference. Choose your topic based on the sessions available at the conference on Monday morning. Those obtaining journal articles can conform more easily to the topic than those using conference papers. Express your topic in conjunction with a brief list of objectives that will guide the team in writing their summaries. This should take about an hour if everyone arrives prepared. You don't have to be exceedingly specific, but you should be consistent. The conference program is online at http://www.aiche.org/conferences/techprogram/date.asp?Day=Monday&DSN=annual04.

Take enough notes at the conference to be able to summarize the topic and tie it to your team objectives. You are only expected to write a few sentences to a paragraph on each paper. The report may have, say, one paragraph on separations papers, one on general chemical processes, one on reactor design, one on process design, and a few on equipment vendors (in addition to appropriate introductions, objective statement, and conclusions).

After the conference, everyone should write their summaries on their own and then send them to their Project Leader. The Project Leader should combine them and prepare an introduction including the team objectives. Gather your group together for a writing/editing session. Prepare your final report for submission before the deadline. This part of the process should take no more than three hours.

Figure 1b. *Page two of the project assignment from the second offering.*

The assignment objectives are that the students:

- *Develop a list of objectives to meet project outcomes.*
- *Write a coherent, concise, and high-quality report as a team.*
- *Compose referenced summaries of information relevant to a project task.*
- *Function effectively as a multidisciplinary team to collect relevant information.*
- *Identify current research related to project objectives.*
- *Identify vendors that produce products suitable for project requirements.*
- *Describe the role of biotechnology or nanotechnology in modern engineering practice.*

To accomplish this task, each team is appointed a leader who is expected to arrange team planning meetings, facilitate determination of the goals for the company, and coordinate the information team members contribute toward the objectives. Additionally, the leader arranges the final composition of the report. Since this last item is a substantial task, leaders have the option of "hiring" an editor from the team, who will assist with this task and receive compensating "bonus" credit for the project. No team has used an editor to date. The team leaders are usually selected from the senior class members who do not typically take on leadership roles but are believed by the instructor to have the ability to lead. They are given more specific guidance, training, and instruction prior to the start of the project.

Students are assigned this task as part of the courses in which they are already enrolled. Cooperation is secured from all instructors required to ensure participation of all three classes (sophomore to senior). The instructors of these courses determine how to apply the project to their grade computations, but typically the report counts for one or two homework assignments or as a fixed percentage of the total grade (~5%). Additionally, the instructors of the courses from which team members are drawn can grade the reports on their own, or use the grading of the project faculty coordinator. To date, no faculty member has asked to grade the reports a second time, choosing to use the grade assigned by the coordinator.

The multidisciplinary aspect of this project is tied to the courses in which the students were enrolled. The number of courses involved depends on the minimum required to secure participation from most sophomores, juniors, and seniors (this was four courses in the first offering, but only two in the second). For example, during the first offering, the topic was biotechnology. Students enrolled in the following courses participated with the course-specific assignment:

- ***Process Principles (sophomores):*** *As a person currently focused on fundamentals, you will need to identify products and processes of interest. General summaries of research involving phase equilibria, or mass & energy balances are a plus.*
- ***Separations (juniors):*** *If it's mixed up, you're the, um, unsolution. You should identify research and equipment associated with separating different materials.*
- ***Process Design I (seniors):*** *Elements of process design and simulation are your forte. You should include simulation software in your investigations, especially ones that include economic analysis (especially "costing").*
- ***Reactor Design (seniors):*** *If it reacts, it's your business. Determining kinetic laws, sizing and designing reactors, and integrating chemical reaction with other processes are among the topics that you are concerned with. Simulation at the molecular level may also float your chemical engineering boat.*

For the first offering, seniors were given this assignment in two courses, but the assignment was limited to one course during the second year of the project. The change resulted from the determination that the workload was too heavy on senior students in the first implementation. Students were to select topics for their research that they could tie to the course in which the assignment was made.

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Since one of the goals of the project was to reduce "lost" time due to conferences, one of the otherwise missed or rescheduled class meetings was allocated to this project. Time spent per student on the project was intended to be 3-6 hours, not including training. Treating the project as a laboratory exercise, this corresponds to a lecture class time loss of 1-2 hours, which is typical during the AIChE Annual Meeting week.

