SUMMARY REPORT

TEACHING OF UNDERGRADUATE

REACTOR DESIGN

A Mini-session presented at the

Annual Meeting

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INTRODUCTION

In 1971, the Chemical Engineering Education Projects Committee conducted a survey on the teaching of Mass and Energy Balances in the chemical engineering curricula of about 150 universities in the United States and Canada. Data on texts, laboratory sessions, course content and placement in the curriculum were compiled. Innovative teaching techniques were shared with other faculty. There were 59 replies to the first questionnaire. This year's survey brought 136 replies.

A questionnaire was mailed to the department chairman at 170 universities in late April. A follow-up letter is sent in July to departments which have not responded. Results are reported at the Undergraduate Free Forum at the Annual Meeting. A copy of the survey is mailed to each department submitting a completed questionnaire.

DIVISION OF ACADEMIC YEAR

101 departments (75%) operate on the semester system. 81 departments use semesters lasting 14-16 weeks. 34 departments (25%) use the quarter system. At 28 departments, a quarter consists of 10-11 weeks of instruction.

PLACEMENT IN CURRICULUM

Table 1 shows that 72% o f the offerings of reactor design occur in the senior year. (Some departments offer the course more than once a year.) 59% of the offerings are in the first quarter or the first semester of the senior year; 23% are in the second semester or third quarter of the junior year. It appears the reactor design course is offered concurently with the beginning of the plant design/process design sequence in the senior year.

SECTIONS AND ENROLLMENTS

Since reactor design is generally taught in the senior year, fewer sections should be needed than for sophomore or junior courses. One section per year is taught at 63% of the departments responding while an additional 27% teach two sections. Responses ranged to six sections per year.

The number of sections offered differs for schools on the semester or quarter system. Under each system, 89% of the departments offer one or two sections. Under the semester system, 67% offer one section and 22% offer two sections. Under the quarter system, 50% offer one section and 39% offer two sections.

The enrollments per section are given in Table 2. About half the schools have enrollments between 25 and 44 persons per section. If the enrollment is taken at the mid-point of the respective ranges for each department, the average is 42.5 students per section.

TEACHING ASSISTANTS

Teaching assistants are used only sparingly in the reactor design course. Only 8% of the departments use TA's. At these schools they teach less than 6% of the lectures.

COURSE STRUCTURE

Reactor design is a required course in the chemical engineering curriculum at all but one of the departments responding. While 85% of the courses include no laboratory section, 6% include 1 hour lab per week and 4% include 3 hours per week. It is reasonable to assume that experiments related to reactor design and kinetics are included in a unit operations laboratory or a similar general course.

The computer is used on a limited basis in this course. In 70% of the courses, the computer is used for less than 10% of the homework. Self-paced instruction is used in 10% of the courses.

About half (47%) the departments schedule 3 tests, exclusive of the final examination in the course. 19% give 2 tests and 16% give 4 tests.

The placement of three topics related to reactor design was studied. The thermodynamics of reaction equilibria is covered in the reactor design course at 65% of the departments and in the chemical engineering thermodynamics course at 12% of the departments. 22% responded "other" or "both."

Catalysis is covered in the reactor design course to varying extents at all but 10 departments. Some of these departments may have a separate course in catalysis. 50% of the departments spend 2 to 3 weeks on catalysis. 20% spend more than 3 weeks and 30% spend less than 2 weeks.

The theory of absolute reaction rates is not covered at 46% of the departments. In the other departments 2 or fewer class periods are devoted to this topic.

TABLE 1

PLACEMENT IN CURRICULUM*

	YEAR	
	Junior	Senior
First Semester	6	69
Second Semester	22	18
First Quarter	1	23
Second Quarter	5	3
Third Quarter	9	--

* Entries are number of departments in each category.

TABLE 2

AVERAGE ENROLLMENT PER SECTION

	DEPARTMENTS
0-14	5
15-24	20
25-34	36
35-44	28
45-54	20
55-64	8
65-74	4
75-84	3
85-94	3
95-104	5
130	1
140	1
TOTAL	134
AVERAGE	42.5

DIMENSIONS

There appears to be an increasing trend toward the use of the SI system of dimensions. Almost half of the departments (47%) used the SI system in over 75% of the class assignments. Only 16% used the British system to the same extent. The remaining departments used both systems.

TEXTBOOKS

The 1974 survey, showed that 61% of the kinetics courses at the 90 departments replying, used the text by Levenspiel. Smith's text, 2nd edition, was used in 21% of the courses.

This year, Levenspiel is still the most popular book being used in 41% of the courses. The text by Hill is used in 23% of the courses, while 15% use Smith's third edition. The remaining 21% use personal notes or one of the seventeen other texts.

CHAPTER PROFILES OF TEXTBOOKS

Chapter	Replies: Levenspiel	Replies: Hill	Replies: Smith
1	59	19	28
2	60	21	24
3	62	22	28
4	63	22	27
5	63	22	27
6	62	12	28
7	58	19	12
8	57	15	30
9	24	15	22
10	11	9	29
11	37	8	20
12	18	1	23
13	10	1	1
14	41	1	
15	3		

QUESTIONNAIRE

A copy of the questionnaire sent to chemical engineering departments follows. The replies from each department regarding difficult concepts and helpful explanations are attached.

QUESTIONNAIRE ON THE TEACHING OF UNDERGRADUATE REACTION KINETICS

INSTRUCTOR________________________ UNIVERSITY______________________________

COURSE NO. TITLE

1. ____

2. ____

TEXTBOOK

Course No.	AUTHOR, TITLE (Circle chapters covered)
1.	____ 1 2 3 4 5 6 7 8 9 10 11 12 13 14
2.	____ 1 2 3 4 5 6 7 8 9 10 11 12 13 14

In what ways do you feel the textbook for the Reaction Kinetics course can be improved?

Answers to the following questions should be based on conditions for the 1982-83 academic year.

	Course Number 1	Course Number 2
1. Is your school on the semester or quarter system (circle one)	S Q	S Q
2. How many equivalent 50-minute lectures are given each week?	________	________
3. How many weeks are there in your semester/quarter?	________	________

	Course Number 1	Course Number 2
4. In which year do most students take this course? (circle one)	Jr. Sr.	Jr. Sr.
5. In which semester/quarter do most students take this course? (circle one)	1 2 3	1 2 3
6. How many sections of this course were offered in 1981-82?	________	________
7. What was the average enrollment in each section?	________	________
8. Did graduate teaching assistants present any lectures in this course (Yes/No)?	________	________
9. If question 8 was answered yes, about what percent of the lectures did TA's give?	________	________
10. Is the course required of chemical engineers?	________	________
11. How many of laboratory hourse per week are part of this course?	________	________
12. Do students use the computer to solve more than 10% of the homework problems in this course? (Yes/No)	________	________
13. How many major tests, excluding final exam, do you give in the course?	________	________
14. Does the course use formal self-paced instruction?	________	________

INSTRUCTOR ______________________________

UNIVERSITY ______________________________

1. Which concepts in this course do you feel are particularly difficult for the student to grasp?

2. What explanations of these concepts have you found particularly effective?

3. Is the thermodynamics of reaction equilibria (equilibrium conversion, etc.) covered in the kinetics or the thermodynamics course? (circle one)

   KINETICS   THERMODYNAMICS   OTHER

4. How many weeks of the kinetics course are devoted to catalytic reactions? ________ weeks

5. Do you cover the theory of Absolute Reaction Rates in the undergraduate kinetics course? (circle one)

   NO   YES   If yes, how many class sessions? ________

6. How many semester hours or quarter hours are there in your chemical engineering curriculum?

   ________ SH or QH (circle one)

7. What system of dimensions do you use in teaching kinetics? (Please check one)

   _____ Over 75% SI

   _____ Over 75% British System

   _____ Neither of the above

INSTRUCTOR____

UNIVERSITY____

8. Please list the titles of any laboratory experiments used in kinetics or other undergraduate courses to illustrate the principles of reaction kinetics and/or catalysis.

