AC 2010-489: HOW WE TEACH: FRESHMAN INTRODUCTION TO CHEMICAL ENGINEERING

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How We Teach: Freshman Instruction in Chemical Engineering

Abstract

The authors present the results of the first survey in the resumption of the AIChE Chemical Engineering Education Special Projects Committee series of annual surveys on how chemical engineering courses are taught. The survey is now conducted by the AIChE Education Division. This year's survey focuses on the freshman engineering courses and details how freshmen are introduced to engineering, what topics are taught, in what environment they are taught, and how they are assessed. Teaching methods and novel approaches are focus elements of this survey. While the survey focuses on courses specific to chemical engineers, innovative teaching methods in general introduction to engineering courses are included as well.

1. Introduction

The former Education Projects Committee of AIChE conducted a series of surveys and studies of how chemical engineering is taught across Canada and the United States between 1957 and 1994. The topics covered by those surveys and related reports ranged from course-specific curricular issues to broader surveys on topics like professional registration, problem solving, electives, and the curriculum as a whole.

The newly formed Education Division of AIChE recognizes the importance of these surveys to chemical engineering educators and programs as they seek to improve the quality of teaching. The surveys do provide basic information about the courses (topics covered, textbooks used, hours taught, etc.) but are intended to expose innovative and effective approaches to teaching the courses to benefit the broader community.

The 2009 AIChE Education Division Survey focused on introductory courses specifically for chemical engineering students.

2. Method

This year's survey was implemented online using the open source survey software package LimeSurvey (LimeSurvey.org). The questions were designed to generate statistical demographic data, ABET assessment/evaluation data, and examples of effective teaching methods in use. A request was sent to all 158 department heads and chairs in Canada and the US to solicit a response from the most appropriate faculty members in their program. From the population of 158 schools, responses were received from 49 schools (31%). Multiple responses were received from several schools, resulting in a total of 59 responses. A print version of the survey is included as Appendix B.

3. Survey Summary

The first year experience, with emphasis on the Chemical Engineering activities, is characterized by great variety. That variety is based on the fundamental difference in philosophy as to whether year 1 has common content for all branches of engineering or discipline specific programs begin in year 1. For the former, many imaginative ways have been introduced to allow students to gain an understanding of the uniqueness of the disciplines.

This summary considers eight options (with the school code in brackets for the school using this option):

1. Common year 1 with no engineering exposure through courses; basic math and sciences, 0% of responders
2. Common year 1 with required common engineering course(s) with no explicit discipline specific activities and no additional course but other informal events to introduce Chemical Engineering, 8% of responders.
3. Common year 1 with required common engineering course(s) with no explicit discipline specific activities and separate Chemical Engineering course, 20% of responders.
4. Common year 1 with required common engineering course(s) with embedded Chemical Engineering projects/activities and no other ChE courses, 16% of responders.
5. Common year 1 with required common engineering course(s) with embedded Chemical Engineering projects/activities and additional Chemical Engineering course, 14% of responders.
6. Common year 1 with elective common engineering course(s) with embedded Chemical Engineering projects/activities and additional Chemical Engineering course, 4% of responders.
7. No common engineering course; required Chemical Engineering course, 32% of responders.
8. Other, 6% of responders.

These classifications are summarized in Table 1.

In this summary, responses are clustered into these options and we describe each separately. Details about the common engineering courses are limited because the Chemical Engineering wording of the survey biased the responses to focus mainly on the Chemical Engineering courses used in options 3, 5, 6, 7 and 8. We relied on website catalog information to provide some details of the general engineering courses. .

Each option is considered in turn.

Option 1
None of the responses indicated this option.

Table 1. Freshman year options as categorized in this report.

Option	Common Year 1	ChE Activities (no course)	Common engineering courses (no ChE content)	Common engineering courses (ChE content)	ChE course(s)	% of responders
1	X					0%
2	X	X	X			8%
3	X		X		X	20%
4	X	X		X		16%
5	X			X	X	14%
6	X			Elective	X	4%
7					X	32%
Other						6%

Option 2

The programs falling into this category feature a common first-year curriculum, common engineering courses without ChE content, and ChE activities. The types of courses offered include a computing course and a design studio. Some activities used to informally introduce the Department include:

- an organized fair where departments describe their discipline (27)
- informal BBQ and/or open-house event sponsored by a Department (27)
- voluntary departmental seminars and information sessions (48)

The numbers in parenthesis are codes referencing the source university as summarized in Appendix A. A complete version of this paper including the responses from each participating institution is available upon request. A summarized response from each institution in this Option category follows.

- Clarkson University has a common Year 1 with *Introduction to Engineering Use of the Computer*, 2 credits. (10)

- Florida State has a 1 credit computer programming and technical skills for all disciplines; details about how students learn about ChE were not available, class size about 400/year with section size ranging from 30 to 60. (15)

- McMaster University offers 4 credits computing; 3 credits design, 3 credits profession with class size 900 sectioned into 10 sections (27).

- Northwestern has a 2 credit course on Engineering Design and Communication, with class size 350 with 20 per section. It features an integrated introduction to the engineering design process and technical communication; approaches to unstructured and poorly defined problems; conceptual and detailed design; team structure and teamwork; project planning; written, oral, graphical, and interpersonal communications; use of software tools; discussion of societal and business issues. It also offers three required general engineering courses on applied mathematics and engineering analysis (31).

- University of Western Ontario has an 8 credit *Introductory Engineering Design and Innovation Studio* and a 4 credit *Programming Fundamentals for Engineers* (48).

Option 3

This category features a common first-year curriculum, common engineering courses without ChE content, and a ChE course. The ChE courses include surveys of the profession, design courses, and a course in material and energy balances.

- Southern California offers an *Introduction to Chemical Engineering* course that is primarily a mass and energy balance course. Other courses include Engng 102, *Freshman Academy*, 2 credits, fall semester Class size 400 with 13 sections of 30 to 35/section (5)

- Clemson University has an elective course *ChE Tools*, 3 credits that includes small team projects.
- This course also functions to highlight material that appears later in the curriculum and/or their career. Class size is 70 students with two sections of 35 each. They also offer a required, first semester 2 credit *Engineering Disciplines and Skill*, CES 102 that includes brief ChE activities. Class size: 850 to 950; with 60 students/section (11).

- Colorado has a 1 credit elective, *Introduction to Chemical and Chemical and Biological Engineering*, which provides a survey, projects, and experiments. Class size is 120 in one section. Other courses include a 3 credit general engineering introduction to computing course. (12)

- Howard has a spring semester ChE course *Introduction to Engineering Design* with design focus, and simple mass balances. Class size is about 25. They also have a required Fall semester 2 credit *Introduction to Engineering* with class size 125 divided into sections of 25 students and 5 instructors. (18)

- Missouri S&T has an elective *Computers and Chemical Engineering*, ChE 20. It is open to others as elective, 1%. It functions as a survey of the discipline. Class size is 43 and is divided into two sections. Other courses include: required Freshman Engineering 10, *Study and Careers in Engineering*, 1 credit Fall, Class size about 1,000 with 10 sections of about 100/section; a required Interdisciplinary Engineering 20, *Introduction to Engineering Design*, 3 credit 2nd semester, lecture. 15 h, lab 45 h. Class size is about 1,000 spread over different semesters with about 50/section with a 1 h to 1 week overview of ChE. (30)

- Ohio State has a 1 credit *Chemical and Biomolecular Engineering Survey.* Other courses include 10 credits of engineering common courses on visualization, sketching and design, design projects, problem solving, computing, team work and communication (32).

