TEACHING PROCESS DESIGN: A SURVEY OF APPROACHES TAKEN

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ABSTRACT

A detailed survey of fifty universities revealed that the major difficulties in teaching process design are lack of time, difficulty in choosing a project topic, inadequate student background, vague teaching philosophy, and encouraging creativity. Comments and suggestions for minimizing these five difficulties are given. Summary tables and figures of the data received from the questionnaire are presented.

The emphasis in the report is to share as much information as possible about teaching process design. Statements are clearly referenced; sources of more information are documented.

SELECTED DATA FOR CHEMICAL ENGINEERING UNDERGRADUATE DESIGN COURSES SUMMARY

by C. W. Balch
Dean of Adult and Continuing Education

and

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In the spring of 1970, questionnaires were sent out to all chemical engineering departments in the United States and Canada. Of the 154 sent out 98 were returned for a 62% success factor. Selected data are reported here.

1. Chemical Engineering design courses open to undergraduates:

Required:	0	1	2	3	Optional:	0	1	2	3
	9%	33%	32%	5%		51%	30%	5%	11%

2. Number of students in first design courses this year. 28

3. Number of faculty involved. 1.7

4. The design course is taken -

Junior year - 7%
Senior year -92%

Semester		Quarter	
1	36%	1	3%
2	36%	2	14%
		3	3%

5. Important Prerequisites (ranked in order of importance)

	N.R.*	A	B	C	D	E	F	Corequisites
A. Unit operations	14	68	16	0	0	0	0	3
B. Thermodynamics	10	59	30	0	0	1	0	4
C. Physical Chemistry	24	32	20	14	3	0	4	1
D. Transport Phenomena	32	29	25	8	0	2	4	2
E. Kinetics	47	27	18	3	1	1	1	16
F. Computer Programming	14	25	33	18	1	0	6	2

*(No response)

6. Time Analysis: How did you devote your time -

	First Design Course	Second Design Course
Lecture	49%	44%
Calculation Period	51%	56%
Laboratory (expt)	42%	24%
Other	39%	49%
Clock Hours (students spend)	142	152

7. Approach used:

	Course		
	First	Second	
(a)	31%	16%	Overall plant design with construction and operating cost estimates plus return on investment.
(b)	10	4	As above plus comparison of alternative route plus level of manufacture/sales.
(c)	8	2	Battery limits process design.
(d)	6	5	AIChE student contest problem.
(e)	6	1	Single step of a process.
(f)	3	2	Single piece of equipment design.
(g)	2	3	Overall plant design.
(h)	2	1	As above plus construction cost estimate.
(i)	2	1	As above plus operating cost estimate.

Source of problems (outside of AIChE) ranked in order of importance

0 (no response) 1 (highest) 5 (lowest)

	0	1	2	3	4	5
Professor's background	20%	40	34	1	4	0
Text	67	10	11	8	2	2
Industry Supplies	75	7	7	6	2	2
Washington University Course Studies	47	18	29	5	1	0
Other Course Studies	72	5	14	7	1	1

9. Industrial Participation.

(a) Is it practical - 61% affirmative

(b) If so, to what extent -

Complete	Substantial	Moderate	Little	No Resp.
1% (2)	18% (27)	32% (49)	14% (21)*	34

(c) If it is practical how much have you used it.

Complete	Substantial	Moderate	Little	No Resp.
1% (2)	14% (25)	15% (27)	25% (46)	45

(d) Visitation frequency: Quarterly (12%), Monthly (6%), Biweekly (5%), Weekly (6%) Other (25%)

(e) Mean distance for industrial man to travel: 153.4 miles

* No response eliminated

10. Topics experienced in courses and projects.

	Design 1	Course 2	Design Project
Library Use	79	37	39
Cost Evaluation Project	76	39	44
Process Design of Kinetics, Chemistry	75	39	41
Report Writing	68	38	44
Cost Estimate of Alternatives	67	34	36
Rule of Thumb Design	68	29	32
Estimation of Physical Properties	64	29	41
Optimization	62	37	33
Computer Programming	61	36	26
Materials Selection	61	34	34
Pollution Consideration	53	37	34
Equipment Design	51	31	36
Process Control	40	25	29
Mechanical Design	24	15	1
Decision Theory	21	15	13
Working Drawings/Layouts	17	14	17
Piping Layout	7	5	7
Scale Model Construction	5	3	9

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

COMMITTEE CORRESPONDENCE
In reply please address:

C. W. Balch, Dean
Division of Adult & Cont. Ed.
The University of Toledo
2801 West Bancroft
Toledo, Ohio 43606

March 11, 1970

Memo to: Chemical Engineering Department Chairman

From: C. W. Balch and G. F. Bennett

Subject: Chemical Engineering Design Questionnaire

In preparation for a Symposium on Chemical Engineering Design Education to be held at the annual meeting in Chicago this year we are sending you the attached questionnaire to determine present practices and goals in the teaching of chemical engineering design.