UNIVERSITY OF AKRON

Levenspiel (Jr, Sem 2)

TEXT
New edition, improve section on heterogeneous catalytic reactions add "bit" on surface science
CONCEPTS
Res. time dist., diffusion resistance in heterogeneous catalysis.
EXPLANATIONS
Good class preparation
EXPERIMENTS
None

UNIVERSITY OF ALABAMA

Levenspiel (Sr, Sem 2)

TEXT
More real life problems, examples
More computer applications
CONCEPTS
Recycle reactors
Non-isothermal reactors
EXPLANATION
A combination of graphical and algebraic equations together seems to help in both concepts.
EXPERIMENTS
(1) Acetic anhydride hydrolysis in batch, mixed flow, and tubular reactors.
(2) Acetaldehyde decomposition in tubular reactor.
(3) Catalytic cracking of cumene.

ARIZONA STATE UNIVERSITY

Hill (Sr, Sem 1 or 2)

TEXT
(1) Add dimensionless plot for analysis of recycle reactor similar to figures 8.15 and 8.16.
(2) Possibly add some short sections illustrating analog and digital computer solutions to simple problems
(3) Eliminate some of the "mechanism" detail
(4) Add some simple lab exercises or demos.
CONCEPTS
(1) Determination of rxn. rate expressions
(2) Non-isothermal reactors
(3) Mechanism problems
(4) Volume expansion effects
(5) Catalysis and transport limitations
(6) Thermal energy balance
EXPLANATIONS
(1) Working out increasingly detailed example problems
(2) Pointing out analogies where possible
(3) Using non-reactive systems.
(4) Rigorous derivation, followed by a feel for the physical meaning of each term.
EXPERIMENTS
None

UNIVERSITY OF ARKANSAS

Levenspiel (Jr, Sem 2 & Sr, Sem 1)

TEXT
More problems; some elementary, some advanced
CONCEPTS
Chemical equilibrium
Elementary/non-elementary reaction (load habit from physical chemistry)
EXPLANATIONS
Concepts are mastered with increased explanation and example
EXPERIMENTS
Conversion of acetic anhydride to acetic acid
Enzymatic reaction with beef catalase.

AUBURN UNIVERSITY

Levenspiel (Jr, Qua. 3)

TEXT
More coverage in kinetics
Addition of practical problems
CONCEPTS
Multiple reaction
EXPERIMENTS
None

BRIGHAM YOUNG UNIVERSITY

Levenspiel (Sr, Sem 1)

TEXT
More emphasis on heterogeneous catalysis
More realistic reactions instead of A $\rightarrow$ B

CONCEPTS
(1) Catalysis - rate limiting step quasi-steady state assumption, mass-transfer limitations
(2) Residence time distributions
(3) Reaction mechanism and its relation to the rate equation
(4) Variable-density systems
(5) Effectiveness factor
(6) Non-isothermal reactors
EXPLANATIONS
Just painstaking repetition and plenty of examples.
EXPERIMENTS
Five experiments

UNIVERSITY OF CALIFORNIA, DAVIS

Smith (Sr, Qua. 2 & 3)

TEXT
Could use more material on basic balances, reactor stability and control.
CONCEPTS
Residence time distributions
EXPLANATION
Statistical analogies work fairly well
EXPERIMENTS
Acetic anhydride hydrolysis reaction is used in the unit operations lab course.

CALIFORNIA TECH

Froment & Bischoff (Jr, Qua. 3
Sr, Qua. 1)

TEXT
None
CONCEPTS
Non-ideal reactors
Residence time distributions
EXPLANATION
None
EXPERIMENTS
None

CAL. STATE POLYTECHNIC UNIV.-POMONA

Smith (Jr, Qua. 3)

TEXT
Too detailed and in too much depth for use with only one quarter course in kinetics. For a quarter course, I prefer L spiel.

More application to industry
More computer problems

EXPLANATIONS
Good real life examples
Showing them real catalysts

EXPERIMENTS
Alkaline fading of organic dyes (See CEE Winter, 1976)
Saponification of ethyl acetate

BROWN UNIVERSITY

Hill (Sr, Sem 1)

TEXT
Good on kinetics (in fact, this is the prime reason the book is used); disorganized in homogeneous reactor aspects; poor in heterogeneous reactor aspects

CONCEPTS
None

EXPLANATIONS
None

EXPERIMENTS
Isothermal bath reactor
Adiabatic reactor
Catalytic wire

BUCKNELL UNIVERSITY

Levenspiel (Jr, Sem 1)

TEXT
More numerical examples

CONCEPTS
Open and closed system for tracers convolution

EXPLANATIONS
None

EXPERIMENTS
Eight experiments

UNIVERSITY OF CALIFORNIA, BERKELEY

Smith (Sr, Qua. 1,2,3)

TEXT
(1) More generalization of different aspects
(2) Better (simpler) examples
(3) The book needs to concentrate more on fundamentals and less on special cases of reactor design and analysis. Students have a difficult time extrapolating from the discussion in this text.

CONCEPTS
(1) Stoichiometric relations in kinetic is one problem area.
(2) Degree of conversion vs. mols converted

EXPLANATIONS
(1) Detailed discussion and analysis of some of a problem embodying numerous complications

EXPERIMENTS
Batch reactor kinetics analysis

CARNEGIE-MELLON

Levenspiel (Sr, Sem 1)

TEXT
Treatment on some sections could be more quantitative and exact.

CONCEPTS
Multiple steady states
Non-ideal flow/residence time distribution
Reaction mechanisms on solid surfaces
Kinetics/diffusion coupling

EXPLANATIONS
Emphasize the physical insights rather than the mathematical aspects

EXPERIMENTS
(1) Alkaline fading of phenol phthalein
(2) Heterogeneous catalysis - butene isomerization

CASE-WESTERN RESERVE

Levenspiel (Jr, Sem 2)

TEXT
No comment

CONCEPTS
I found in the past the students have most difficulty in non-ideal flow; i.e. residence time distribution. Thus, I did not spend much time on this topic this time, but rather we spent more time on the temperature effects of Chapter 8 of the text.

EXPLANATIONS
No comment

EXPERIMENTS
None

CHRISTIAN BROTHERS COLLEGE

Hill (Sr, Sem 1)

TEXT
Need more reactor design early on in the text. I like Hill, but it is more engr. science oriented than design. This fall I will try the new book by Chen (Allyn & Bacon).

CONCEPTS
What a chemical reaction is and how to treat it mathematically.
How to analyze a reactor.

EXPLANATIONS
Two Apple computer programs for classroom demo have helped some:
(1) Profile of chemical species
(2) Simulation of conc. of reactant in various reactors by density of white pixels coupled with design of graphs of rate vs. conc., etc.

EXPERIMENTS
None

UNIVERSITY OF CINCINNATI

Levenspiel (Jr, Qua. 1)

TEXT
More practical problems

CONCEPTS
Basic concepts and mathematical treatment. Application of the concept to practical reactors.

EXPLANATIONS
Simple practical examples.

EXPERIMENTS
(1) Residence time distribution of 3-tanks in series.
(2) Batch and flow reactor experiments in a well-stirred tank (Hydrolysis, etc.)

CLARKSON

Youngquist (Jr, Sem 2)
Smith (Sr, Sem 2)

TEXT
Not applicable

CONCEPTS
Not applicable

EXPLANATION
Not applicable

EXPERIMENTS
(1) Adiabatic batch reaction
(2) Dye extinction in a tubular reactor

CLEVELAND STATE UNIV.

Hill (Sr, Qua. 1)

TEXT
Pleased with text
CONCEPTS
(1) Determination of reaction rate expressions
(2) Molecular interpretation of kinetic data
EXPLANATIONS
None yet.
I use a large number of examples and homework problems.
EXPERIMENTS
Deviation from ideal flow in a CSTR and PFR using the hydrolysis of ethyl acetate.