- Penn State offers a required 1 credit *Exploring Chemical Engineering First-Year Seminar,* 3 sections, about 3% of enrollment is non-majors. The emphasis is on college skills, projects and experiments. Class size 75 with 25 per section. Other courses include a required *Introduction to engineering* but more related to other engineering majors than chemical engineering. (35)

- Tennessee Tech has a required, 2 contact hour *Introduction to Chemical Engineering*, ChE 1010, emphasizing college level skills, design projects and experiments. Other required courses are: *Computer Applications in Chemical Engineering*; *Introduction to Engineering* with no ChE activities, 1 credit; and *Programming for Engineers* also with no ChE activities. 2 credits. (39)

Option 4

This option includes a common first-year, a common engineering course with ChE content, and ChE activities. Common course content typically includes programming, teamwork, ethics, software, projects, and communication/writing.

- Auburn University has a ChE section of a general engineering course, *Introduction to Engineering*, ENGR 1110, required for ChE majors, with emphasis on design, college level skills and projects. (2)

- Bucknell University has a required *Introduction to Engineering* with an overview about ChE lasting from 1 h to 1 week with students working on a project. The course is team taught and includes a chemical engineering ethics segment. Class size 210, section size 26 to 27. (4)

- Lafayette College has a required *Introduction to Engineering*, with more than a week of ChE activities. The course is team taught with a class size of 180 students with 18 students per section. (24)

- Texas A&M offers two *Foundations* courses total 4 credits required: course 1 is an introduction to the profession plus computer programming, teamwork, and projects; course 2 is computer programming. (40)

- Tulane has a 1 credit *Introduction to Engineering* that includes some ChE activities. In addition, there is a required 4 credit course in software design and a 3 credit, lecture/tutorial introduction to engineering and computer science. (42)

- Louisville offers Eng 100, *Introduction to Engineering,* which includes an introduction to engineering departments with ethics, software, and case studies. The course is team taught for 2 credits. Class size is 350 divided into sections of 90 to 100; each section is subdivided into groups of 30 for hands-on activities. Additional common engineering courses include 2 credits of graphics.(25)

- Youngstown has a 3 credit required *Engineering Concepts* that includes ChE faculty directing projects lasting more than a week. Additional common engineering courses include 3 credit *Engineering Computing* and 9 credits on *Writing/Communication.* (49)

- Rowan University has no course specific for ChE. A series of two multidisciplinary, project-based general engineering courses are required with a ChE project that lasts over 1 week. The projects serve as a framework for teaching a core set of engineering skills. Class size is about 160 with about 80 each section. *Freshman Engineering Clinic* includes technical communication formats; analytical tools; computer-based tools and an introduction to design; engineering ethics; teamwork. *Freshman Engineering Clinic II* explores the practice of engineering through applications drawn from engineering disciplines. Project work includes a variety of technical communication topics, analytic and computer-based tools, including the design process, engineering ethics, safety, and team work. In addition there is a required course *Introduction to Scientific Programming* (3 credits) (37).

Option 5

This option features a common first-year curriculum, common engineering courses with ChE content, and ChE courses. The ChE course includes seminars, surveys, and AIChE student chapter activities.

- Arkansas offers a unique option. There are common, year 1 engineering courses, but if the students know they want to enter ChE, they may instead take 8 credits of ChE: two 3-credit courses *Introduction to ChE* plus a 2 credit lab course. If the student is unsure or interested in branches other than ChE, then the common engineering courses, which are required by all branches except ChE, are GNEG 1111 *Introduction to Engineering I* with ChE project/activities with focus on key technical skills needed by all professionals. Class size is 300 to 400 with six sections; and GNEG *Introduction to Engineering II* 1121 with class size 300 to 400 with six sections. (1)

- Georgia Tech has a required *Introduction to Engineering* with ChE specific activities lasting longer than a week plus an elective 1 credit *Freshman Seminar* (Chemical and

Biomolecular section). In the seminar the emphasis includes a survey of engineering, college level skills, design projects and experiments. Class size is 79, not sectioned. Another required first year course is 3 credits of computing. (17)

- Mississippi State University has a required 1 credit *Freshman Seminar*, CHE 1101 that provides a survey of engineering and college skills. Class size is 50 to 75. Also required is *Introduction to Engineering* with part of one lecture to describe ChE. (29)

- Oregon State University has a required, 3 credit *Introduction to Chemical, Biological, and Environmental Engineering*. 50% of students enrolled in the course take it as an elective with another major. Class size is 80 for the lecture, 40 for the tutorial, and 15 for the lab. The course meets 15-20 times a term with an emphasis on a survey of ChE and college skills development. They also have as a 3-hour required ChE course *Engineering Problem Solving and Computations.* Additional courses include *Introduction to engineering,* required for ChE, focusing on general engineering skills for all disciplines with a ChE project. (34)

- Polytechnic Institute of New York University offers a required, 3 credit *Introduction to Chemical and Biological Engineering* that is open as an infrequently taken elective. Emphasis is on a survey of the profession and has a design focus. Class size is 35-40 in one section. Three additional general engineering courses are required: *Introduction to Engineering and Design,* 3 credits with 1 h to 1 week for ChE activities, class size 445, 15/section; *Engineering and Technology Forum*, 1 credit, focus on invention, innovation and entrepreneurship, size 460 with 33/section; and *Engineering Problem Solving and Programming*, 3 credits, class size about 460 spread over different semesters, lecture about 60 per lecture section, maximum of 15 per lab section. (36)

- South Dakota School of Mines and Technology has two required courses specific for ChE. One is the 2 credit *Professional Practices in Chemical Engineering* that is an introduction to chemical engineering through the development of computational and laboratory skills. The course is open to non-majors who typically fill 5% of the class. The course emphasizes programming and coupling math concepts with measurements and data. The second required, 1 credit course is *Introduction to Engineering Modeling.* This is an introduction to mathematical modeling of physical and chemical systems; verification of mathematical models by experiment; development and interpretation of engineering drawings, process flow diagrams (PFDs), and piping and instrumentation diagrams (P&IDs); use of a drawing program, such as Visiotec; and an introduction to the process simulator AspenPlus. Other courses include a required, 2 credit *Introduction to Engineering* with emphasis on projects and experiments; an introduction to engineering profession and its various disciplines; how to solve engineering analysis and design problems; training in communication skills, team building, technology tools, and project management. Includes interaction with industry. (38)

- West Virginia University offers an elective, 2 credit, *Introduction to Chemical Engineering.* It is open as an elective to non-majors who fill 11% of the class. The course

emphasis is on a survey, design, college skills, and projects. Other courses include a required *Introduction to Engineering* with less than week of ChE activities, and ENGR 101, Engineering Problem Solving, 3 credits. (46)

- Western Michigan University offers a required 3 credit *Introduction to chemical engineering*, available as an elective for non-majors. Emphasis is on a survey of ChE, college level skill development and projects. Other courses include a required *Introduction to Engineering*, with students working on a ChE project for longer than a week plus skills general engineers need. (47)

Option 6

This category includes a common first-year, an elective common engineering course with ChE content, and a ChE course.