As part of the assignment, students were provided a grading rubric to make expectations clear and to guide them on their writing. Newell, Newell, and Dahm[14] provide guidelines for rubric development appropriate to this sort of project. The rubric used in this project is provided in Figure 2.

Students are given creative freedom to define their objectives to take advantage of available resources. This approach differs from one concerned with developing problem-solving skills due to the constraints associated with the conference presentation element of the project. Since those students attending the conference are required to summarize two presentations, the availability of appropriate sessions on the Monday of the conference (their last full day at conference) is the limiting factor in their completion of the project. Consequently, prior to the conference, students are directed to the AIChE technical program online to identify presentations

suitable to define objectives. Since the student conference usually conducts 90-minute overview sessions on emerging areas in chemical engineering, multiple students in each group are allowed to summarize part of that session to fulfill one of their technical summary requirements. Additionally, students attending the conference are required to identify their vendor from among those exhibiting at the conference. This requires students to define their objectives carefully based on available resources—a useful skill in dealing with poorly defined scenarios.

Those attending the conference typically spend about two extra hours at the conference attending technical sessions and visiting exhibitors, still leaving significant time for sightseeing and other activities. Those remaining home use library resources to obtain their technical summaries and the Internet to find vendor information. During the days following the conference, teams are expected to meet and combine their summaries into a coherent paper meeting assignment objectives. Each team is required to submit its paper on the Monday following the conference.

Grading Description:

Objective (weight)	0- unacceptable	1- marginal	2-acceptable	3- excellent
Write a coherent, concise, and high quality report as a team (20%)	Not all objectives addressed.	Addresses all objectives, significant spelling, grammar, punctuation, and style issues.	Addresses all objectives, some notable spelling, grammar, punctuation, and style issues.	Addresses all objectives, well-written with very minor spelling, grammar, punctuation, and style issues.
Compose referenced summaries of information relevant to a project task (10%)	Most summaries fail to include references to the source paper or presentation. End notes style inconsistent.	Most summaries include references to the source paper or presentation with minor inconsistencies in end note style.	All summaries include references to the source paper or presentation with minor inconsistencies in end note style.	All summaries include references to the source paper or presentation using a consistent end note style.
Function effectively as a multidisciplinary team to collect relevant information (15%)	Some specified subject areas not included in the report. Some team members fail to fully participate.	All specified subject areas included in the report and but not tied together by a common concept (product or process). Some team members fail to fully participate.	All specified subject areas included in the report and tied together by a common concept (product or process) with some inconsistencies. All team members participated.	All specified subject areas included in the report and tied together by a common concept (product or process). All team members participated in all aspects of the project.
Develop a list of objectives to meet project outcomes (10%)	Report indicates no advance planning to obtain information required for the report.	Report indicates the plan prepared to obtain information required for the report was inadequate.	Report indicates a loosely structured plan prepared to obtain minimal information required for the report.	Report indicates a well-structured plan prepared to obtain cohesive information required for the report.
Identify current research related to project objectives (25%)	Fewer than 2 unique papers (conference presentations or journal articles) included for each person for each participating course. Some topics are inconsistent with the team objective. Summaries may be incomplete and fail to establish relevance.	Summaries of at least 2 unique papers (conference presentations or journal articles) included for each person for each participating course. Some topics are inconsistent with the team objective. Summaries may be incomplete and fail to establish relevance.	Summaries of at least 2 unique papers (conference presentations or journal articles) included for each person for each participating course. Topics are not necessarily consistent with the team objective. Summaries may not be complete and establish relevance.	Summaries of at least 2 unique papers (conference presentations or journal articles) included for each person for each participating course. Topics are consistent with the team objective. Summaries will be one paragraph per paper, be complete, and tie the topic to the team objective.
Identify vendors which produce products suitable for project requirements (20%)	Descriptions of fewer than one unique product or service included for each person for each participating course.	Descriptions of at least 1 unique product or service included for each person for each participating course. Items are consistent with the team objective. Several descriptions will be incomplete and fail to tie the item to the team objective.	Descriptions of at least 1 unique product or service included for each person for each participating course. Items are not necessarily consistent with the team objective. Some descriptions may be incomplete or fail to tie the item to the team objective.	Descriptions of at least 1 unique product or service included for each person for each participating course. Items are consistent with the team objective. Descriptions will be complete, and tie the item to the team objective.