UNIVERSITY OF COLORADO

Levenspiel (Sr, Sem 1)

TEXT
More of the examples and problems should refer to actual chemical reactions and data, not hypothetical ones.
CONCEPTS
Selectivity of heterogeneous multiple reactions
Coupling of transport & Reaction rate for heterogeneous reactions.
EXPLANATIONS
General explanations on physical grounds rather than mathematics.
EXPERIMENTS
"Kinetics Experiment" in undergrad lab course.

COLORADO SCHOOL OF MINES

(Graboski & Baldwin) (Sr, Sem 1)
Personal notes

TEXT
Our text is a compilation of notes from Prof. Graboski & myself, and needs revision.
CONCEPTS
(1) RTD (2) L-H mechanisms
(3) Diffusion/mass transfer limitations
EXPLANATIONS
(1) Experiments in the lab
(2-3) Still reaching

EXPERIMENTS
Saponifications of ethyl acetate in (1) batch reactor (2) CSTR
(3) PFR (4) RTD in stirred tank

COLORADO STATE UNIV.

Levenspiel (Sr, Sem 1)

TEXT
Very difficult to do, Levenspiel is an excellent undergraduate text.
CONCEPTS
Combination series/parallel reactions
EXPLANATIONS
None yet (I keep trying)
EXPERIMENTS
None

COLUMBIA UNIV.

Froment & Bischoff (Sr, Sem 1)
Weston & Schwartz

TEXT
Better organization (not overall but within)
CONCEPT
None
EXPLANATION
None
EXPERIMENTS
(1) Hydrolysis of ethyl acetate
(2) Decomposition of hydrogen peroxide.

COOPER UNION

Levenspiel (Jr, Sem 2)

TEXT
Not applicable
CONCEPTS
Residence time distributions
EXPLANATIONS
None
EXPERIMENTS
None

CORNELL UNIV.

Hill (Sr, Sem 1)

TEXT
Good text for undergrad course - might be improved organizatinally- e.g. discuss series and parallel reactions (Ch. 5) in conjunction with selectivity considerations in reaction design (Ch. 9), move discussion of catalytic kinetics (Ch. 6) so that it leads into catalytic reactor design (Ch. 12)
CONCEPTS
(1) Coupling of chemical and transport processes in heterogeneous reactions
(2) Formulation of material and energy balance equations for multiple reaction systems
EXPLANATIONS
(1) Discuss transport and reaction processes for a nonporous catalyst before proceeding to porous catalyst.
(2) Illustrate examples, good homework problems
EXPERIMENTS
"Kinetic and Transport Effects in the Catalytic Oxidation of Carbon Monoxide"
A couple of reaction experiments in Physical Chemistry Laboratory, perhaps one in Organic Chemistry Lab as well.

UNIVERSITY OF CONNECTICUT

Fogler (Sr, Sem 1)

TEXT
Better use as a reference for students
CONCEPT
(1) Application of general balances to determine vector design equation (either integral or differential)
(2) Simultaneous material and energy balances.
EXPLANATIONS
(1) Always derive equations from an elementary balance; INPUT + GENERATION = OUTPUT + ACCUMULATION
(2) Use care in deriving for students, and use numerical solutions easily available on a computer

ENTS
(1) Batch reactor - Homogeneous
(2) CSTR reactor - homogeneous
(3) Catalytic reactor - plug flow or CSTR

UNIV. OF DELAWARE

Hill (Jr, Sem 2)

TEXT
Poorly written (too long); Students really don't appreciate all the details and verbage; will use Carberry next semester.
CONCEPT
Reaction and diffusion; steady state approx.; rate-determining step; RTD implications
EXPLANATIONS
Electrical circuits; isolated batch reactors with exponential distribution of holding times.
EXPERIMENTS
Yeast growth
Heterogeneous catalysis (see handout)

UNIV. OF DETROIT

Smith (Sr, Sem 1)
Hill (Sr, Sem 2)

TEXT
Not applicable
CONCEPT
Analysis of stability
EXPLANATIONS
Derlmutter's lectures and development , close look at flame reactors.
EXPERIMENTS
(1) Unsteady batch reactor
(2) CSTR's in series
(3) Flow in packed beds
(4) Absorption/desorption equilibrium

DREXEL UNIVERSITY

Levenspiel (Sr, Qua. 1)

TEXT
More detailed design examples - especially of the non-isothermal PFR. More fundamental treatment of catalysis.

CONCEPT
Instantaneous fractional yield.
EXPLANATIONS
Draw the analogy to the thermodynamic state function concept.
EXPERIMENT
None

UNIV. OF FLORIDA

Sandler (9) (Jr, Sem 2)
Levenspiel (1-10) (Sr, Sem 1)
Smith (4,5,6) (Sr, Sem 2)

TEXT
(1) none are adequate although many texts have good points
(2) Textbooks available are quite inadequate to the reactor design part of heterogeneous reactions.
CONCEPTS
Use of the material and energy balance, Interaction between reaction and transport resistances
EXPLANATION
Lots of practice, Repitition
EXPERIMENTS
None

FLORIDA INSTITUTE OF TECH.

Espenson (Jr, Qua. 3)
Levenspiel (Sr, Qua. 1)

TEXT
(1) Addition of chapters on catalysis, multiphase reactions
(2) Discussion of complex reaction mechanisms from a kinetics (rate modeling) viewpoint before discussion of reactor design.
CONCEPTS
(1) Complex mechanisms - modeling reactions networks
(2) Mathematical methods of attacking complex mechanisms ("steady-state" approx., "rate-limiting step" approx., etc.)
EXPLANATIONS
None
EXPERIMENTS
Bromination of acetone (Phys. Chem Lab) Iodine Clock Reaction (Gen. Chem Lab)

GEORGIA TECH

Hill (Sr, Qua. 1)

TEXT
Not applicable
CONCEPTS
Volume expansion upon reaction in flow reactors.
EXPLANATIONS
Not applicable
EXPERIMENTS
Not applicable

HARVEY MUDD COLLEGE

Levenspiel -Minibook (Sr, Sem 1)
Smith

TEXT
Several excellent texts available. I like the minibook approach supplemented by Smith, Levenspiel, Hill, etc.
CONCEPT
Problem formulation for ill-defined cases.
EXPLANATIONS
Discuss "formal checklist" then give much practice solving "new" cases.
EXPERIMENTS
Not applicable

UNIV. OF HOUSTON

Hill (Sr, Sem 1)

TEXT
More biochemical reaction
CONCEPTS
(1) Multiplicity
(2) Residence time distribution
EXPLANATIONS
(1) Graphical in terms of 1/v vs. C diagrams
EXPERIMENTS
Not applicable

UNIV. OF IDAHO

Levenspiel (Sr, Sem 1)

TEXT
Not much improvement is needed as far as the contents are concerned. However, the kinetics of catalytic reactions is covered immediately after the kinetics of homogeneous

reactions in the present course, which is then followed by reactor design both for homogeneous reactions and for catalytic reactions

CONCEPTS
The reaction rate is an intensive property of a reacting fluid, not a time derivative of concentration

EXPLANATIONS
One whole class period is used to explain this concept through "examples".

EXPERIMENTS
Catalytic conversion of carbon monoxide "Carberry's Spinning Basket Rxt., Berty's Internal Recycle Rxt., Packed Bed Rxt., Des. & Op. of Packed Bed & Fluidized Bed Rxt.)

UNIV. OF ILLINOIS, URBANA

C1-Levenspiel (Sr, Sem 1)
C2-Wilkinson (Sr, Sem 2)

TEXT
C2- plan to change to Moore & Pearson, Discussion of non-ideal flow, heterogeneous catalysis multiphase reactors need major improvements

CONCEPTS
Non-ideal flow
Effectiveness factors

EXPLANATIONS
None

EXPERIMENTS
(1) Continuous flow stirred tank reactor
(2) Batch stirred tank reactor
(3) Coal gasification

ILLINOIS INSTITUTE OF TECH.