- Kansas State has a required 1 credit course entitled *Current topics in Chemical Engineering,* and a 0 credit *Engineering Assembly* in ChE. This is a survey including college level skills, projects, and experiments. Also offered is an elective common *Introduction to Engineering* with 1 week of ChE activities. (22)

- Ohio University has a required 2 credit *Introduction to Chemical Engineering* containing a survey, college level skills, projects and experiments; and 3 credit *Approaches to Chemical Engineering Problem Solving*, focusing on problem-solving and computers. Also offered is an elective, *Introduction to Engineering,* with 1 h to 1 week of ChE material. (33)

Option 7

In this option, chemical engineering courses are required of freshman. Of particular note are seven institutions that teach material and energy balances in the first year.

- Brigham Young University has a 2 credit required course *Introduction to Chemical Engineering,* ChEN 170, with emphasis on a survey highlighting difference concepts/ideas/courses that will appear later in the curriculum and/or their career, and design. (3)

- The University of California at Berkeley has an elective, 1 credit, Chemical Engineering 24 *Freshman Seminar* with emphasis on ChE recent topics and on critical reading. (6)

- University of California at Los Angeles requires *Introduction to Chemical and Biomolecular Engineering,* 1 credit, CHE 10. This is a survey including microelectronic devices, design of processes with minimal environmental impact, nanotechnology, genetic-level design of recombinant microbes. (7)

- Carnegie Mellon University offers a required, 3 credit *Introduction to Chemical Engineering*, 06-100. The emphasis is on mass and energy balances, highlighting differences and introducing material needed later, design, college level skills, projects and experiments. Class size is 81 in one section. (8)

- Cornell University has a 2 credit elective, *Introduction to Chemical Engineering*, with emphasis on design, general skills, and projects. Class size is 110 with 55 per section and utilizes 3 teaching assistants for each section. (13)

- The University of Florida has a 1 credit *Freshman Seminar in Chemical Engineering* featuring small group discussion with faculty in addition to a 1 credit elective *Introduction to Engineering* with 1 h to 1 week overview of ChE activities. (16)

- Illinois Institute of Technology offers a required 6 credit sequence *Introduction to the Profession I,* CHE 100 and CHE 101 *Introduction to the Profession II* with emphasis on design, college level skills, and projects. (19)

- The University of Iowa uses a multi-track system with three courses: a 0 credit *CBE Departmental Seminar*; and two 3-credit courses, *Engineering Problem Solving I and II.* (21)

- The University of Kentucky offers a required, 1 credit *Introduction to Chemical Engineering*, CME 101. The emphases are a professional survey and college skills. The course introduces the chemical engineering profession and includes problem-solving techniques, use of computers, computer problems, and lectures by practitioners. Class size is 81 in a single section at the main campus and 12 at the extended campus. Another required, 3 credit course is *Computational Tools in Chemical Engineering,* also taken as an elective for non-majors. This is an introduction to computational tools used in chemical engineering, such as Microsoft Excel, Visual Basic for Applications, and MATLAB.

- The Massachusetts Institute of Technology offers a required 8 credit Introduction to Chemical Engineering, which is open to non-majors as an elective. This course is open to freshman, but many are sophomores since this is Mass and Energy Balances, survey of courses in the program, and applied math. During the fall, class size is 75; in the spring, class size 20 to 35. (26)

- The University of Minnesota, Duluth, has a required 3 credit *Introduction to Chemical Engineering*, open to others as elective. This gives a survey of ChE, college level skills, projects, and experiments. Class size is a maximum of 40, usually 30 - 35. (28)

- University of Texas at Austin has an optional 1 credit CHE 102 Introduction to ChE and a required 2 credit course in computing, CHE 210. The former (CHE 102, 15 h, no text, lecture style) shows students how to succeed, faculty describe research and practicing engineers share experience in wide range of careers. Also describe variety of departmental activities including a fall exposition, descriptions of co-ops and internships. Contains a team project and group presentations. Class size is 102 in a single section. (41)

- The University of Utah offers a required 3 credit *Introduction to Engineering Computing*. This is a survey of computing tools. (43)

- Washington State has a required, 3 credit combination of introduction to mass and energy balances and an introduction to the discipline. Forty-one hours are devoted to lecture with 4 hours spend in lab. Felder and Rousseau's text is used in the course text along with desktop learning modules for fluids and heat transfer. Software taught includes HYSYS, Excel, and MathCAD. Guest lectures are also given. There is a particular emphasis on building *esprit de corps*.(44)

- Ecole Polytechnique has a required 3 credit course *Introduction to chemical engineering design.* (14)

- West Virginia University Institute of Technology offers a required 3 credit *Introduction to Chemical Engineering*. The focus is on design, college skills, and lab. (45)

Option 8
This option includes scenarios not previously considered.

- The University of Illinois requires a 3 credit CS 101 computing course; a required 0 credit 1st semester ENG 100 Engineering Orientation; and a required ChE 121, *The CHBE Profession.* (20)

- At the University of Arkansas, ChE students select 8 credits of two 3 credit courses plus 2 single credit labs with emphasis on material and energy balances, professional survey, design, and college level skills. All other branches of engineering take a required alternative stream with common *Introduction to Engineering I and II* courses. (1)

- Case Western Reserve offers an elective non-credit ChE course, *Introduction to Chemical Engineering*. (9)

2. Engineering general courses

From our responders and web catalog, the required engineering courses in year 1 are

- Computing
- Professional survey
- Design
- Visualization/graphics

The class size, as large as 1,000, is usually sectioned to sizes less than 100 with usually multiple faculty per section together with graduate and/or undergraduate mentors.

Even for the larger classes, efforts are made to bring active learning into the class, especially via clickers. (27)

For those general engineering courses that focus on design or a general introduction to the profession, usually there is a team design project. The options include devising generic type projects that illustrate many of the disciplines or to ask departments to present discipline-specific

projects. For the former, the challenge is to find projects that include ChE; for the latter, to find representative projects that are capable of being done by first years students and in the time available.

