# Freshman Seminar in Chemical Engineering: Strategies for Student Success

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**Abstract** – A first year seminar for chemical engineering freshmen was developed to address a number of critical needs during the first semester on campus. In addition to developing a sense of community among the students and a sense of belonging to a department 'family', this first semester also provides the venue to introduce students to their profession and its diverse opportunities. Modules developed for the course focused on personal development, professional development, and topics related to the chemical engineering profession.

*Keywords:* Freshman seminar, professional development, acclimation to campus life; history of chemical engineering, chemical and environmental accidents.

## INTRODUCTION

Freshmen entering the university are embarking on the journey to establish credentials for future employment in the industrial sector. Often, those subjects that interested them or that the student excelled in during high school guide their choice of a major in college. In chemical engineering, students who excel in and are interested in high school subjects such as chemistry, physics and mathematics form the basis for the undergraduate student population.

As entering freshmen, they often have limited information regarding the diversity of opportunities that their career choice may provide. Their experience from high school does not often lend itself to self-recognition of the importance of every course in the chemical engineering curriculum. The first year offers an opportunity to explore the diverse opportunities that their future career holds and to learn how their education during the coming four years will prepare them for these opportunities. Freshman students transitioning into college may need assistance in navigating that experience, as it is typically very different from what they have been exposed to in a traditional high school setting. As educators, the desired outcome for every single freshman entering the chemical engineering curriculum is graduation with a B.S. degree in chemical engineering. Successful navigation through the undergraduate curriculum is a result of many different influential factors.

The one-hour freshman chemical engineering seminar was added to the curriculum at Mississippi State University (MSU) in 1997. Having been taught by a variety of individuals, the course has developed over the years to encompass a variety of activities that are beneficial to the entering freshman. This paper presents some of the activities that the instructors feel are particularly useful in promoting the professional and personal development of the student, and to these students learning about their profession, its history, and its future early in the undergraduate endeavor. Silverstein et al. [1] presented the results of a survey of freshman engineering courses offered by chemical engineering departments across the country. Visco and Arce [2] describe a similar course at Tennessee Tech. Many of the elements incorporated into the MSU seminar are similar to those discussed in these papers and used at other institutions.

## COURSE STRUCTURE

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The course was scheduled as a one credit hour seminar, scheduled during the fall semester of the freshman year. Specific course objectives are shown in Table I, and fall into five primary categories: community building, academic success skills, personal development, professional development, and orientation. The semester activities were fairly well distributed across these five objectives and examples of these activities are given in subsequent sections. Many of these activities are readily adaptable to similar courses in other engineering disciplines.

Table I. CHE Freshman Seminar Course Objectives

| Primary Objective | Specific Elements |
|---|---|
| Community Building | Development of a supportive, learning environment for all CHE freshman |
| Academic Success Skills | Understanding personal learning style, individual and group study skills, collaborative learning strategies, campus resources, time management |
| Personal Development | Identifying personal goals, building self-confidence and self esteem, group dynamics and teamwork skills, maintaining balance in one's life |
| Professional Development | Rewards and opportunities of engineering study, understanding what engineering is, exposure to the history and industrial practice of chemical engineering, professional student organizations, ethics and professionalism, cooperative education opportunities |
| Orientation | Making effective use of campus resources, organization of the college, college regulations, academic advising, information regarding curriculum and concentrations |

**Community Building Activities**

On the first day of class, students were teamed in groups of 3 to 4 and asked to compile of list of traits/characteristics that all had in common. The listing of items compiled from among the teams included some that were expected:

1) All liked chemistry in high school
2) All freshmen
3) All were in the top five in their high school graduating class
4) All have not yet purchased all of their books
5) All received scholarship to attend MSU

However, common characteristics also included some that were unexpected:

1) All have an A in first name
2) None was born in Mississippi
3) All have Facebook page/account
4) All from the gulf coast of Mississippi
5) All drive jeeps

This exercise provided the students a means to get to know something about a few of their classmates that they might not normally find out through traditional means. Getting to know classmates is the first step in building a community among students. The instructors also participated and used this activity to introduce themselves to the class. Key to the community building is development of a rapport between students and department faculty. By teaming the instruction in this course, students became aware during that first semester that they had advocates who were there to help them navigate through the undergraduate experience and could serve as resources to them, should they have questions.

**Personal Development Activities**

Time management is a skill that students often must develop independently. In the freshman seminar, four activities were devoted to helping students mature this essential skill.