Smith (Sr, Sem 1)

TEXT
More emphasis on the physical chemistry.

CONCEPTS
(1) Chain reactions
(2) Rate controlling steps in heterogeneous catalysis
(3) Unsteady state operations

EXPLANATIONS
(1) Through realistic examples involving real chemical reactions, these concepts can be nicely explained
(2) Use of A $\rightarrow$ B type generalized treatments were relatively less effective.

EXPERIMENTS
Iodine clock experiment
Alkaline fading of phenophtaleine
Catalytic CO oxidation packed-bed reactors
Residence time distribution studies.

UNIVERSITY OF IOWA

Levenspiel (Sr, Sem 1)

TEXT
I think the text by C.G. Hill is much better, esp. on the coverage of formulation of mass and energy balances.

CONCEPTS
Heterogeneous catalysis kinetic rate forms.

EXPLANATIONS
Used assigned readin from Smith's kinetics text as supplement, student's reaction was favorable.

EXPERIMENTS
(1) Transient response of single CSTR and 2 ESTR's in series.
(2) Tubular reactors
(3) Batch reactor kinetics
(4) Batch kinetics of biological enzymes.

IOWA STATE UNIVERSITY

Hill (Jr, Sem 1)

TEXT
None

CONCEPTS
Non-ideal flow

EXPLANATIONS
None

EXPERIMENTS
"Well stirred batch reactor"

JOHN HOPKINS UNIVERSITY

Hill (Jr, Sem 1)

TEXT
None

CONCEPTS
Deviations from ideal flow conditions; residence time distributions and the dispersion model.

EXPLANATIONS
None

EXPERIMENTS
(1) Hydrolysis of crystal violet dye by NaOH in a tubular reactor.
(2) First order reaction in a fluidized bed.

UNIVERSITY OF KANSAS

Smith (Sr, Sem 1)
Personal Notes -Grad (Sr, Sem)

TEXT
None

CONCEPT
None

EXPLANATION
None

EXPERIMENTS
List of 25.

KANSAS STATE UNIVERSITY

Levenspiel (Sr, Sem 1)

TEXT
Needs more emphasis on basic catalysis - Reactor balances need to use the macro balances of Bird, Stewart & Lightfoot.

CONCEPT
Not a conceptually difficult course, generally they find it new and interesting.

EXPLANATIONS
Smith-ChE kinetics has good material on catalyst characterization and the rate equations of catalytic reactions.

EXPERIMENTS
Not applicable

UNIVERSITY OF KENTUCKY

Levenspiel (Sr, Sem 1)

increase in accord with industrially important reactions, i.e. catalytic.
CONCEPTS
K (Thermo. Eq. Const.) = f (Pressure)
EXPLANATIONS
Detailed examples
EXPERIMENTS
Not applicable

LAFAYETTE COLLEGE

Levenspiel (Sr, Sem 1)

TEXT
Treat each kind of reactor separately with isothermal and non-isothermal conditions ina single chapter - use of computer programs
CONCEPTS
Design of multiple reactions
Non-isothermal
EXPLANATIONS
None
EXPERIMENTS
None

LAMAR UNIVERSITY

Holland (Jr, Sem 2)

TEXT
Not applicable

LOUISIANA STATE UNIV.

Hill (Sr, Sem 1)

TEXT
The treatment on multiple reactions and on adiabatic and other nonisothermal reactors are substandard. The derivations are unnecessarily complicated and the example problems not nearly extensive enough.
CONCEPTS
(1) How mechanistic reaction pathways are formulated and used to generate rate expressions
(2) Transition-state theory and its extensions
(3) Reactor design for nonisothermal reactors
EXPLANATIONS
For (3), I have tried to work a series or examples thoroughly both by algebraic and graphical methods, starting with a first-order adiabatic reaction, then a reversible adiabatic reaction, then for a multiple reaction scheme with heat transfer (which we solve on the computer)
EXPERIMENTS
One lab in a physical chemical course, on measurement of the kinetics of a liquid-phase batch reaction.

LOUISIANA TECH

Smith, Levenspiel
School is on quarter calendar with semester hours credit with 75 min. class periods for 12 weeks period.
(Sr, Sem 1)

TEXT
More short problems with real data
CONCEPTS
(1) Macromixing VRS Micromixing in non-ideal flow
(2) Surface area from "pore" volume and models of adsorption
EXPLANATIONS
Simply to stress to students that these are simplified models used in engineering prediction of very complex phenomena.
EXPERIMENTS
Batch saponification of ethyl acetate (Senior lab exp.)

UNIV. OF LOUISVILLE

Hill (Sr, Sem 1) Summer

TEXT
Remove "Extent of Reaction" as the main variable in data analysis (Ch. 3,5) and just use fractional conversion, esp. since f is the variable later in Reactor Design.
CONCEPTS
(1) Analysis of CSTR, PFR
(2) Heat effects
EXPLANATIONS
(1) Levenspiel's book
(2) Hill's book is excellent here
EXPERIMENTS
(1) Steady and transient st[illegible] operation of stirred tank re[illegible]s in series.
(2) Simulation of reactions by hydraulic analogies.

UNIVERSITY OF LOWELL

Hill (Sr, Sem 1)

TEXT
The text is too wordy. Many explanations can be shortened. The material and energy balances can be generalized. The design can be computerized.
CONCEPTS
The problems are too long for manual calculations.
EXPLANATIONS
The effective remedy is to computerize the calculation. The book "PROCESS REACTOR DESIGN" authored by me (Dr. N.H. Chen) (published by Allyn & Bacon, Inc. Newton, MA) is recommended.
EXPERIMENTS
None

MANHATTAN COLLEGE

Fogler (Sr, Sem 1)

TEXT
There is a need for a good undergraduate kinetics book. Smith is a horror. I just can't assign a text that I have some difficulty reading.

MASSACHUSETTS INST. OF TECH.

Smith (Sem)

TEXT
It is an excellent text; I would leave it alone.

UNIVERSITY OF MICHIGAN

Fogler (Jr, Sem 1,2)
Fogler (Grad, Sem 1)

TEXT
Not applicable

CONCEPTS
Mass transfer with chemical reaction. Evaluating the bulk flow term for cases other than equal molar counter diffusion.
EXPLANATIONS
Not applicable
EXPERIMENTS
Not applicable

MICHIGAN STATE UNIVERSITY

Levenspiel (Sr, Qua. 1)

TEXT
Development of general material and energy balances over a control volume specified for a particular reactor.
CONCEPTS
(1) Selectivity and yield in multiple reactions
(2) Diffusion in heterogeneous catalysis.
EXPLANATIONS
(1) Comparison of selectivities in different reactors and at different reaction conditions via several examples provide an adequate understanding.
(2) Give physical explanations of the mathematics of diffusion.
EXPERIMENTS
Batch reaction involving NaI - catalyzed H_2O_2 decomposition, in unit operations laboratory.

MICHIGAN TECH. UNIV.

Personal Notes of Dr. Skoates (I,II) (Sr, Qua. 2) (Sr, Qua. 3)

TEXT
Not applicable
CONCEPTS
Setting up of steady-state mass and energy balances in flowing, reacting streams.
EXPLANATIONS
None
EXPERIMENTS
None

UNIVERSITY OF MINNESOTA

Hill (Jr, Qua. 3)
Hi'' (Sr, Qua. 1)

TEXT
More quantitative problems/ examples from commercial experience which complement models and principles in theoretical development
CONCEPTS
Application of rate expressions
EXPLANATIONS
None-otherwise it wouldn't be a problem
EXPERIMENTS
None

UNIV. OF MISSISSIPPI

Levenspiel (Jr, Sem 2)

TEXT
None
CONCEPTS
Multiple reactions
Thermodynamic equilibrium
EXPLANATIONS
I have found in both cases that numerous simple examples help. Regarding the concept of equilibrium, I present a discussion of deriving force and chemical potential in simple language stressing the balance of effects that results in equilibrium.
EXPERIMENTS
A series of expr. is carried out to give the student a concrete experience with reaction behavior in CSTR and tubular reactors.