An example where a separate ChE section is identified in the general engineering course is Auburn University. Auburn University has a required general engineering course, *Introduction to Engineering - Chemical Engineering Sections*, ENGR 1110. The ChE section is required for ChE and no text is required, but PowerPoint materials, a department Student Success Handbook and Guides are distributed. A project to design a fuel cell car is used. The teaming project and having a set of 3 or 4 others to work with the whole semester helps with development of confidence. Learning to work on a schedule and to complete a term project is challenging- but the instructors provide weekly guidance on what should be happening, and have periodic group meetings with instructor to assess and encourage progress. Professional development memos get the freshmen in contact with upperclassmen. Several faculty and staff work with teams on aspects of the project and they serve as guest lecturers, showing that many are approachable and want to be helpful. But also helpful is maintaining clarity and rigidity of due dates, expectations, and a sense of professionalism Emphasis in the course is on design, college level skills, and projects. The prioritized list of topics in the course: 1. Teamwork, 2. Technical Communications, 3. Problem Solving. (2)

The Polytechnic Institute of New York University offers *Engineering and Technology Forum* for 1 credit. The course focus is on invention, innovation and entrepreneurship (i2e). Students are exposed to elements of a research-intensive institution and diverse research performed by leading engineers, scientists, inventors and entrepreneurs. Class size is 460, with 33 per section. (36)

An example of a general engineering course whose focus is primarily on professionalism is McMaster University's 3 credit *Introduction to Professional Engineering*. There are no ChE specific activities in the course. The course stretches over two semesters, Fall and Winter, with 24 hours of lecture and 22 hours of tutorial sessions. The required texts are C.L. Dym, "Engineering design: a project-based introduction" published by Wiley; and M. Northey, "Making sense in engineering and the technical sciences: a student's guide to research and writing," published by Oxford University Press in 2009; plus instructor's notes. This introduction to the practice of engineering including ethics, health and safety, roles and responsibilities to society, engineering communication, design skills and group work, Professional Engineers of Ontario, design and problem solving, change management and lifelong learning. The course features an eclectic set of 99 objectives including how to greet professionals, stress management, professional requirements, professionalism, e-mail correspondence, project management, meeting deadlines, teamwork, self and peer assessment, giving and receiving feedback, respect, assertiveness, conflict resolution, group problem solving, goal setting, patents, design process, creativity, creating metrics, client needs and wants, stakeholders, and elements of interpersonal communication skills. Included is an *Engineers Without Borders* poverty project. Class size, is 800 with 10 sections. (27)

3. Details about ChE courses

Consider now details about the ChE courses. About 60% had no required text and have created their own notes or made copies of their PowerPoint materials. The required texts suggested the flavor of the course:

- Felder and Rousseau[1] (5 schools)
- Himmelblau[2] (1 school)
- *The Engineering Student Survival Guide*[3] (2 schools)
- Holtzapple & Reece *Concepts in Engineering*[4] (1 school)
- Solen and Harb *Introduction to Chemical Processes* [5] (5 schools)
- Duncan and Reimer [6] (2 schools)
- Recktenwald [7] (1 school)
- Cutlip[8] (1 school)

The basic pattern is that those who offer a ChE course in the first year (usually as a required course) is:

- 3 credit introduction with great imaginative variations
- 1 credit seminar type, again with many creative ideas.

With three-credit hours available, some provide a general overview of the profession (46, 3, 33, 34, 36, 47, 44, 28); others focus on design (14, 13, 19, 45), computation (34, 23, 41, 43) and some on mass and energy balances (8, 26, 11).

With one-credit hour available, the courses tend to be surveys of ChE as a profession (17, 6, 29, 22, 7, 23). Illinois gives an interesting course on orientation to the university. (20) A focus on general useful skills is given. (6, 41)

Naturally the course content and flavor was driven by the purpose as perceived by the instructor. Not all the responders listed the priorities for their course, but here is a sampling of the top three priorities. Here the bold face is for three-credit courses; no bold face indicates one-credit courses.

The most popular priority was to answer the questions

- *"What is ChE? What do they do?"* **(1, 3, 8,** 12, 20, 23, 29, **30, 34**, 39, **44, 46**) or 60% of responders. Other related priorities were *How to train to be a ChE? What courses are needed?* (12, 20, **30**) or 15% of responders and *Awaken an interest in ChE* **(3,** 6, 23**)** or 15% of responders.
- An interesting priority was to *meet the students, show them that the Department cares* (6, 12, 29, **34**, 39, **44**) or 30% of responders.
- A very popular objective was to develop student's *skill in problem solving* (**1, 2, 5, 11**, 23**, 28,30**, **34, 38, 43**), or 50% of responders
- Related priorities for the development of skills needed to succeed and for a professional were the development of
    - communication (**2**) or 5% of responders ;
    - critical thinking and logic (6, **38**) or 10% of responders
    - learning styles (**13**) or 5% of responders
    - team skills (**2, 34**) or 10% of responders
    - University resources and skills to do well (20, **34**) or 10% of responders.
- How to succeed in university (1, 20)

Other priorities were

- to teach design (**13)** or 5%
- to introduce Math and ChE concepts (**5, 11, 30, 38, 43, 46**) or 30% of responders.

What is ChE?

- Pease of the University of Utah has an excellent, three paragraph introduction the profession of ChE. This is included in his syllabus *for Introduction to Chemical Engineering (Computing)*, CHEN 1703. (43)

- The University of Arkansas with a 3 credit course describes alternatives to traditional chemical engineering (medical school, law school, etc.); employment; co-op, internship and research opportunities; curriculum; study habits. (1)

- Carnegie Mellon University uses a mass and energy balance context to provide both awareness of Chemical Engineering discipline and problem solving skills. (8)

- Clemson University's 3 credit elective highlights material that appears later in the curriculum and/or their career and focuses on developing problem solving skills.(11)

- Cornell University helps students grasp professional perspective by introducing a rich set of current issues. (13)

- Missouri University of Science and Technology in its elective, 3 credit course, use the pair of texts by Solen and Harb[5] and by Cutlip and Shacham[8] to provide an overview of the ChE profession and curriculum. (30)

- The University of Oregon's 3 credit course uses the first three chapters of Felder and Rousseau, plus notes for environmental ethics, resumes, and writing. The course includes an introduction to the engineering profession, problem solving, and teamwork. The weekly lab on engineering uses examples from daily life (Fluid Mechanics of Showering, Tea Brewing, etc.). The AIChE ChemE Car Competition is a project. Some guest lecturers are also used.(34)

- The University of Minnesota Duluth's 3 credit course uses Solen and Harb[5] and Fleddermann[9.] It introduces a broad spectrum of engineering issues: describes the differences between natural sciences and chemical engineering, introduces the concepts of continuous processing and waste disposal, process flow sheets and equipment (with a tour of the senior lab including details of the internals of pumps and valves and with web information equipment vendors of pumps, tanks, columns); hazardous waste; engineering economy, including value of money and rate of return along with process paths based on economics; species allocation and separation. The course includes a team case study. Guest speakers from industry are also features. (28)

- Tennessee Technological University offers a 2 credit course that surveys curriculum linkages, the profession, collaborative work environments, professional societies and laboratory skills and has speakers from industry. (39)

- At the University of Utah, Leonard Pease's version of the 3 credit course uses Solen and Harb[5] as required text and focuses on an overview of ChE, resume writing, an essay on "What excites me about chemical engineering," and students identifying everyday examples of heat transfer, mass transfer, fluid mechanics, mass balances and thermo. (43)

- At the West Virginia University Institute of Technology student teams develop a consumer product including a market estimate, location assessment, manufacturing process, P&ID and Visio diagram, environmental impact, and desirable product features. They also write a reaction paper about technology impact on social problem: "Do Biofuels Starve the Poor", "What Should the U.S. Government do to Respond to Climate Change?" (45)

- The University of Colorado's elective 1 credit course has tours of labs, faculty describing research, student panels, team work and group project, and field trips. Examples of specific projects include an imaginative "scavenger hunt" and an egg drop project. Teams (with upper class mentor) are assigned an American state and for that state students identify two companies and select a chemical product. For the product they document process, reactions, energy, and use of compound, then present their report as a poster. For discovery, teams interview faculty, graduate students and other undergraduates to discover information about key words related to ChE. (12)

- In West Virginia University's 2-credit course students prepare two brief projects (diads report on traditional ChE area; report on emerging ChE topic); three short projects (diads use Excel, use visual basic to solve ChE problem and optimize ChE or Bio process); and complete a team major project that synthesizes all skills and knowledge in course. (46)

- The University of Illinois at Urbana-Champaign gives brief descriptions of ChE course in curriculum, three industrial engineers describing their career, university resources, offices, minors, cooperative education, internships, and the importance of leadership. Imaginative variety of activities including resume writing, identifying short and long term career goals, researching famous alumni and their remarkable inventions. Offers optional activities from among research paper, active participation in AIChE local Chapter or in the Engineering Open House, a tour of BP refinery, talk about famous alumni or present a demo on a ChE topic (20).