Would you or your staff member most concerned with design please be kind enough to complete the questionnaire and return it to me at the University of Toledo, Division of Adult and Continuing Education.

We will incorporate your reply and comments in the report to be given at Chicago. Your assistance in making this presentation successful will be very much appreciated.

We would appreciate the questionnaire's return by March 31, 1970.

CWB/lb

March, 1970

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

Education Projects Committee

Undergraduate Education Subcommittee

Design Questionnaire
Undergraduate Chemical Engineering

C. W. Balch
Professor of Chemical Engineering
Dean, Adult & Continuing Education

G. F. Bennett
Associate Professor of
Biochemical Engineering

The University of Toledo
Toledo, Ohio 43606

(Please check one of following)
This institution is on the:

Quarter System _____

Semester System _____

Trimester System _____

Other _____

_____
Name of University

_____
Name of Professor Completing Questionnaire

I. How many courses open to undergraduates do you have in chemical engineering design that are: A. Required -- 0 1 2 3 B. Optional -- 0 1 2 3

II. What is the total equivalent semester hours involved in these courses:

A. Required: _____ B. Optional: _____

III. How many students did you have in your first design course this year_____?

IV. How many faculty members worked with the above students_____?

V. When may first design course be taken? (Circle one)

A. Junior Year

1. First Semester
2. Second Semester
3. First Quarter
4. Second Quarter
5. Third Quarter

B. Senior Year

1. First Semester
2. Second Semester
3. First Quarter
4. Second Quarter
5. Third Quarter

VI. What are the important prerequisites and corequisites to this first course?

(please rate in degree of importance -- A for high, F for low)

	Prerequisites	Corequisites
A. Unit Operations	1 _____	2 _____
B. Transport Phenomena	1 _____	2 _____
C. Kinetics (reactor design)	1 _____	2 _____
D. Thermodynamics	1 _____	2 _____
E. Economics	1 _____	2 _____
F. Physical Chemistry	1 _____	2 _____
G. Computer Programming	1 _____	2 _____
H. Other _____	1 _____	2 _____
I. _____	1 _____	2 _____
J. _____	1 _____	2 _____

VII. How is the time devoted (by %) in first design course:

A. Lecture _____ C. Laboratory (experimental) _____

B. Calculation Period _____ D. Other _____

VIII. How is the time devoted (by %) in second design course:

A. Lecture _____ C. Laboratory (experimental) _____

B. Calculation Period _____ D. Other (specify) _____

IX. How many total clock hours do you estimate the student spends A. _____ first B. _____ second courses. Include classes and outside work.

X. A. During early design courses the students work: (Circle one)

1. Individually
2. In Groups
3. Both

B. The students working as you have indicated above attempt to solve:

(Circle one)

1. Different Problems

2. The Same Problem

3. Variations of the Same Problem

XI. Which of the following most nearly describes the approaches used: (Mark one correct answer for each course)

A. First Course	B. Second Course		
_____	_____	1.	AIChE contest problem
_____	_____	2.	Single piece of equipment design
_____	_____	3.	Single step of a process
_____	_____	4.	Battery limits process design
_____	_____	5.	Overall plant design
_____	_____	6.	Overall plant design plus site selection
_____	_____	7.	Overall plant design with construction cost estimate
_____	_____	8.	Overall plant design with construction and operating cost estimates
_____	_____	9.	Overall plant design with construction and operating cost estimates plus return on investment
_____	_____	10.	Overall plant design with construction and operating cost estimates plus return on investment
_____	_____	11.	Overall plant design with construction and operating cost estimate plus return on investment plus comparison of alternative route plus level of manufacture/sales
_____	_____	12.	Other (state nature) _____