MISSISSIPPI STATE UNIV.

Smith (Sr, Sem 2)

TEXT
Need a textbook which is suitable for one-semester course.

UNIV. OF MISSOURI - COLUMBIA

Hill (Sr, Sem 1)

TEXT
No major improvements needed.
CONCEPTS
No one particular concept.
EXPLANATIONS
None
EXPERIMENTS
Measurements of reaction rate of a liquid phase ion.

UNIVERSITY OF MISSOURI - ROLLA

(1) Holland & Anthony (Sr, Sem 1)
(2) Levenspiel (Sr, Sem 2)

TEXT
Course 1: H & A is poor regarding non-ideal flow in reactors and optimization of thermal reactors. The latter is covered in course 1 using supplementary material from Levenspiel.

Course 2: Levenspiel is supplemented with material on non-ideal flow and design of catalytic reactors both from Bischoff & Froment and from the literature. The need for supplementary material is indicative of the inadequacy of above textbooks in certain areas.
CONCEPTS:
Course 2: The residence time distribution.
EXPLANATIONS
Qualitatively explain the physics of the concept using molecular micromixing arguments particularly in novation to the dispersion model
EXPERIMENTS
Phys. Chem. Course

MONTANA STATE UNIV.

(1) (2) Holland & Anthony (both courses required) (Sr, Qua. 1,2)

TEXT
Most texts do not have good introductory material for students
CONCEPTS
Setting up the balances for the reactor, so arrive at correct form to design reactor.
EXPLANATIONS
None
EXPERIMENTS
None

UNIVERSITY OF NEBRASKA

Levenspiel (Sr, Sem 1)

CONCEPTS
EXPLANATIONS
First time to teach - no comment.
EXPERIMENTS
Use a homogeneous catalytic reaction which generate gas product. Students measure collector gas.

UNIV. OF NEVADA - RENO

Levenspiel (Sr, Sem 2)

TEXT
More computer orientation.

UNIV. OF NEW HAMPSHIRE

Hill (Sr, Sem 1)

TEXT
It is too detailed and wordy, much irrelevant or advanced material could be eliminated to make the text accessible to a beginner. I personally dislike the molar balance used as the basis for reactor design. I use a mass balance approach which makes more sense to most undergraduate students and is less susceptible to error.
CONCEPTS
Catalytic reaction mechanisms.
Rsidence time distribution functions.
EXPLANATIONS
Nothing noteworthy, although I save catalytic mechanisms till the end of the semester.
EXPERIMENTS
None

NEW JERSEY INST. OF TECH.

Levenspiel (Jr, Sem 2)
(Recommended text: Satlerfield)

TEXT
(1) Better chapter on mechanisms, with better example problems
(2) More examples of Real Reactions; not just A&B types.
(3) Chapter on mechanisms and catalytic reactions with sample problems and problem set.
(4) Examples of Bimolecular reactions of two different molecular species.

EXPERIMENTS
10 experiments

UNIV. OF NEW MEXICO, ALBEQUERQUE

Levenspiel (Sr, Sem 1)

TEXT
More industrial examples
More computer based problems
CONCEPTS
(1) Mixing - residence time distribution
(2) Rate determining step.
(3) Simultaneous mass and energy balance w/reaction.
EXPLANATIONS
(1) Bead model of Smith, mixing cup for packed beds of carberry.
(2) Water flow/head analogy.
(3) Actual computer simulation of solutions to the equations.
EXPERIMENTS
(1) Surface area measurements of modified powders.
(2) Transport limitations on catalytic CO oxidation.

NEW MEXICO STATE

(1) Hill (Sr, Sem 1)
(2) Hill (Sr, Sem. 2)

TEXT
More experimental emphasis.
CONCEPTS
Generally, the interaction of mass, heat transfer with reaction.
EXPLANATIONS
We use actual experimental data and a rather detailed description of the experiments.
EXPERIMENTS
"Reaction Rate of Crystal Violet Decolorization"
"Polymer Synthesis"
"Reaction Kinetics of Saponification of Ethyl Acetqte"

ST. UNIV. OF NEW YORK - BUFFALO

Levenspiel (Sr, Sem 1)

TEXT
(1) New edition needed
(2) New problems needed
(3) Greater attention to real-life kinetics (instead of A→B→C)

EXPERIMENTS
Saponification of ac[illegible]
(Batch)
G.C. for analyzing reaction products
Mass transfer limitation of reaction rate
Catalytic isomerization of [illegible].

CITY UNIV. OF NEW YORK

Levenspiel (Sr, Sem 1)

TEXT
A more correct approach to field and constitutive equations
CONCEPTS
Expansion and contraction of reactant stream coupled heat transfer, equilibrium and reaction
EXPLANATIONS
Example problems.
EXPERIMENTS
Tracer response of a non-ideal mixed tank.

POLYTECH. INST. OF NEW YORK

Hill (Sr, Sem 1)

CONCEPTS
Variable density effects in flow reactors
Mixing effects in flow reactors
EXPLANATIONS
Analogy with batch reactors
EXPERIMENTS
Batch reactor calibration
CSTR Kinetics

NORTH CAROLINA STATE

Levenspiel (Sr, Sem 1)

TEXT
I'd like more (or even some) problems about real process, and inclusion of generalized stoichiometric notation (I don't want to lose Levenspiel's readability, though, which is why I've stayed with this text.
CONCEPTS
Mechanistic analysis (steady-state kinetics, etc.)
EXPLANATIONS
Just need to go through example after example.

EXPERIMENTS
Kinetics of a bimolecular batch reactor.

UNIV. OF NORTH DAKOTA

Fogler (Sr, Sem 2)

TEXT
More example and exercise problems esp. in Ch. 5.
EXPERIMENTS
Oxidation of H_2O_2 by KI.

NORTHEASTERN UNIV.

Levenspiel (Jr, Qua. 2,3)

TEXT
Include problems related to real chemical reactions and reaction mechanisms.

NORTHWESTERN UNIV.

Butt (Jr, Qua. 2,3)

TEXT
More examples in text.
CONCEPTS
Residence time distribution; micro-mixing and macro-mixing.
EXPLANATIONS
For residence time distribution, give illustrations using conceptual expr. using dye pulses, and fluid elements that contain time clocks. Sometimes small variation of the same experiment are repeatedly mentioned to reinforce the concept.
EXPERIMENTS
(1) Kinetics of catalytic cumene tracking.
(2) Residence time distribution of a series of plug flow and stirred tank vessels.

NOTRE DAME UNIV.

Butt (Sr, Qua.)

TEXT
De-emphasize chemical kinetics, emphasize conservation laws.
CONCEPTS
Kinetic Theory (transition state theory [illegible])

OHIO STATE UNIV.

Levenspiel (Jr, Qua. 3)

TEXT
More reactor design.
CONCEPTS
Interaction of all fundamentals with reactor design.
EXPLANATIONS
Examples and case studies.
EXPERIMENTS
Process Development Lab
Process Design Course

OHIO UNIVERSITY

Levenspiel (Jr, Qua. 2)
Levenspiel (Jr, Qua. 3)

TEXT
I like this text very much as it is.
CONCEPTS
(1) Rates of reversible rxn
(2) Rates of multiple rxn
(3) Multiple reactor design
EXPLANATIONS
I believe that Levenspiel's explanations with some additional explanation by me, are adequate and clear.
EXPERIMENTS
Kinetics of polyesterification

UNIV. OF OKLAHOMA

Hill (Sr, Sem 1)

TEXT
Order of presentation of material should be 2-3-5-4-7-8-10-9-11 6-12 (13 optional).
EXPERIMENTS
In preparation; there are currently no kinetics expr. in any ChE lab course here.