- Penn State's 3 credit course includes introduction to Career Services, a Career Fairs assignment, and a research projects assignment. (35)

- Some encourage active participation in AIChE student Chapter. (1, 20, 29, 30, 39)

How does our program train you as a ChE?

- Ken Solen at Brigham Young University, in a 2 credit course highlights difference concepts/ideas/courses that will appear later in the curriculum and/or their career and design. It offers an excellent introduction to most dimensions of chemical engineering through practical calculations following a case study considering safety, environment, heat

exchangers, CSTR, fluid flow, process synthesis, and economics. Teams then apply this knowledge solving another case design problem. (3)

- Washington State University has produced Desktop Learning Modules for Hands-on learning of fluid mechanics and heat transfer, and have also developed a computer programs that assists students in learning material balances. (44)

- UIUC includes in their 1 credit course one hour example lectures for each course in the curriculum: mass and energy balances, thermo, fluids, heat and mass transfer, reaction engineering and reactor design. (20)

Developing problem solving skill

- The University of Southern California's required 3 credit course has novel group projects such as synthesis of gold nanoparticles and growth of *e. coli* cells in their mass & energy balance type course. (5)
- Carnegie Mellon, similarly, uses a mass and energy balance course to develop problem solving skill. (8)
- The University of Iowa has two, 3 credit courses, with a focus on basic problem solving skills, communication, and team skills. (21)

Developing communication skills

The emphasis in West Virginia University's 2-credit course is to improve the student's communication skills through writing numerous reports. (46)

Team skills

Most schools have a lot of team projects/ activities.

Developing esprit de corps

In this category is the use of tasks requiring the students interact with the faculty in the department and with other students in the program.

- Tennessee Tech requires students to report on an AIChE student chapter event. Students write reports about interviews with upper class students on *how to succeed* and also survey 20 peers. (39)

- Washington State places emphasis on communicating to first year students that "we care about them". Details are not given about how this is done. (44)

- Colorado's elective 1 credit course has teams interviewing faculty, graduate students and other undergraduates to discover information about key words related to ChE. (12)

- Kentucky in its 1 credit course has material on the website. But students need a secret code to access those materials. To get the secret code students must introduce themselves to all faculty members and obtain a personal code (that students then unscramble for success). (23)

- In Illinois's 1 credit course, students are introduced to different faculty because each gives a one hour example lecture for each course in the curriculum: mass and energy balances, thermo, fluids, heat and mass transfer, reaction engineering and reactor design. (20)

Exciting students about ChE

- A goal of Berkeley's elective 1 credit course is to excite students about ChE through critical thinking and discussion of recent readings from CEP, Science, Nature, and Physics Today. (6)

- At UCLA, the required 1 credit course surveys microelectronic devices, design of processes with minimal environmental impact, nanotechnology, and genetic-level design of recombinant microbes. (7)

- At MIT, in the 8 course sequence, each section of the course is introduced via a question. It starts with "What is ChE?" and builds from there. (26)

Design

- Cornell University's 3 credit elective uses Duncan and Reimer's text[6] to introduce design. (13)
- Design is also a focus at École Polytechnique de Montréal. (14)
- Oregon has a required, 3 credit ChE course, with a team-based design competition using the LEGO RCX microprocessor for data acquisition. (34)

Helping students succeed

- Learning styles are included in the Cornell program. (13)
- Tennessee Tech provides sexual harassment awareness training; has a community service project; emergency preparedness training; requires students to attend (and report on) non-engineering club event and fine arts event, a multicultural event, and an AIChE student chapter event; time and stress management training; and a locus of control inventory. (39)
- University of Minnesota Duluth's 3 credit course contains activities for self awareness, ethics, communication and team skills. They also use inventories to help students identify career preferences and behavior in teams. (28)
- Illinois Institute of Technology has an eclectic two-course sequence with invited speakers from the Entrepreneurship program, Career Management Center, Library, and Study Abroad office. (19)
- Kentucky uses Donaldson's *The Engineering Student Survival Guide*,[3] to help students succeed. They include a wide range of imaginative assignments including time management. (23)
- At Mississippi State University in a 1 credit course, they work to enable students to establish strong working relationships with their peers and to support learning in science and math courses taken concurrently. Details of how they do this are not given in their response to the survey. (29)

4. Pedagogy:

Where course details were available they are viewed considering the five goals for course design.[10,11]

- the course is in a continuum in developing program outcomes
- there are clear goals and criteria
- the learning environment promotes learning
- there is appropriate assessment
- there are elements to monitor effectiveness

4.1 Course in a continuum in developing the program outcomes

The student's should know the overall outcomes of the program and how each particular course helps the student work toward the achievement of those outcomes. These are not course objectives/goals or outcomes; these are overall program outcomes. Some used ABET criteria as the program's outcomes (for example 28 and 44). From the survey, here are some examples:

- At Arkansas, Ed Clausen provides a good summary of Departmental Program outcomes and how this course fits in to achieving those objectives. (1)
- At BYU, 12 program outcomes are listed with a clear indication of how this course contributes. (3)
- WVU lists four course outcomes with a clear indication of how elements of this course will help student's achieve the overall program outcomes. (46)
- Oregon State gives a clear relationship between course components and program outcomes. (34)
- MIT gives 13 overall program outcomes and clearly shows the course in this context. (26)

4.2 Clear goals and criteria

Usually one would expect published, observable goals with measurable criteria. Typically in a syllabus there will be about 10 to 20 with about 60 to 80 specific goals distributed throughout the term. Whether or not such details are available, rarely did the responders provide such details. The learning objectives we received usually were not expressed in observable terms and were often a list of 6 to 12 goals. Some examples of more extensive course learning objectives include: 27 listed (36), 99 listed (27), 11 listed and keyed to the outcomes in the syllabus. (28)

4.3 The learning environment promotes learning

The lecture with 50 minutes of teacher-talk is likely the least effective method of promoting learning. Here are some approaches faculty members have taken to improve learning in the context of a lecture format:

- ask for team presentations (41)
- based on engagement, feedback and transparency; use guided inquiry, clickers and ELM (e-learning at Mac); think-pair-share, team blogs, multimedia lectures, brainstorming sessions, design project competition, *Engineers Without Borders* poverty project (27)
- some one-on-one problem solving work (1)
- extensive use of a class web page and also have a wiki page that has supplemental tutorials and information (43).
- active learning activities (30, 39)

- UC Berkeley, Jeff Reimer uses small class with active discussion; visits to research facilities; occasionally an experiment in a lab Discussion to add reflection, build confidence. To promote discussion for all, he uses random selection and a "dice-roll". (6)
- clickers (27, 29, 30)
- in class team work (3, 11, 8, 39)
- posting material in advance and lectures are recorded and delivered as podcasts (43)
- active tutorials with discussion and team work (21)
- in-class problem-based learning (8)
- work problems in class as individuals, group activities for brainstorming, work more elaborate problems and ethics discussions (28)
- each student has computer (that faculty can monitor, 30) or that teams can use to work on project (35)
- use multimedia, including videos (30), films (3)
- use a tablet-pc for modeling, data taking, and P&ID drawings (38)
- use guest speakers from alumni, from industry (26), from professors from subsequent courses
- pose a question at the beginning of each section of the course: what is ChE? M&E B; formulating learning math to solve problems (26)

The lecture hall also provides the meeting-place to help achieve a range of course goals. Occasionally, recent literature that applies to problems relevant to chemical engineering are distributed and discussed. Roughly two weeks are dedicated to discussions of progress on the team term project. Students present results. (26)

South Dakota uses the approach where new ideas/techniques are presented, followed by students using, or exploring immediately via an in-class exercise that they must finish (individually or in teams) before they leave. As they leave they are given the instructor's solution and a homework assignment that is due the next class periods (38).

Some imaginative methods are used to combine activities and goals (in the context of what happens in the class-room. For example, AIChE meetings are held immediately after class (29).

An integral and important part of creating the learning environment is the syllabus. Unfortunately, many see the syllabus as a summary of the rules for the course, names of the instructors, office hours, methods of assessment, policies of lateness and cheating, required texts and perhaps the schedule of events and names. But, there are over 50 elements that might be included in the syllabus and some of the most important elements set the tone for the learning environment[12].

Doyle's 16-page syllabus is excellent, includes students' and instructors' expectations and a very good two-page section on how to succeed (27). Leonard Pease's syllabus provides an outstanding, three-paragraph overview of the profession that we recommend that everyone peruses. The syllabus includes excellent rationalization of class activities, clearly expects the students to succeed and outlines how the students can do well in the course. (43)

4.4 Appropriate assessment related to the learning goals

For all the responders, a rich variety of assessment options were used consistent with the learning outcomes.

Some interesting additional variations included

- mark draft reports and give feedback to improve final version (27).
- use peer and self assessment (27, 3, 8, 30).
- biweekly quizzes; and weekly in-class programming exercises (38)
- daily "clicker" quizzes embedded in the PowerPoint presentations (30)

For team monitoring and assessment Rowan (37) uses Comprehensive Assessment of Team Member Effectiveness (CATME) surveys for peer evaluation of contributions to team assignments**.** See https://engineering.purdue.edu/CATME

4.5 Monitoring and program evaluation

Angelo and Cross give a rich set of options for monitoring the quality of the learning that occurs[13].

Options used for end of semester included

- a survey or course evaluation(41, 1, 30, 8). For example, Arkansas uses the Purdue "cafeteria style" 200 item evaluation forms (see http://www.uark.edu/admin/vcacsey/AcaPolicySeries/140515.pdf) (1)
- consultation with later course instructors and potential employers (8)
- focus group at the end of the semester.(39)

Options used during the semester included

- using clickers (30).
- Brigham Young has good explicit monitoring via in-course questionnaires. Good explicit activities provide faculty-student interaction (3).
- quality of in-class relationships with the following explicit methods of obtaining feedback.
- at the start of each class asks individuals to summarize previous class. (6). Such monitoring also promotes reflection and active learning.
- conversations with students (8, 28)
- conversations with the TAs (27)
- periodic surveys (26, 43),
- asking the class to complete ("the 5 minute paper") the following statement: "I still don't understand..."(26)
- mid-term and end-of-term surveys (26)
- use ombudspersons (27)
- Students' technical writing ability and presentation skills were assessed at the beginning of the semester, throughout the semester, then at the end of the semester. Improvements in writing and presentation skills (along with technical skills) were assessed using the same rubrics throughout and tracking the progress of the class (46).

Options for before and after included

- concept inventory pre-and post-tests in collaboration with the School of Education (5)
- pre and post class surveys (39)

5. Greatest challenges

Common concerns and challenges are: getting first year students up to speed with the expectations in the ChE program; finding good problems/ cases or materials; coping with the larger size class and the need for multiple sessions; and coordinating the TAs and mentors.

The responses in terms of frequency include:

1. maturity, self confidence, and diverse backgrounds (1, 2, 3, 5, 6, 8, 26, 27, 28, 43). Some options we are aware of to address this include:
    - use inventories to help students identify their personal uniqueness and help them realize that each is special[14]. For example, Washington State uses learning style inventories (44), Tennessee Tech uses locus of control plus stress and time management (39). Other useful inventories include Belbin team contribution inventory or equivalent, MBTI or Jungian typology, Kellner-Sheffield stress and self confidence, Kirton inventory, Lancaster approaches to studying LASQ, Beck attitude, and Billings-Moos.
    - use the syllabus and first class to clarify your role and their expected role, that you expect them to succeed and outline activities they can do to do well in the course, and rationalize the choice of learning environment selected and assessment activities chosen[12,15].

2. good ChE problems that are within background of first year students (8, 11, 28, 37, 46)

3. Students unwilling to work hard enough (1, 3, 5, 23)

4. Limit of time in a 1 credit offering (6, 23, 29)

5. motivation (30), with possible answers supplied by (38), students unclear about how best to use the resources (1), good videotapes/CDs showing ChE processes (3), class size of 120 students (12), of 140 (20), students don't know what ChEs do (39), and finding the right text (43).

Some faculty have prepared problems (3, 46) and it would be valuable to develop a "share the problem" site. For example, those teaching senior design courses had a similar challenge; in 1989 a 42 page guide to resources was prepared[16]. For McMaster's first year projects, the topics we used were: design of a hydrogenator to convert edible oil to margarine; design of a treatment process for waste automobile lubricating oil and an analysis of a fossil-fuel fired power generation station.

6. Conclusion

Great variety in approach - that is how one might characterize the approach to teaching Chemical Engineering in year 1. A few have no explicit activities in any year 1 courses, and in some the students learn about ChE via job fairs and Departmental events. There are required common engineering courses that feature design, computer programming, drawing/visualization,

professionalism and the development of skills such as teamwork. These are important courses but our survey did not elicit much detailed information about this approach.

Many have a required common engineering course that does include a ChE experience – whether it is a separate section specific to ChE and projects unique to ChE. Many ChE Departments offer courses that are either elective or required. Often these provide an introductory survey of the profession and an introduction to the Department. Great imagination has been used in creating such courses.