The first assignment of the semester was for students to complete a semester calendar, identifying tests dates, draft and final paper due dates, project due dates, final exam dates, and any personal activities that would occur during their first semester (i.e., family birthdays, weddings and other planned events; sports activities). To facilitate this, students were supplied with an Excel file structured as a monthly calendar, with university holidays, football games and freshman seminar assignment due dates already in place. In addition to using their syllabi from other classes to identify when tests were scheduled, students were asked to examine what course elements were used in determining their final grade in each class.

During the next class session, results from the calendar assignment were compiled for the class in an interactive manner. A 'raise your hand' poll allowed quick tallying of the number of tests/project due dates scheduled for each student each week of the semester. Not surprisingly, some weeks were relatively free of these activities, while some weeks were packed full of tests/projects. Discussion about how professors divide up the semester into equal intervals for scheduling of tests ensued, combined with discussion of how to best approach such a week as a student. Some students found that every time they had a chemistry test scheduled, they had a calculus test the same day. Being proactive and effective planning of studying to accommodate such a schedule was discussed, with input sought from the students.

Also discussed was the determination of final grades for their courses. In many cases, the only elements that contributed to final grades in a course were the tests and the final examination. This was a revelation to many of the freshmen as they were expecting contributions from homework, daily grades, bonus or extra credit assignments to be included as in high school. Students came away from the discussion with an understanding of how important it was to do well on each of their exams and some strategies to implement.

The second assignment of the semester was for students to complete a time management log for a seven-day period (24-hour log). Specific categories were defined:

1) Attending class
2) Studying (be specific - studying what subject)
3) Physical activity (exercise, participation in intramurals, etc.)
4) Relaxation (watching TV, talking on phone, using internet for non-academic endeavors)
5) Personal health (meals, personal hygiene)
6) Sleep

Students brought the time management logs to class the next week and were asked to tally up the number of hours spent in the first four categories. Many students found that they spent far less time than the traditional 3 hours of study for each credit hour of class. The importance of physical activity and relaxation to overall work/life balance was discussed. Instructors provided strategies for maximizing use of the time between classes for effective studying.

A brainstorming exercise where student teams identified 'What do you need to master to be successful in your courses?' was conducted. Student teams were asked to list as many elements as they could in a five-minute period. The lists were turned in with a master list compiled by the instructor and posted to the course website. A short presentation at the beginning of the next class reinforced to the students that they knew what they needed to do to be successful. Some of the particularly insightful answers were pointed out to the class, including:

1) Know test/homework format
2) Make serious effort to understand the text
3) Make sure you have an understanding of problem before moving onto next problem
4) Produce a game plan for the test
5) Variation of problems (how can professor ask similar question, but give different input data?)

A second brainstorming exercise was conducted with student teams answering the prompt: "Identify all distractions that prevent you from studying effectively". For thirteen of the seventeen teams, the number one distraction was identified as Face book. Student discussion of the distractions identified also revealed strategies for minimizing the impact of these distractions on studying.

The third assignment required students to complete the online 'Index of Learning Styles' developed by Silverman and Felder [3]. Students were required to submit their results electronically to the instructors prior to the next class meeting. Results were compiled for the class and presented graphically. The conclusion that everyone learns

differently and needs input from a variety of modes was very apparent from the graphical results. Materials taken from the National Effective Teaching Institute short course [4] and from resources available on Felder's website [5] were used in the learning styles presentation. Links to these materials were provided to the students on the course website. In addition, links to Felder's 'Meet the Students' compilation [6] were provided, giving students a better comparison/contrast of sequential/global learners and other learning style categories.

The seminar was also used as a vehicle to discuss the various concentrations available in chemical engineering at MSU (chemical engineering practice, chemical engineering research and development and biomolecular engineering), highlighting the distinct elements of each. This information was provided in a class meeting prior to preregistration for the coming semester. Advising was accomplished for all of the freshmen in the course, with the instructors circulating to discuss what courses needed to be scheduled the coming semester for each individual (students not being advised used the time to work on their semester project described in a later section of this paper). The required courses were very similar for the majority of the students. Specific issues that arose during on-line registration were also readily handled during class. For example, often courses/course sections are full before a particular student is able to register. By providing the students with concrete instructions of what to do should this occur, the impact of registration issues/frustration was minimized.

**Professional Development Activities**

Two course elements are particularly adaptable to other chemical engineering departments or to similar freshman seminars in other engineering disciplines. These elements provided the venue for students to learn about the profession through participation in the Career Fair and through participation in discipline specific student organizations.

