

What Happens When We Change the Way We Teach Organic Chemistry?

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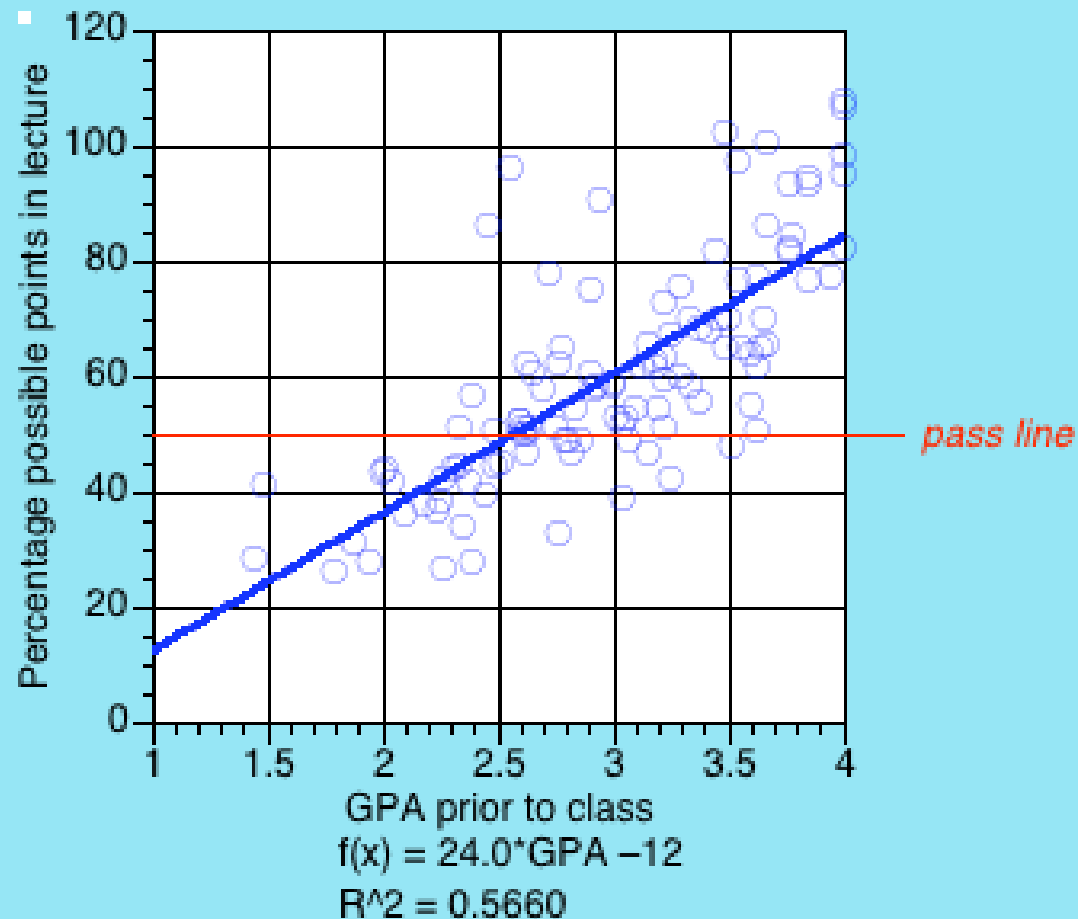
Purdue University



What factors affect students' ability to learn organic chemistry?

- ◆ Extrinsic factors (not under teachers' control)
 - Student ability
 - Student course background
 - Student interest in the subject
 - Student self-discipline
 - Student problems (*e.g.*, learning disabilities)
- ◆ Intrinsic factors: How we teach

Performance in MCMP 204 vs. Entering GPA (*F2002 Sec. A*)