How many of the courses are taught is interesting. The class size is some is 1,000 but most are sectioned to sizes of 100 or less. Efforts are being made to change the student learning experience from passive to active. Some put the course in context of the overall program outcomes and the role this course plays in achieving some of those outcomes. A variety of methods are being used to monitor the student learning throughout the year.

The greatest challenge is the student's lack of maturity and self confidence and the diversity among the students.

We hope faculty will be able to use the results of this survey to better tailor their classes to meet the needs of their program through the innovative ideas and delivery mechanisms described within.

7. Acknowledgements

We apologize to those who patiently completed the survey describing sophomore courses in mass and energy balances. Because our emphasis was on first year courses, we did not include your input in this summary.

We also offer our sincere thanks for those who invested the time in responding to this survey, and to the department chairs who passed on our request to their faculty.

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Appendix A. Code number of responding institutions.

1. Arkansas, University of,
2. Auburn University,
3. Brigham Young University,
4. Bucknell University;
5. California, University of Southern,
6. California, UC Berkeley,
7. California, University of Los Angeles
8. Carnegie Mellon University,
9. Case Western Reserve,
10. Clarkson University
11. Clemson University,
12. Colorado, University of at Boulder
13. Cornell University
14. École Polytechnique de Montréal
15. Florida State University
16. Florida, University of,
17. Georgia Institute of Technology
18. Howard University
19. Illinois Institute of Technology;
20. Illinois, University of Urbana-Champaign,
21. Iowa, University
22. Kansas State University
23 Kentucky, University of
24. Lafayette College
25. Louisville, University
26. Massachusetts Institute of Technology
27. McMaster University
28. Minnesota Duluth, University
29. Mississippi State University,
30. Missouri S&T
31. Northwestern University
32. Ohio State University
33. Ohio University
34. Oregon State University
35. Penn State
36. Polytechnic Institute of New York University
37. Rowan University
38. South Dakota School Mines T
39. Tennessee Tech
40. Texas A&M University
41. Texas The University of at Austin
42. Tulane University,
43. Utah, University of,
44. Washington State University
45. West Virginia Univ Institute of Technology
46. West Virginia University
47. Western Michigan University
48. Western Ontario, The University of
49. Youngstown

Appendix B. Print version of the survey instrument.

AIChE Best Practices in Teaching

This Year's Theme: Freshman "Introduction to Chemical Engineering" (different from "Introduction to Mass and Energy Balances") Freshman in Chemical Engineering.

Our goal is to improve our teaching. You add your unique style to how you teach your course. The purpose of this survey is to gather and share innovative ideas about how we teach the course selected for this year's theme. Please share your approach with us so that we can summarize the current approaches and have a "sharing session" at the annual AIChE meeting.

Part 0: Your information

First, we have a few questions about the person completing this survey and other personnel involved in the course.

Respondant What is your name?
Please write your answer here:
_____

Email What is your e-mail address?
Your email address will not be shared with anyone or used outside of the context of this survey.
Please write your answer here:
_____

University What is the name of your institution?
Please write your answer here:
_____

ReportCopy Should we send the summary findings to you?
Please choose *only one* of the following:
- o Yes
- o No

Colleagues If this course is team taught, please give the names and email addresses of your colleagues.
Please write your answer here:
_____
_____
_____
_____
_____
_____
_____
_____
_____

Part 1: The Freshman in Chemical Engineering Course

ChECourse Does your program offer an "introduction to chemical engineering" course?
Please choose *only one* of the following:
o Yes
o No

1.1 What is the introduction to chemical engineering course title?

Please write your answer here:
_____

1.2 What is the introduction to chemical engineering course catalog number/designation?
Please write your answer here:
_____

1.3 Is this course:
Please choose *all* that apply:
o Required for Chem Eng majors
o Elective for Chem Eng majors

1.4 Is this course open to students other than ChEs?
Please choose *only one* of the following:
o Yes
o No

1.4a % of non-ChE's in class
Please write your answer here:
_____

1.4b Is there a separate section for non-ChE students?
Please choose *only one* of the following:
o Yes
o No

1.4c For non-ChE students is the course:
Please choose *only one* of the following:
o Required
o Elective

1.5 During which term is it offered?
Please choose *all* that apply:
o Fall
o Winter
o Spring
o Summer

1.5b How many weeks are in the term?
Please choose *only one* of the following:
o 10
o 12
o 15
o Other: _____

1.6 What are the total contact hours for each compent of the course?
Please write your answer(s) here:
Lecture: _____

Tutorial: _____
Lab: _____
Other: _____

1.7 What is the required text?
Please choose *all* that apply:
 o Basic Principles and Calculations in Chemical Engineering, Himmelblau and Riggs
 o Introduction to Chemical Processes, Solen and Harb
 o Elementary Principles of Chemical Processes, Felder and Rousseau
 o Introduction to Chemical Processes, Murphy
 o The Engineering Student Survival Guide
 o Engineers and Their Profession, Kemper & Sanders
 o Engineering Success, Schiavone
 o Concepts in Engineering, Holtzapple, Reece
 o Engineering Your Future, Oakes, Leone, Gunn
 o Introduction to Engineering Analysis, Hagen
 o Self-made course pack
 o None, course notes only
Other: _____

1.8 What other resources are required to be used by students? This may include enrichment notes, web activities developed by you or others, developed by others but accessed by your students, PowerPoint materials, etc. Please be as specific as you can.
Please write your answer here:
_____
_____
_____
_____
_____
_____
_____
_____
_____

1.9 Which of the following describes your freshman/first-year chemical engineering course? (Select all that apply)
Please choose *all* that apply:
 o It is a mass-and-energy balances class
 o It is a survey class highlighting difference concepts/ideas/courses that will appear later in the curriculum and/or their career.
 o It is focused on design
 o It is focused on college-level skills (study skills, note taking, public speaking, time management, writing, etc.)
 o It has several hands-on projects/experiments throughout the semester
Other: _____

1.10 Previous questions pertained to first-year courses specifically about chemical engineering. We would also like to know a little about your general engineering intro course, if there is one.
Does your institution currently offer an "introduction to engineering" course in the freshman/first year?
Please choose *all* that apply:
 o Yes, is required
 o Yes, but it is elective
 o No, not offered

o Offered in lieu of discipline-specific intro course

1.10a In what way(s) is/are the discipline of Chemical Engineering incorporated in your general engineering intro course (Select all that apply)
Please choose *all* that apply:
o It isn't.
o An overview segment of between one lecture and one week is included.
o An overview segment of longer than one week is included.
o Students work on a chemical engineering project during the course.
o It focuses on key technical skills common to all engineering disciplines (ex: computer programming, mathematical modeling, fluid mechanics, etc).
o Other

1.10aa In what other ways are Chemical Engineering topics incorporated in the Introduction to Engineering course?
Please write your answer here:
_____
_____
_____
_____
_____
_____
_____
_____
_____

Part 2: The Context

In this section we are trying to develop a profile on where an "Introduction to Chemical Engineering" Course fits into the curriculum. If you do not teach such a course, you may move to the next page.