The Career Fair is held each fall early in the semester on the MSU campus. Companies who recruit on campus typically send recent graduates from MSU to represent them at the Career Fair. In addition to obtaining company literature and the usual assortment of goodies that one takes away from such an event, students were tasked with asking the company representatives from at least three different companies the following question: What two items do recruiters look for on the resumes of prospective employees?

The class period following the Career Fair began with the students teaming in groups of 3 to 4 and compiling a common list from among their answers. The instructors then asked each team to provide the top item on their list. Not surprisingly, the top item on the list of many teams was 'work experience'. Early in the semester, a representative from the Cooperative Education Office came to speak to the class about the cooperative education program and summer employment as engineering interns. Discussion led by the course instructors followed on the timing of such employment and how to readily integrate the coop experience with the current chemical engineering curriculum. Alternate methods of gaining work experience include summer internships. The advantages of such a course of action include the opportunity to work summer terms for different employers, thus, gaining first hand experience in how companies and possibly industries differ. More recently, some seniors in our curriculum have opted to split their senior year, completing the fall semester and then embarking on a year-long cooperative education assignment, followed by the spring semester of the senior year. The projects taken on during the coop experience have been more demanding and have drawn on these students' considerable coursework, but perhaps, really provide the students with a work experience that is very comparable to that of an entry level engineer.

The traditional cooperative education experience at MSU alternates three work semesters with three school semesters. Curriculum sheets showing navigation through the program, with attention to critical prerequisites, were provided to the students, along with the suggestion to seek advice from one of the instructors for long-range planning. Since course offerings have been reduced to once per year for many of the chemical engineering courses at this institution, timing of co-op semesters is critical to avoid delay in matriculation because a key prerequisite had not been taken at the right time. For students considering co-op, the importance of discussing this with their advisor and mapping out co-op/school cycles to ensure that matriculation is accomplished in an efficient manner was emphasized. This fall semester, one of the students enrolled in the freshman seminar last year came in to discuss when she should co-op and a tentative schedule was put together for the remainder of her undergraduate education. For this student, the selection of which semester to begin the cooperative education program (spring versus summer) actually resulted in a 1 year difference in when the student could graduate, because of the once per year course offerings.

Another item commonly identified was 'demonstration of leadership'. Discussion ensued as to how one might demonstrate leadership on a resume. This discussion was preceded by a brainstorming activity where groups of 3 to 4 students compiled a list of possible ways to accomplish this. The key mechanism identified for demonstration of leadership was to actually serve as a leader in a student organization on campus. The pathway to becoming a leader requires that the individual become an active member of a student professional organization to establish themselves as a potential leader.

Each student was required to attend a minimum of two meetings of a student professional organization over the course of the semester. Representatives from the various student organizations that students might be interested in came to the class and gave a five to ten minute presentation on their organization. Organizations participating included American Institute of Chemical Engineers (AIChE), the National Society of Black Engineers (NSBE), the Society of Women Engineers (SWE), the National Organization of Black Chemists and Chemical Engineers (NOBCChE) and Theta Tau (a general engineering fraternity open to all engineers regardless of major or gender). A graded element of the course was a one-page summary for each meeting attended that identified the meeting attended, the meeting date, the speaker, and what the student learned from the meeting. Students enrolled in the course attended meetings where speakers from industry (Chevron, Exxon, Dow, Albermarle, Georgia Pacific, Georgia Gulf among others) talked about career opportunities with their organization. Many of these speakers were recent alumni who could provide the freshmen with an idea of the types of positions that they might obtain in that first job after graduation.

One of the advantages of a requirement such as this in a course scheduled during that first semester of the freshman year is that it encourages early participation in the student professional organizations. This early participation is essential to develop and sustain the development of leaders for these organizations, as the freshmen can observe role models in the form of the junior and senior level students who are currently serving in leadership roles.

The freshman seminar was purposefully scheduled for the 4:00 to 5:00 PM time slot on Thursday afternoon. In addition to being a relatively free time slot that was normally not in conflict with offerings of required chemistry, math and physics courses, this time slot immediately preceded the standing meeting time for the AIChE student chapter. Students were encouraged to stay for the meeting(s) and a number of freshmen have become active chapter members.