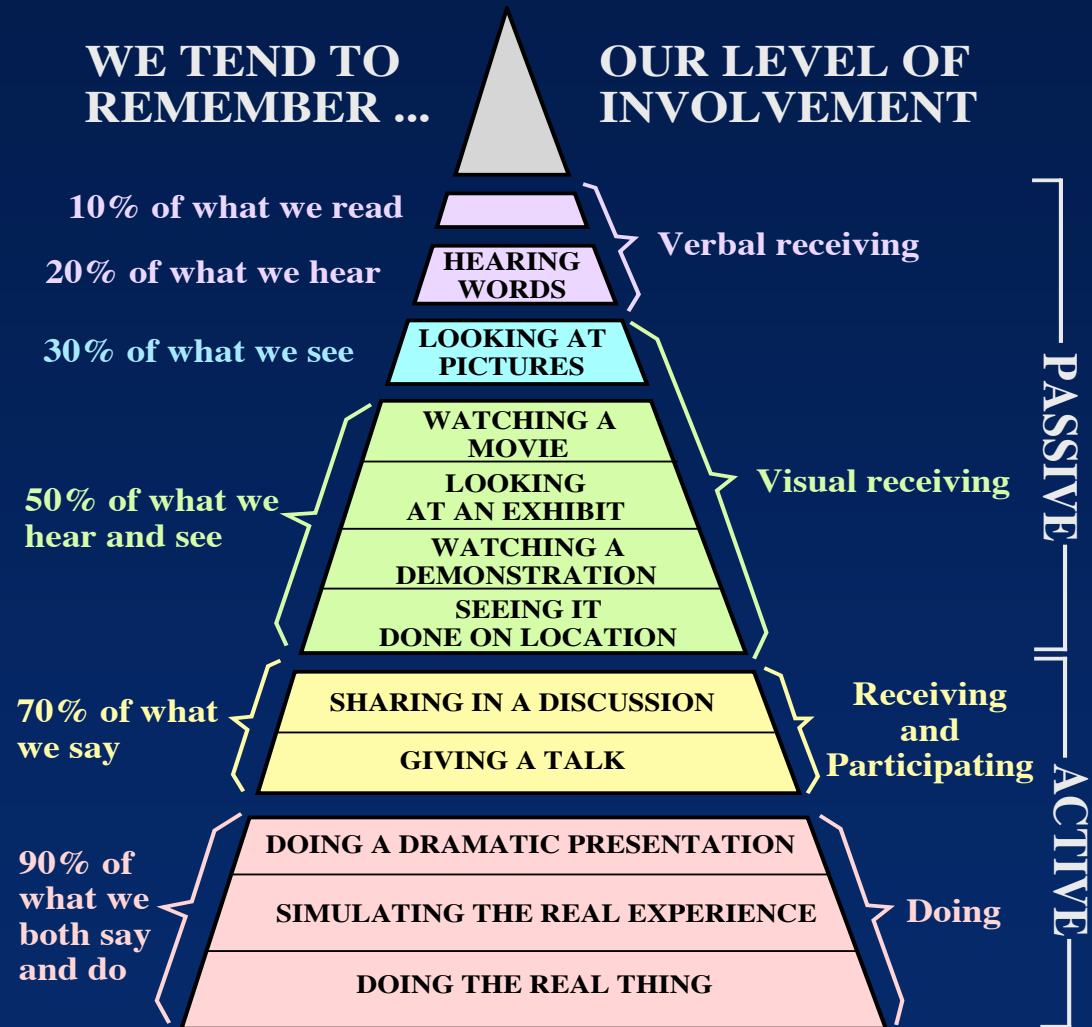
The Big Picture

I abandoned the standard lecture format for teaching organic chemistry and used an active/learning group-study process, *including* group examinations.

What problems would be expected?

What advantages would be expected?

Learning and Experience



“Cone of Learning”
after Bruce Hyland and Edgar Dale

Dr. Samuel Johnson said....

“People nowadays have the strange opinion that everything should be taught by lectures. Now I cannot see that lectures can do so much good as reading the books from which the lectures are taken.”