2.1 What are the published prerequisite subjects (subject area, course number, course title, credit hours, ex: Math, MA201, Calculus I, 4) ?
Please write your answer here:
_____
_____
_____
_____
_____
_____
_____
_____
_____

2.2 For what other courses is this course a prerequisite (subject area, course number, course title, credit hours, ex: Math, MA201, Calculus I, 4) ?
Please write your answer here:
_____
_____
_____
_____
_____

_____
_____
_____
_____

2.3 What program outcomes does this course contribute to satisfying, and how does it do so?

Program outcomes in this survey refers to those objectives which students should be able to meet upon graduation.

Please write your answer here:

_____
_____
_____
_____
_____
_____
_____
_____
_____

2.4 What are your course learning objectives?

Please write your answer here:

_____
_____
_____
_____
_____
_____
_____
_____
_____

2.5 Please copy your course syllabus/outline (that is usually posted or given to students at the beginning of the course that provides details, regulations, assessment criteria, office hours, global objectives, university policies on cheating, etc.). Alternately, please email the syllabus to SilverDL@engr.uky.edu or provide a URL linking to the document..

Please write your answer here:

_____
_____
_____
_____
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_____
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_____
_____
_____

2.6 Please provide a prioritized list of your top three goals for this course. For example: Problem solving? Learning fundamentals? Application of fundamentals? Illustrating fundamentals? Learning to apply mathmatics? Use of modeling?
Please write your answer(s) here:
1.: _____
2.: _____
3.: _____

Part 3: Accreditation dimensions

3.1 As appropriate for ABET criteria and Canadian CEAB standards: please rate the extent to which this course satisfies each.
Please choose the appropriate response for each item:

(3a) an ability to apply knowledge of mathmatics, sc
(3b) an ability to design and conduct experiments, as well a
an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, e
(3d) an ability to function on multidiscip
(3e) an ability to identify, formulate, and solve
(3f) an understanding of professional and ethic
(3g) an ability to communicate effec
(3h) the broad education necessary to understand the impact of engineering solutions
(3i) a recognition of the need for, and an ability to en
(3j) a knowledge of contemporary i
(3k) an ability to use the techniques, skills, and modern engineering

3.2a How do you assess the outcome (3a) an ability to apply knowledge of mathmatics, science, and engineering? Please give more detail on options you select.
Please choose all that apply and provide a comment:

- o 32a1 _____
- o 32a2 _____
- o 32a3 _____
- o 32a4 _____
- o 32a5 _____

3.2b How do you assess the outcome (3b) an ability to design and conduct experiments, as well as to analyze and interpret data? Please give more detail on options you select.
Please choose all that apply and provide a comment:

- o 32a1 _____
- o 32a2 _____
- o 32a3 _____
- o 32a4 _____
- o 32a5 _____

3.2c How do you assess the outcome (3c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic,

environmental, social, political, ethical, health and safety, manufacturability, and sustainability? Please give more detail on options you select.

Please choose all that apply and provide a comment:

- o 32a1 _____
- o 32a2 _____
- o 32a3 _____
- o 32a4 _____
- o 32a5 _____

3.2d How do you assess the outcome (3d) an ability to function on multidisciplinary teams? Please give more detail on options you select.

Please choose all that apply and provide a comment:

- o 32a1 _____
- o 32a2 _____
- o 32a3 _____
- o 32a4 _____
- o 32a5 _____

3.2e How do you assess the outcome (3e) an ability to identify, formulate, and solve engineering problems? Please give more detail on options you select.

Please choose all that apply and provide a comment:

- o 32a1 _____
- o 32a2 _____
- o 32a3 _____
- o 32a4 _____
- o 32a5 _____

3.2f How do you assess the outcome (3f) an understanding of professional and ethical responsibility? Please give more detail on options you select.

Please choose all that apply and provide a comment:

- o 32a1 _____
- o 32a2 _____
- o 32a3 _____
- o 32a4 _____
- o 32a5 _____

3.2g How do you assess the outcome (3g) an ability to communicate effectively? Please give more detail on options you select.

Please choose all that apply and provide a comment:

- o 32a1 _____
- o 32a2 _____
- o 32a3 _____
- o 32a4 _____
- o 32a5 _____

3.2h How do you assess the outcome (3h) the broad education necessary to understand the impact of engineering solutions in global, economic, environmental, and societal context? Please give more detail on options you select.

Please choose all that apply and provide a comment:

- o 32a1 _____
- o 32a2 _____
- o 32a3 _____
- o 32a4 _____

- o 32a5 _____

3.2i How do you assess the outcome (3i) a recognition of the need for, and an ability to engage in life-long learning? Please give more detail on options you select.
Please choose all that apply and provide a comment:

- o 32a1 _____
- o 32a2 _____
- o 32a3 _____
- o 32a4 _____
- o 32a5 _____

3.2j How do you assess the outcome (3j) a knowledge of contemporary issues? Please give more detail on options you select.
Please choose all that apply and provide a comment:

- o 32a1 _____
- o 32a2 _____
- o 32a3 _____
- o 32a4 _____
- o 32a5 _____

3.2k How do you assess the outcome (3k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice? Please give more detail on options you select.
Please choose all that apply and provide a comment:

- o 32a1 _____
- o 32a2 _____
- o 32a3 _____
- o 32a4 _____
- o 32a5 _____

3.3 Please share how explicitly you developed those abilities you rated 3 or 4.
Please write your answer here:

_____
_____
_____
_____
_____
_____
_____
_____
_____

Part 4: Assessment

4.1 Please describe the methods of student assessment used, this time outside of the context of accreditation. Please give details for methods that you use. This could include things like "pop quizes", use of "clickers", other active learning techniques with feedback, tests, reports, reflective exercises, surveys, etc.
Please choose all that apply and provide a comment:

- o 41a _____
- o 41b _____
- o 41c _____

- o 41d _____
- o 41e _____

4.2 Please elaborate on "other" methods you use.
Please write your answer here:

_____
_____
_____
_____
_____
_____
_____
_____
_____

Part 5: The Learning Environment

5.1 Please describe the learning environment used. This can include the classroom type (large lecture hall, small classroom, multimedia enhanced classroom, computer lab, small group tables, etc.) and class activities (lecture, active learning, projects, cooperative groups, team projects, problem-based learning, experiments, posters, plant/site visits, etc.). Please give details of the features you use in the class.
Please write your answer here:

_____
_____
_____
_____
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_____
_____
_____
_____

Part 6: Monitoring and evaluation

6.1 What methods to you use to monitor (formative and summative assessment) and evaluate (use results of assessment) the effectiveness of your course? Examples include "concept tests", pre- and post- tests, etc.
Please write your answer here:

_____
_____
_____
_____
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_____
_____
_____
_____

Part 7: Major challenges

7.1 What are the major challenges associated with this course, and how do you overcome them? Possibile challenges include: developing self-confidence, maturity, professional attitude; finding ood problems; sources of practical applications.
Please write your answer here:

Part 8: Wrapping up

8.1 If you have a website for this course you are willing to share with use, please give the URL. If needed, please supply a student ID/password that would allow us to check out materials.
Please write your answer here:

8.2 Any other comments regarding the first-year experience of your chemical engineering students would be welcome.
Please write your answer here:

8.3 Any comments regarding this survey would be welcome.
Please write your answer here:

Submit Your Survey.

Thank you for completing this survey.

Please fax your completed survey to:270-534-6317