OKLAHOMA STATE UNIV.

Levenspiel (Sr, Sem 1)

TEXT
More real examples.

OREGON STATE UNIV.

Levenspiel (Sr, Qua. 1)

CONCEPTS
Difference in Reactor Types
EXPLANATIONS
Problems, problems, problems.
EXPERIMENTS
(1) Flow analog to 1st order reactions.
(2) Flow modeling of chemical reactors.

UNIV. OF PENNSYLVANIA

Hill (Sr, Sem 1)

TEXT
I would like to see a better section on heterogeneous kinetics.
EXPERIMENTS
(1) Partial oxidation Methanol over Platinum.
(2) Hydrolysis of ethyl acetate.

PENNSYLVANIA STATE UNIV.

(1) Hill (Jr, Sem 2)
(2) Hill (Sr, Sem 2)

TEXT
Use of more realistic problems. Too much algebra - too much detail often doing difficult problems before the simple ones.
CONCEPTS
The worst thing is overcoming the teachings of chemistry books and instructors and also Hill.
EXPLANATIONS
I use Churchill's rate concept and my paper notes (Chem. Eng. Comm. 9, 18 (B1)).
Posing of real problems (eg. development of a rate equation or kinetic model from chemist's data, group work on feasibility study or preliminary process design for an industrial reaction, choice of reactor type and configuration based on reaction network and kinetic and thermodynamic information.
EXPERIMENTS
(1) Catalytic Dehydration (of hexanol-1)
(2) Ester Saponificat[illegible]
(3) Batch kinetics (h[illegible]sis of ethyl acetate)

PRATT UTE

Levenspiel (Sr, Sem 1)

TEXT
It should incorporate most optimal design problems that examine process alternatives.
CONCEPTS
Temperature and pressure effects on the design.
EXPERIMENTS
(1) Mass transfer limitation on chemical reaction. Effect of agitation on a gas liquid reaction
(2) Saponification of acetamide- Calculation of the rate constant and activation energy.

PRINCETON UNIV.

Hill (Sr, Sem)

TEXT
Should emphasize design of packed bed, fluidized bed reactors more.
CONCEPTS
(1) Micromixing and macromixing.
(2) Polymerization kinetics - particularly the relative importance of propogation ns-a-ns initiation and termination.
EXPLANATIONS
Still reaching for good explanations to an undergraduate class!
EXPERIMENTS
The lab is handled in a separate course. Approximately four experiments qualify.

PURDUE UNIV.

Levenspiel (Jr, Sem 2)

TEXT
I think that Levenspiel is an excellent book and the best available for some parts of the course. I also think that the course should have more kinetics than Levenspiel offers.
CONCEPTS
Non-ideal reactors
Definition of the rate, the thermodynamic inconsistency of the treatment of nonisothermal reactors, and the treatment of heterogeneous reactions.

EXPLANATIONS
Heavy use of examples.
EXPERIMENTS
(1) Continuous esterification in a tubular reactor.
(2) CSTR
(3) Catalytic cracking
(4) Gas-phase dehydrogenation
(5) Liquid-phase hydrogenation
(6) Production of Baker's Yeast

RENSSELAER POLYTECH INST.

Levenspiel (Sr, Sem 1)

TEXT
Integrate modern computer-aided design methods into the text.
EXPERIMENTS
Sr. Lab Expr.: "Laminar Flow Reactor"

UNIV. OF RHODE ISLAND

Hill (82)
Smith (83) (Sr, Sem 1)

TEXT
Hill - Computer-simulation type computations
Smith - Show units with every number (except dimensionless ones)

RICE UNIVERSITY

Hill (Jr, Sem 2)

TEXT
The book has many very good sample problems as well as homework problems. However, I think the course should begin with the design equations and then develop kinetic equations as required.
CONCEPTS
Sometimes the students use the wrong design equations for measurements of reaction rates e.g. use batch for CSTR applications. They always want to integrate the equations.
EXPLANATIONS
Describe in detail the residence time distribution patterns in the various flow reactors!
EXPERIMENTS
"Kinetics of Cumene Dealkylation over Cracking Catalysts"

UNIV. OF ROCHESTER

Smith (req'd)
Butt (non req'd) (Jr, Sem 2)

TEXT
Base solution methods on modern computer methods. No one does Runga-Kutta by hand any more.
CONCEPTS
The various age distributions (residence time, exit age, internal age)
EXPLANATIONS
The description in Butt above, coupled with literature papers.
EXPERIMENTS
(1) Batch reactor - kinetics of phinophtalein "fading rxn"
(2) Stirred tank reactors in series - mixing studies and kinetics of phenophtalein "fading rxn."
(3) Tubular catalytic reactor (studies - N_2O decomposition on a Nickel Oxide Catalyst.

ROSE-HULMAN INST. OF TECH.

Levenspiel (1) (Sr, Qua. 2)
Levenspiel (2) (Qua.)

TEXT
The examples and problems should be concerned with actual reactions not A, B, R, and S.
CONCEPTS
(1) Recycle reactors.
(2) Design for multiple reactions.
EXPLANATIONS
(1) No completely satisfactory info.
(2) Books by Dentigh and by Wales are helpful.
EXPERIMENTS
"Reaction in a mixed reactor"

RUTGERS - THE STATE UNIV.

Smith (Sr, Sem 1)

CONCEPTS
Development of non-isothermal model, equations for "non-conventional" reactors.
EXPLANATIONS
Many examples.

SAN JOSE STATE UNIV.

Levenspiel (Sr, Sem 2)

CONCEPTS
No major problems.
EXPERIMENTS
None at present.

UNIV. OF SOUTH ALABAMA

Levenspiel (Sr, Qua. 2)

TEXT
Some of the examples need editing. Problems need revising.
CONCEPTS
Generally, the concepts when isolated are not difficult. The difficulty is in the formulation of a model and concepts are selected.
EXPLANATIONS
Graphical explanation and solutions of the type found in Levenspiel.

UNIV. OF SOUTHERN CALIFORNIA

Hill (Jr, Sem 1)

TEXT
Better homework problems.
CONCEPTS
The concept of a chemical reactor and chemical reaction rate.
EXPERIMENTS
(1) Study of the kinetics of phenophthalein fading in a basic solution.
(2) Ammonia oxidation reaction over a platinum wire in a CSTR reactor.

SOUTH DAKOTA SCHOOL OF MINES & TECH.

(1) Levenspiel (Sr, Sem 1)
(2) Levenspiel (Sr, Sem 2)

EXPERIMENTS
Batch reactor kinetics

UNIV. OF SOUTH FLORIDA

Levenspiel (Sr, Sem 1)
[illegible] high

TEXT
Include computer oriented solutions.
CONCEPTS
Finding reaction mechanisms.
Non-isothermal reactor design.

STANFORD UNIV.

Boudart
Denhigh & Turner (Sr, Qua. 2)

TEXT
Merging both texts into one.
CONCEPTS
Chemical aspects of chemical kinetics.
EXPLANATIONS
My own book.
EXPERIMENTS
(1) Batch reactor
(2) Continuous stirred tank reactor
(3) Tubular reactor

STEVENS INST. OF TECH.

Levenspiel (Jr, Sem 2)

EXPERIMENTS
(1) Dilatometry (at several temp.)
(2) Ester hydrolysis in flow system
(3) Sucrose inversion (by polarimetry)
ALL ABOVE IN P. CHEM LAB COURSE
(4) Clock reaction - Freshman Lab

SYRACUSE UNIV.