XII. If you do use the AIChE contest problem, how? (Circle answer)

A. Under contest conditions

B. With assistance to the student (and nonsubmission)

C. At student's option to choose a or b route

D. Other (state) _____

XIII. If you do not use the AIChE problem or use other problems in addition to it, what is your problem source. Please rank (in margin) in order of importance (1st, 2nd, 3rd, 4th, 5th)

_____ A. Professor's background

_____ B. Text (s) (list by author) (1)_____

(2)_____

(3)_____

_____ C. Industry supplies

_____ D. Washington University Case Studies

_____ E. Other case studies (source)_____

(nature)_____

XIV. What texts do your students normally purchase (state by author).

_____

_____

_____

_____

XV. In the course do you

A. include consideration of process uncertainties? (Yes) (No)

B. include consideration of economic uncertainties? (Yes) (No)

C. use optimization techniques? (Yes) (No)

XVI. A. Are computers used in the course? 1. (Yes) 2. (No)

B. If so, please rate degree of utilization. (A for high, F for low)_____

XVII. In your opinion, is industrial aid in your design courses practical in your location? (Yes) (No)

XVIII. Returning to question XVII, if you feel aid <u>is</u> practical, to what extent is it practical.

A. Little

B. Moderate

C. Substantial

D. Complete

XIX. If industrial aid is practical, <u>have you</u> utilized it? (Yes) (No)

XX. To what degree has it been utilized:

A. Little

B. Moderate

C. Substantial

D. Complete (industry handles the whole course)

XXI. What frequency does the industrial man who has aided you visit the school:

A. Weekly

B. Biweekly

C. Monthly

D. Semesterly or quarterly

E. Other _____

XXII. How far does he come _____ miles.

XXIII. What company aids you _____

XXIV. Have you approached industry for aid without success?

A. (One company) B. (More than one company - give number) _____

XXV. What would help you in teaching design?

_____

_____

_____

_____

XXVI. A. Have you ever been able to make field trips to inspect the process involved? (Yes) (No)

B. If yes, do you consider them valuable (A) or of no use at all (F)? Please rank _____

XXVII. A. To what extent are the students made responsible for acquiring necessary physical property data?

None _____ Some _____ Entirely _____

B. What sources do they use (check answer(s)):

Literature _____ Laboratory _____ Estimation _____

XXVIII. Do you include any work to stimulate "social" awareness e.g. pollution consideration, impact of technology on society, etc.? Please comment:

_____

_____

_____

XXIX. Do you have any problems in the design area in cooperation or attitudes of other members of your own department? Please comment:_____

_____

_____

XXX. Topics Experienced in Course & Project

Topic	Design Course		Design Project
	First	Second	
A. Optimization			
B. Decision Theory			
C. Computer Programming			
D. Rule-of-Thumb Design			
E. Mechanical Design			
F. Working Drawings/Layout			
G. Scale Model Construction			
H. Piping Layout			
I. Cost Estimates of Alternatives			
J. Cost Evaluation of Project			
K. Equipment Design (Equipment, Hardware, etc.)			
L. Process Design (Kinetics, Chemistry, etc.)			
M. Materials Selection			
N. Process Control			
O. Estimation of Physical Properties			
P. Pollution Consideration			
Q. Use of Library			
R. Report Writing			

3.7 More Information

The purpose of this summary is not just to present some of the impressions I gained from the survey, but to share as much information about process design teaching as possible. It is hoped that the list of respondents could be used to facilitate correspondence between interested staff members. To this list should be added

Indiana Institute of Tech., Dr. T. G. Dixon,
Laval,University of, Dr. P. H. Roy
Massachusetts, University of, Dr. K. D. Cashin
Northwestern University, Dr. H. M. Hulburt

Sample problems and rather extensive details of the courses were sent by the following universities: 2, 6, 7, 11, 12, 13, 23, 25, 26, 31, 33, 36, 44, 46, 48, 49, 51.

An informal inter-university design group was set up last year for those interested in teaching design, process design and related topics. The purposes of the group are

1. to share teaching experiences and ideas in this course where many novel and different approaches are taken,
2. to try to collect a rule-of-thumb design manual,
3. to circulate, hand-out literature so that duplication of effort will be minimized,
4. to try to standardize on economic nomenclature and definitions,
5. to exploit the possibilities of interuniversity cooperation and competition.

Most Canadian universities have been contacted; Dr. P. L. Silveston of Waterloo University has agreed to be the coordinator of this effort.