Chronology

Semester	Enrollmt.	Nature of Class
F1993	40	Experimental section of pharmacy majors; colleagues taught a large section
S1995	165	One section of pharmacy majors; co-taught by Loudon and Bergstrom
S1996	195	Two sections of prepharmacy students; co-taught by Loudon and Bergstrom
S1997	180	Two sections of prepharmacy students; taught by Loudon
F1997	220	Two sections of prepharmacy students; taught by Loudon
F1998	188	One section of prepharmacy students; taught by Loudon
F1999	168	One section of prepharmacy students; taught by Loudon/Meyers

Chronology, continued

Semester	Enrollmt.	Nature of Class
F2000	187	One section of prepharmacy students; taught by Loudon
F2001	197	One section of prepharmacy students; taught by Loudon
F2002	240	Two sections of prepharmacy students; taught by Loudon but in different ways: Section A = study group; Section B = lecture
F2003	242	Two sections of prepharmacy students taught with Study Groups

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What you're in for...

- ◆ Why we got into group study
- ◆ How we run the class; evolution of process
- ◆ Problems real or imagined and how we dealt with them
- ◆ Assessment
 1. Student performance
 2. Retention/probation data
 3. Student attitudes
- ◆ Summary and Overview

Desired Outcomes (Student Needs)

Student learning should be a goal of successful teaching.
Some requirements for student learning:

- ◆ Students should be actively engaged.
- ◆ Earlier material should be continually reinforced.
- ◆ Teaching should emphasize process.
- ◆ Testing/grading should, where possible, offer encouragement.

These requirements are met ***at a cost.***

Issues in Student-Learning Climate

- ◆ Student focus (concentration) in class
- ◆ Student interaction with the professor
- ◆ Examination environment
- ◆ Evaluation of student performance (exams)

Bill Gates said.....

“The worst class I ever took was introductory organic chemistry. The instructor just kept giving specific chemical reactions without explaining the principles behind them. It was just a bunch of memorization, and it seemed totally irrelevant because I wasn't *learning in the larger sense.*”

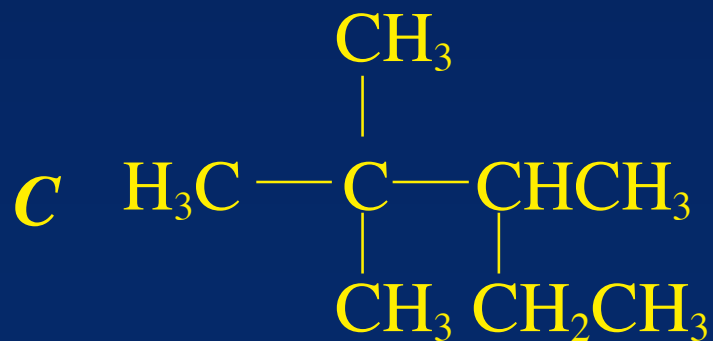
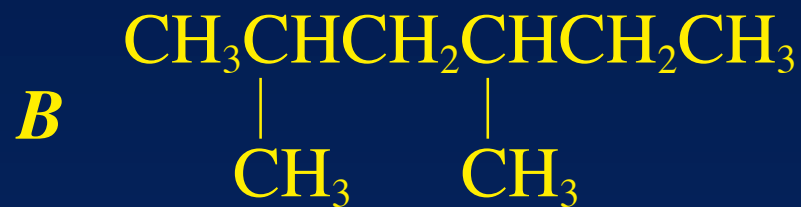
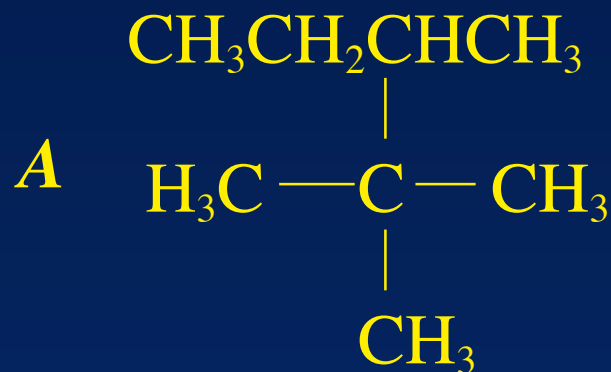
Group-Study Approach: Classwork

- ◆ Class is organized and seated within study groups
- ◆ Seating in fixed-seating hall is not a problem.
- ◆ Class is used to convey process.
- ◆ Students are engaged with a *problem-solving format*.
- ◆ Every opportunity is seized to *reinforce and review*.