Levenspiel (Sr, Sem 1)

TEXT
(1) More examples, especially on polymerization and biochemical reactions.
(2) Perhaps a more complete approach to real industrial processes.
CONCEPTS
(1) Rate mechanisms
(2) An organized and logical approach to problem solving
EXPLANATIONS
Examples.
EXPERIMENTS
Batch kinetics of a saponification reaction.

UNIV. OF TENNESSEE, KNOXVILLE

Levenspiel (Sr, Qua. 2)

EXPERIMENTS
Saponification of ethyl acetate in a tubular flow reactor.

TENNESSEE TECHNOLOGICAL UNIV.

(Sr, Qua. 2)

TEXT
Computer Input.
CONCEPTS
Nonideal flow.

UNIV. OF TEXAS - AUSTIN

Smith (Sr, Sem 2)

TEXT
Better development and demonstration of non-isothermal reactor design. The treatment is simplified for constant heat of reaction and constant capacities.
CONCEPTS
(1) Non-isothermal plug flow reactors.
(2) Integral reactor design for a heterogeneous reaction.
EXPLANATIONS
Several homework problems in these areas followed by a major design project incorporating both.
EXPERIMENTS
(1) HOOH Decomposition over Iron Oxide in a Fixed-Bed Pilot Plant Scale Reactor.
(2) Ethylacetate Saponification in a Laminar Flow Reactor.

TEXAS A&I UNIV.

Levenspiel (Sr, Sem 1)

TEXT
Update the material for textbook use. (3rd ed. needed)
CONCEPTS
Multiple reactions.
EXPLANATIONS
Use Levenspiel's approach.
EXPERIMENTS
Acetil anhydride and water reaction is studied to det[illegible]ne reaction rate.

TEXAS A&M UNIV.

Holland & Anthony (Sr, Sem 1,2)

TEXT

Package programs to extract various kinetics mechanisms from data, design reactors, handle non-ideal behavior, etc. Now the students write their own programs which takes some time.

CONCEPTS

Non-isothermal reactor design, relationship between composition, temperatures and pressure - effect of inlet condition on yield, selectivity, runaway, etc.

EXPLANATIONS

Analog-digital simulation.

TEXAS TECH UNIV.

Hill (Sr, Sem 1)

TEXT

Be more compact and providing more examples

CONCEPTS

1) Diffusion effects - effectiveness factor
2) Steady-state multiplicities
3) Stabilities
4) Non-isothermal reactor design

EXPLANATIONS

1) Examples from other areas on rate processes in series.
(2)-(4) Examples of real situations

UNIV. OF TOLEDO

Levenspiel (Sr, Qua. 1)

TEXT

None

CONCEPTS

1) Instantaneous mixing in C.S.T-R.
2) Exponential R.T.D. of C.S.T-R.

EXPLANATIONS

Lots of work and examples

UNIV. OF TENNESSEE, KNOXVILLE

Levenspiel (Sr, Qua. 2)

EXPERIMENTS

Saponification of ethyl acetate in a tubular flow reactor.

TENNESSEE TECHNOLOGICAL UNIV.

(Sr, Qua. 2)

TEXT

Computer Input.

CONCEPTS

Nonideal flow.

UNIV. OF TEXAS - AUSTIN

Smith (Sr, Sem 2)

TEXT

Better development and demonstration of non-isothermal reactor design. The treatment is simplified for constant heat of reaction and constant capacities.

CONCEPTS

(1) Non-isothermal plug flow reactors.
(2) Integral reactor design for a heterogeneous reaction.

EXPLANATIONS

Several homework problems in these areas followed by a major design project incorporating both.

EXPERIMENTS

(1) HOOH Decomposition over Iron Oxide in a Fixed-Bed Pilot Plant Scale Reactor.
(2) Ethylacetate Saponification in a Laminar Flow Reactor.

TEXAS A&I UNIV.

Levenspiel (Sr, Sem 1)

TEXT

Update the material for textbook use. (3rd ed. needed)

CONCEPTS

Multiple reactions.

EXPLANATIONS

Use Levenspiel's approach.

EXPERIMENTS

Acetil anhydride and water reaction is studied to determine reaction rate.

TRI-STATE UNIV.

Levenspiel (Sr, Qua. 1)

TEXT

Quite good as is

CONCEPTS

Multiple reaction design

EXPLANATIONS

A detailed solved problem

UNIV. OF TULSA

Fogler (Sr, Sem 1)

TEXT

None

CONCEPTS

Making judgments in design

EXPLANATIONS

Practice

EXPERIMENTS

Saponification of ethyl acetate
Solvolysis of t-butyl chloride
The Clock Reaction
Tubular reactor for hydrolysis of Crystal Violet Dye
Stirred tank reactor design

UNIV. OF UTAH

Smith (Sr, Qua. 1)

TEXT

I'm quite happy with Smith's 3rd edition. He has now included numerical techniques for solving non-isothermal systems, which was the big hole in the 2nd edition (and is still the big hole in Levenspiel).

CONCEPTS

Writing the governing material balance and energy balance with chemical reaction

EXPLANATIONS

Just repetitive explanations of the basic ideas. I offer no magic technique on methods

EXPERIMENTS

We have the following pieces of equipment used regularly in our kinetics laboratory.

1. CSTR - series of 2
2. Tubular Flow reactor
3. Combined CSTR and Tubular Flow Reactor
4. Adiabatic CSTR for multiple steady states

We use a variety of system and experimental condition.
Typical is the saponification of ethyl acetate in either a CSTR or tubular flow reactor. For multiple steady states in an adiabatic CSTR, we have used H_2O and $Na_2S_2O_2$ in aqueous solution.

VILLANOVA UNIV.

Hill (Sr, Sem 2)

TEXT
1. By relating the rate-controlling step and the reactor zone (where the kinetics step takes place) to show how the homogeneous mechanisms relate to the heterogeneous mechanisms.
2. Take more time for teaching non-ideal reactor design.

CONCEPTS
A. Rate-controlling step vs. Reaction Zone.
B. Non-ideal flows in reactors and their effects on the reactor performance.
C. Product distribution in multiple reactions.

EXPLANATIONS
Show the students the similarities as well as the differences between homogeneous reactions and heterogeneous reactions. Show how non-ideal flows may be characterized in terms of ideal flows.

EXPERIMENTS
"Bench-scale Pilot Plent-Kinetics" Expt. No. 80, ChE Lab III.

VIRGINIA POLYTECHNIC INSTITUTE

Levenspiel (Jr, Qua. 3)

TEXT
Actual Reactor details, case history of reactor evolution as in NH_3 catalytic reactors over the past 10 years.

CONCEPTS
Interrelationships of equilibrium as it affects driving force, temperature, reaction [illegible] and reactor type, as well as mass and heat transfer.

EXPLANATION
Following the progress of reaction by following reactants thru a reactor (usual plug flow type reactor).

EXPERIMENT
On expt. on kinetics in Unit Operations Laboratory.

UNIV. OF WASHINGTON

Hill (Sr, Qua. 2)

WASHINGTON STATE UNIV.

Hill (Sr, Sem 1)
Switching to Smith

TEXT
Focus on differential balances, canned computer programs can be used to solve sets of differential equations.

CONCEPTS
Differential modeling, analysis

EXPLANATION
Multi exposure

EXPERIMENT
Saponification of ethyl acetate.

WAYNE STATE UNIV.

Fogler (Jr, Sem 2)

TEXT
More computer applications, earlier in text. Better numerical treatment of rate data; less graphical methods and more numerical methods.

CONCEPTS
Effect of changes in total moles in gas phase reactions on the intrinsic reaction expression.

EXPLANATION
Chapters 2 and 3 of Fogler's Text.

EXPERIMENT
Batch Reactor Measurements
- Acetic Anhydride Hydrolysis
CSTR and Tubular Play Flow Reactors
- Acetic Anhydride Hydrolysis

WEST VIRGINIA INST. OF TECH

Hill (Jr, Sem. 2)

TEXT
I think Hill has done a good job

EXPERIMENTS
1. Hydrolysis of acetic anhydride
2. Hydrogenetion of corn oil.
3. Saponification of ethyl acetate
4. "Clock Reaction" oxidation of I using Ca# catalyst.