Figure 2. *Rubric distributed to students and used for project grading.*

ASSESSMENT

The first year of this project, students completed post-project surveys. For the second offering, students were asked to complete both pre- and post-project surveys. Summaries of the results for the two years combined are given here.

- *Among those attending the conferences, nine had not attended technical sessions prior to this project, four had attended such sessions. Afterward, all had attended conference technical sessions.*
- *Prior to this assignment, seven had previously located articles in the literature, five had not. All had done so after the project.*
- *Prior to this assignment, six had previously identified vendors for engineering products or services, six had not. All had done so after the project.*
- *This project was the first time working with some of their teammates for all but four students participating.*
- *Of 26 respondents, 22 indicated they assisted other students with decisions they needed to make to complete the project.*
- *Five students indicated they spent 0-3 hours on the project; 13 said 4-6 hours; and nine said 6 or more hours. The average self-reported time spent on the project was about 6 hours in both years.*

In the second year of the project, students were surveyed both before and after the project. Table 1 summarizes the results, which indicate that students did make significant gains in knowledge and lifelong-learning capability, with more modest gains in their perceived ability to work in teams.

Students were also asked to name the best and worst elements of the project. The most popular responses for best element included learning about topics not covered in the curriculum and interacting with other classes. The worst elements included poor student leadership, confusion about the project (mostly in the first year), and the time required for the project.

Instructor concerns prior to assigning the project included the amount of grading. With a team size of about seven students, however, the number of reports to grade was limited. The use of the aforementioned rubric also simplified the grading process. A grade sheet for each student, with adjustments for peer evaluation and for leadership, was provided to each class instructor for recording and distribution to the students. The confusion issue was also a great concern and was addressed in part by providing students in the second year with successful examples of reports from the previous year. One mistake made the first time this project was assigned was not providing teamwork training to the students. This has been rectified through a program held through the AIChE student chapter prior to the assignment's distribution. Additionally, library training sessions were provided in the second year, along with focused training for team leaders and distribution of background materials to each team on that year's topic.

Participation of other faculty in the department is also a key concern. Changing an existing course requires effort on the part of the instructor to integrate the project into the course. That effort would result in little benefit to the instructor, so there needs to be "buy-in" to the efficacy of the project significantly improving achievement of program outcomes. Additionally, concern regarding the project contributing to achieving course outcomes has been raised, particularly in the courses involving sophomores. The load on the faculty member coordinating the assignment is about four contact hours (teamwork training, library training if not provided elsewhere, and project organization meetings) plus preparation time, grading time for reports, and time for meeting with student leaders to address their concerns and questions.

The assessment of teamwork proved unsatisfying to the instructor, consisting of the third item on the rubric (Figure 2), review of student peer evaluations, and review of student project evaluations. Other assessment methods for teamwork are suggested in the literature and should be considered for the next offering.[15,16]

SUMMARY

A project to vertically integrate chemical engineering students into a multidisciplinary team was successful in developing an introductory understanding of emerging areas in chemical engineering. Students experienced the pain of multidisciplinary teams as they successfully completed a

TABLE 1

Summary of Student Responses to Pre- and Post-Project Survey Questions in the Second Year of the Project

Students were asked to respond to a set of questions and indicate their agreement according to a five-point Likert scale, where 5 indicates strong agreement and 1 indicates strong disagreement. Sample size was eight students.

Question	Pre-Project Average (Std. Dev.)	Post-Project Average (Std. Dev.)
I work well with teams.	3.625 (1.69)	4.000 (1.31)
I know the relevance of nanotechnology to chemical engineering.	1.875 (1.13)	3.875 (1.55)
I can find the technical information I need in chemical engineering from the literature.	3.250 (0.89)	4.125 (0.64)
I know what is meant by "the literature."	2.750 (1.49)	4.125 (1.13)
I know what nanotechnology means.	2.875 (1.36)	3.625 (1.69)

report consisting of referenced summaries of technical papers and identification of vendors of products and services, all tied to objectives the team previously developed and the courses in which they were enrolled. The project made contributions to program outcomes in communication, lifelong learning, multidisciplinary teamwork, and contemporary issues. An additional benefit was the increased interaction among students in a small, nontraditional chemical engineering program.

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