**The Chemical Engineering Profession**

It is important for freshmen to begin learning about their chosen profession early in their academic career. Two activities/presentations focused on this aspect. One activity was recurrent and conducted each week. In the undergraduate curriculum, reductions in program credit hours have resulted in a very lean, compact curriculum, where every course is an essential element of instruction. The curriculum can be viewed as a pyramid, with the foundation laid by chemistry, mathematics and physics courses. Subsequent courses build on this foundation by expanding on particular concepts/topics that are important in chemical engineering. This is very different from the typical high school curriculum, where the curriculum is structured as aligned pillars (English, Math, Science, History). Each week at the start of class, students were asked to identify what they were learning in their math course and in their chemistry course - use of index cards allowed for easy gathering of this information. The following week at the beginning of class, the instructors would identify those topics from the previous week, and provide two to three examples of where that particular concept/topic was used in chemical engineering and/or would be revisited in later chemical engineering courses. For example, students were learning about derivatives in calculus. Derivatives are used in chemical engineering in a variety of ways but may be identified by a different name (rate, gradient or driving force, flux). A brief introduction of how gradients/driving forces are used in chemical engineering was provided to the students. Knowing that topics they are seeing in these fundamental courses will be revisited in more depth in later classes provides an incentive for mastery of material.

A presentation on the history of the chemical industry in the U.S. was developed for the course. This included not only information about individual companies and their early products, but also information about how chemicals were produced in batch wise fashion in the early days. A summary of technological milestones for the industry for the early part of the 20th century was given. Facts and figures regarding the U.S. Chemical Industry today were provided, as was a discussion of specialty chemicals versus commodity chemicals, economy of scale, and the various product chains. Few students, upon entering the chemical engineering undergraduate curriculum, have knowledge of the breadth of products that are manufactured from a relatively few feedstock lines. They also have

limited, if any, knowledge of the vast range of production capacities for chemicals. An excellent resource for understanding the production platforms in the chemical industry is available at the Office of Energy Efficiency and Renewable Energy website in the May 2000 Energy and Environmental Profile [7]. Production in the chemical industry is classified into five chains: ethylene chain, propylene chain, benzene-toluene-xylenes chain, agricultural chemicals chain and the chlor-alkali chain. Schematics showing the different chemicals produced and consumer end-use of products in each of these chains provide the freshman chemical engineering student with an overview of the diversity of products that arise from a relatively short list of feedstock materials. There are also tabulated data regarding annual production of commodity chemicals. Students are often surprised to learn that the top 10 chemicals on the basis of annual production are not all organic chemicals (note: data in these tables are from 1997, indicating that perhaps an update of the information on this website is warranted). In fact, the appearance of nitrogen at the top of the list can be used to introduce the class to the concept of process safety. In addition to being used in ammonia production; one of the major industrial uses of nitrogen is to provide an inert atmosphere during hydrocarbon processing.

The concepts of batch versus continuous processing were introduced. Essentially all exposure to chemical reactions in the undergraduate chemistry laboratory is conducted in a batch wise manner; thus, students are familiar with this concept. However, in chemical production via batch processing, additional factors impact the cycle time. Not only is reaction time important, but also the time required for feed preparation, as well as for equipment cleaning between batch runs are important . Introduction of these concepts was then used as a platform for recognizing that batch processing of commodity chemicals would be very impractical.

Energy consumption in chemical production can also be introduced at this time. The enormous energy burden that producing and refining a variety of products from a limited number of feedstocks has tremendous consequences, both from an operational as well as an economic standpoint. Students are learning about energy effects in their general chemistry course, in particular, energy effects associated with phase changes (melting, boiling), those associated with sensible heating of single phase streams and those associated with reactions (enthalpy of reaction; nature of reactions as endothermic or exothermic). Thus, discussing the importance of energy in the chemical industry also provides students with a basic framework in which to cast their study of topics in allied areas.

**Safety and Environmental Awareness in the Chemical Industry**

While serving as instructors for upper level chemical engineering courses, it became apparent that some students had no or limited knowledge of events such as the oil embargo of 1973, Love Canal, Times Beach and Bhopal. This was particularly bothersome to the authors, having lived through these events. In fact, one of the authors (RKT) was living in St. Louis working in the chemical industry when the government testing of the Times Beach area was performed. One of the most gripping images from that environmental tragedy appeared in the St. Louis Post-Dispatch and showed a woman standing in her doorway, holding a toddler clothed in only a diaper on her hip, while government employees fully equipped with appropriate safety gear took soil samples from her yard.