WEST VIRGINIA

Levenspiel (Sr, Sem 1)

TEXT
Strengthen heterogeneous reaction and nonisothermal reactors.

EXPERIMENTS
Operation of a pilot plant (Methenol Reaction) Nonisothermal CSTR.

WIDENER

Levenspiel (Sr, Sem 2)

TEXT
Less idealism, more real life examples, more detailed treatment of heterogeneous catalysis.

CONCEPTS
The level of comprehension was fairly even throughout the course.

EXPLANATION
Difficult to answer

WISCONSIN

Hill (Sr, Sem 1)

TEXT
More realistic problems with real chemical systems could be employed.

CONCEPTS
Residence time reactor modeling concepts.

EXPLANATION
Worked out examples of their use.

EXPERIMENT
We use several kinetics experiments in our undergraduate summer laboratory experience [illegible]ey are

unstructured experiments which include topics ranging from solvolysis of benzoyl chloride to phase transfer catalysis reactions.

WORCESTER POLYTECHNIC INSTITUTE

Levenspiel (Jr, Qua. 4 - 7 wks)

TEXT
Needs a lot more chemistry. More detail in basic math. Sophisticated sections can be eliminated in favor of better explanations and examples.
CONCEPTS
Fitting data and graphical analysis
EXPERIMENTS
Quto catalysis: Formose reaction
Mass Transfer Control: Blue Bottle Expr.

YALE

Smith (Sr, Sem 1)

TEXT
Smith could use a little more material on modern chemical kinetics - but not so much as in Butt or Hill. All texts should put more emphasis on computer problems and numerial solutions.
CONCEPTS
Non-ideal flow or mixing effects on reactor performance.
EXPLANATION
Levenspiel: Graphical models found in "The Chemical Reactor Omnibook"
EXPERIMENT
1) Continuous Stirred Tank Reactors
2) Absorption by Activated Carbon.

YOUNGSTOWN STATE UNIV.

Smith (Sr, Qua. 1 & 2)

CONCEPTS
The discrepancy between theory and practice.

EXPLANATION
Admitting the Truth
EXPERIMENT
Various experiments (mostly esterification) to determine rates.
Work on a pilot plant scale reaction.

MCNEESE STATE UNIVERSITY

Smith (Sr, Sem 1)

TEXT
The book in general must include practical examples from industry to motivate students.
EXPERIMENTS
"Batch saponification of Ethyl Acetate".

UNIV. OF ALBERTA, EDMONTEN

Hill (Sr, Sem 1)

TEXT
1) More rigorous development of general energy balance for non-isothermal reactors.
2) More consistent use of extent of RXN and conversion. Preferably only conversion should be used in most of the text.
3) Shortened SOAS to contain only that material which is covered in the introductory course (A less expensive text)
EXPERIMENTS
Alkaline Fading of Phenolphthalein

UNIV. OF BRITISH COLUMBIA

Levenspiel (Sr, Sem 1 & 2)

TEXT
Upgrade section on heterogeneous reactions: add section on packed bed reactors (catalytic).
CONCEPTS
Heterogeneous Reactions
EXPLANATION
Start with known mass transfer processes without reaction and expand
EXPERIMENT
10 experiments

UNIV. OF CALGARY

Fogler (Sr, Qua. 1)

TEXT
I would welcome a new edition.
EXPERIMENTS
1) Batch Reactor - Hydrolysis of Mothy 1 Acetate.
2) Computer Simulation languages (CSSLIV, ACSL)
3) CSTR reactor - Hydrolysis of Metyle Acetate.
4) Non-ideal reactor flow → tracer studies.

LAKEHEAD

Fogler (Sr, Sem 1)

TEXT
There is no truly satisfactory text in this area. I would like to see a text which provides technical examples and case studies.
CONCEPT
No single concept with possible exception being heterogeneous reactions
Math difficulty is maintaining a semblance of relevance in a course which usually is taught in abstract fashion.
EXPLANATION
Introduced a series of case studies (some from RASE) some of which were student presentations.
EXPERIMENTS
1) Batch Reactor - pseudo-1st order rxn.
2) Batch Reactor - 2nd order rxn.
3) Constant flowed stirred tank reactors in series.
4) Tubular reaction - pseudo - 1st order rxn.

TECHNICAL UNIV OF NOVA SCOTIA

Levenspiel (Jr, Sem 2)
(Sr, Sem 1)

TEXT
Expanded section on the chemistry as a science.

CONCEPTS
Non-ideal flow
EXPERIMENTS
1) Hydrolysis of methyl acetate.
2) Photohydrolysis of mono-chloroacetic acid.
3) Heterogeneous reaction.
4) Clock reaction.
5) Pipe reaction.
6) CSTR

OTTAWA

Levenspiel (Sr, Sem 1)

TEXT
Chapters 8 & 14 should be expanded.

ECOLE POLYTECHNIQUE

Smith (Jr, Sem 2)

CONCEPTS
Definition of reaction rate. If the rate is defined as $\frac{1}{v}\frac{dn}{dt}$, this causes difficulty when we reach continuous reactors.
EXPLANATION
It is better to define it in words, rather than by a mathematical expression.

QUEEN'S

Wojciechowski (Jr, Sem 2)

CONCEPTS
Integration of rate equations.
EXPLANATIONS
Back to Basics
EXPERIMENTS
Acetic Anhydride; Hydrolysis in Batch CSTR & PFR.

UNIV. OF SASKATCHEWAN

Levenspiel (Sr, Sem 1)

TEXT
1) Students should have some familiarity with catalysis. Enough material on catalysis should be present in the textbook so that a few lectures can be given on it.
2) Some problems on various reactor designs, etc., based on real life situations from industry.
CONCEPTS
Some difficulty in appreciating heterogeneous rxn.
EXPLANATION
Talk about a variety of situations, both reactors and catalytic processes.
Number of repetitions with a wide variety of industrial processes where reactions from the heart of the process.

UNIV. OF SHERBROOKE

Fogler (Sr, Sem 2)

TEXT
Complimentary reading in other textbooks.
CONCEPTS
Reaction mechanisms
EXPLANATION
Several mechanisms can explain one specific reaction.

TORONTO

Levenspiel (Jr, Sem 1 & 2)

TEXT
Revised and updated
We might adopt C.G. Hill in place of Levenspiel.
CONCEPTS
Choosing appropriate measure of extent of reaction.
Unsteady state mass & energy balances
Modeling of non-ideal flow.
EXPLANATION
Repetition
Using a variety of approaches and giving specific examples.
EXPERIMENT
1) Esterification of Methyl Alcohol with Acetic Acid in a CSTR.
2) Catalytic Oxidation of Methanol.
3) Catalytic Dehydration of Isopropanol.
4) Others

UNIV. OF WATERLOO

Levenspiel (Jr.)

TEXT
Its emphasis is on applied math: I prefer to deal with real reactors and reactions whenever possible, rather than just $A + B \longrightarrow C$ type reactions.
CONCEPTS
Stoichiometry and conversion always seems to be a challenge. Conversion is always perplexing when more than 1 reactor stage is involved.

UNIV. OF WESTERN ONTARIO

Smith (Jr, Qua. 2) or
(Sr, Qua. 1)

TEXT
Two or three case studies of operating industrial reactors, if well researched, would help to make clear the applicability of the theory to the design and operation of a "real" reactor.

WINDSOR

Personal Notes (Sr, Sem 1 & 2)

EXPLANATION
Fading of a dye (Batch Reactor)
Fading of a dye (Plug flow & Laminar flow Reactor)
Saponification of esters (CSTR + 2 CSTR's in Series)
Decomposition of H_2O_2