As a result of curriculum assessment activities, the department recently began to offer a process safety course as a senior/graduate elective. The need for graduating chemical engineers to be well aware of safety concerns and how process safety is implemented in industry was a concern that was identified through an alumni assessment survey. Exposure to process safety at the freshman level, including those events in the past that identified major weaknesses/issues in chemical engineering practice, provides the opportunity to have students think about safety as they matriculate through various courses in the chemical engineering curriculum.

A short survey, conducted in class, identified that the majority of students had not heard of at least half of the 13 items listed (Rachel Carson, Silent Spring, Superfund, Love Canal, Times Beach, Chernobyl, Three Mile Island, Seveso, Italy, Rhine River, Woburn, MA, Bhopal, Exxon Valdez, BP/Deep Horizon Spill). Every student was aware of the last event, and some had been personally affected by this environmental accident. A brief overview of each item was provided to the class.

An extensive presentation on the Love Canal incident was provided to the class. This presentation utilized resources available on the web such as the videos of Lois Gibbs talking about Love Canal [8]. Class discussion after the presentation focused on standard practices for waste disposal, how this environmental incident led to the passage of the CERCLA legislation (Comprehensive Enviromental Response, Compensation and Liability Act), and how the chemical industry practices for waste disposal have changed over the years.

The last activity of the semester was a team project focused on an environmental accident/chemical accident. Students were teamed randomly into groups of three or four. All students were given a listing of events that their teams would choose from during class the following week; no more than two teams were allowed to choose the same event. The events are shown in Table II.

Table II. Events for the Final Semester Project

| Event | Location/Date | Event | Location/Date |
|---|---|---|---|
| Texas City Disaster | Texas City, TX, 1947 | Rhine River, Sandoz Chemical | Switzerland, 1986 |
| Flixborough Disaster | Flixborough, England, 1974 | Shell Oil Refinery Explosion | Norco, LA, 1988 |
| Seveso Disaster | Seveso, Italy, 1976 | Piper Alpha | North Sea, 1988 |
| Times Beach | Times Beach, MO, ~1981 | Exxon Valdez | Cordova, Alaska, 1989 |
| Union Oil Refinery | Romeoville, IL, 1984 | Phillips Disaster | Pasadena, TX, 1989 |
| Pemex LPG Center | Mexico City, Mexico, 1984 | BP Refinery Disaster | Texas City, TX, 2005 |
| Bhopal | Bhopal, India, 1984 | BP/Deepwater Horizon Spill | Gulf of Mexico, 2010 |

The assignment was for each team to develop an informative poster presentation to share with the class that provided information about the particular event. Specific guidelines for content required in the presentation included:

Background information
Timeline of the event
What actually happened?
If process plant accident, chemistry involved, safety issues
If environmental event, toxicity information about chemicals
Impact of event (fatalities, injuries, environmental impact)
Resolution - positive and/or negative outcomes resulting from event (positive outcomes might include new legislation, new safety protocols, etc.)

Students were given the opportunity to work in class twice on their poster development. This provided the instructors the opportunity to aid student teams in locating information on the web, and help them identify other resources that might be helpful. The assignment was given 4 weeks prior to the actual day of presentations. The poster presentations were scheduled for one class period. One specific requirement for the presentation was that each team member contributes to the required ten-minute presentation. A rubric was provided to students the week prior to presentations, so that they would know the expectations of the instructors. Each team presented their poster three times. One presentation was to the instructor/professional staff (a Ph.D. chemical engineer and a Ph.D. chemist from one of the university research centers were enlisted to aid the two instructors). The other two presentations were made to teams of student evaluators (seniors enrolled in the Chemical Process Safety course). In addition to learning about an environmental/chemical process event, students gained valuable experience from this activity. More than one student mentioned the need to learn more about a prospective employer with respect to their safety record prior to accepting a coop assignment or permanent employment.

## CONCLUSION/SUMMARY

A variety of activities have been described that have been successfully incorporated into the chemical engineering freshman seminar at MSU. Many of these activities are designed to help the student understand their personal learning style and adapt their study skills/strategies for success in their courses. Students are also exposed to the rich history of their discipline, with particular emphasis on how current events influenced the practice of chemical engineering. Exposure to safety and environmental issues through the team semester project was very informative

for the students and gave them experience in working as part of a team. The course also provided the opportunity for chemical engineering freshmen, new to the university, to meet their peers and department faculty and begin the establishment of a support network that will benefit them as they continue through the curriculum.

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