A photograph of a study group in a lecture hall. In the foreground, a man with a beard and glasses, wearing a green and white plaid shirt and grey shorts, sits at a desk, looking at a document. Behind him, a woman in a grey tank top is writing with a yellow pen, and another woman in a yellow and black shirt is also writing. Other students are visible in the background, some looking at their phones or papers. The desks are dark wood with a light-colored top. A blue bag is on the floor next to the woman in the yellow shirt. The text 'Study-Group Seating in large Lecture hall' is overlaid in a yellow box on the right side of the image.

Study-Group
Seating in large
Lecture hall

Sample Lecture



?

Sample Old Lecture Notes

I. Isomers

A. Definition of isomers-molecules w/same mol. form.

B. Constitutional isomers-isomers that differ by connectivity

C. Large no. of isomers-each must have separate name

II. Nomenclature

etc.

Sample New Lecture Notes

I. Isomerism and Nomenclature

- What's the relationship between molecules A & B?
- What are isomers? Develop def.
- What's the relationship between A & C? Why?
- Notion of connectivity
- Name the structures...stress points of nomen.

etc.

Group-Study Approach: Classwork

◆ Consequences

1. Less control by instructor
2. Unexpected student responses
3. Reduced *in-class* syllabus coverage
4. Students are responsible and accountable for material not covered in class
5. Students have the tools to master material not covered in class
6. Students use study groups outside of class

Study-Group Organization

- ◆ S1995, S1996, S1997
 - Students allowed to organize their own groups
- ◆ F1997–F2000
 - Instructor organized the groups
 - Typical Group (in 180 students)
 - Group 1: #1, #180, #90, #91
 - Group 2: #2, #179, #89, #92 ... etc.
 - Some adjustments made for gender and racial diversity per School strategic plan.

Study-Group Organization, contd.

◆ F2001–F2003

- Groups were chosen at random *BUT*...
- No group had >1 “superstar”
- No group had >1 “weak” student
- Some adjustments made for gender and racial diversity per School strategic plan.

Group-Study Work

- ◆ Basic idea: students are supposed to see the value of groups from class and export it to their work outside of class

Assessment: *Did your study group meet fairly regularly?*

Responses	Y (Exp. Grd.)	N (Exp. Grd.)
S1995	25% (2.73 ± 0.63)	75% (2.41 ± 0.59) (N = 142)
S1996	43% (2.34 ± 0.80)	57% (2.49 ± 0.80) (N = 144)
S1997	47% (2.15 ± 0.87)	53% (2.18 ± 0.80) (N = 143)

Group-Study Work

- ◆ “Instructor-catalyzed” outside-of-class group work with extra-credit “Study-Group Exercises.”
- ◆ Each group turns in one paper; grade on paper is given to each group member.
- ◆ Students can earn up to 40 extra points.
- ◆ How do you tell whether group members contribute?
Use a *Study-Group Assessment*.

Study-Group Assessment for Each Student

◆ Self Assessment

- Attendance
- Participation
- Preparation
- Helpfulness

◆ Group Assessment (one for each member)

- Attendance
- Participation
- Preparation
- Helpfulness

Points on Study-Group Exercises are multiplied by a percentage based on this assessment.

Group-Study Work

Assessment: *How often did your study group meet?*

Responses \geq once/wk (Exp. Grd.) $<$ once/wk (Exp. Grd.)

F1997 93% (2.61 \pm 0.84) 7% (1.55 \pm 1.4)

F1998 87% (2.70 \pm 1.0) 13% (1.95 \pm 1.6)

Analysis of variance: *Significant to $p \leq 0.01$*

F1999 85% (2.43 \pm 1.05) 15% (2.16 \pm 0.94)

F2000 73% (2.95 \pm 0.76) 27% (2.86 \pm 0.63)

F2001 77% (2.70 \pm 1.20) 23% (2.95 \pm 0.84)

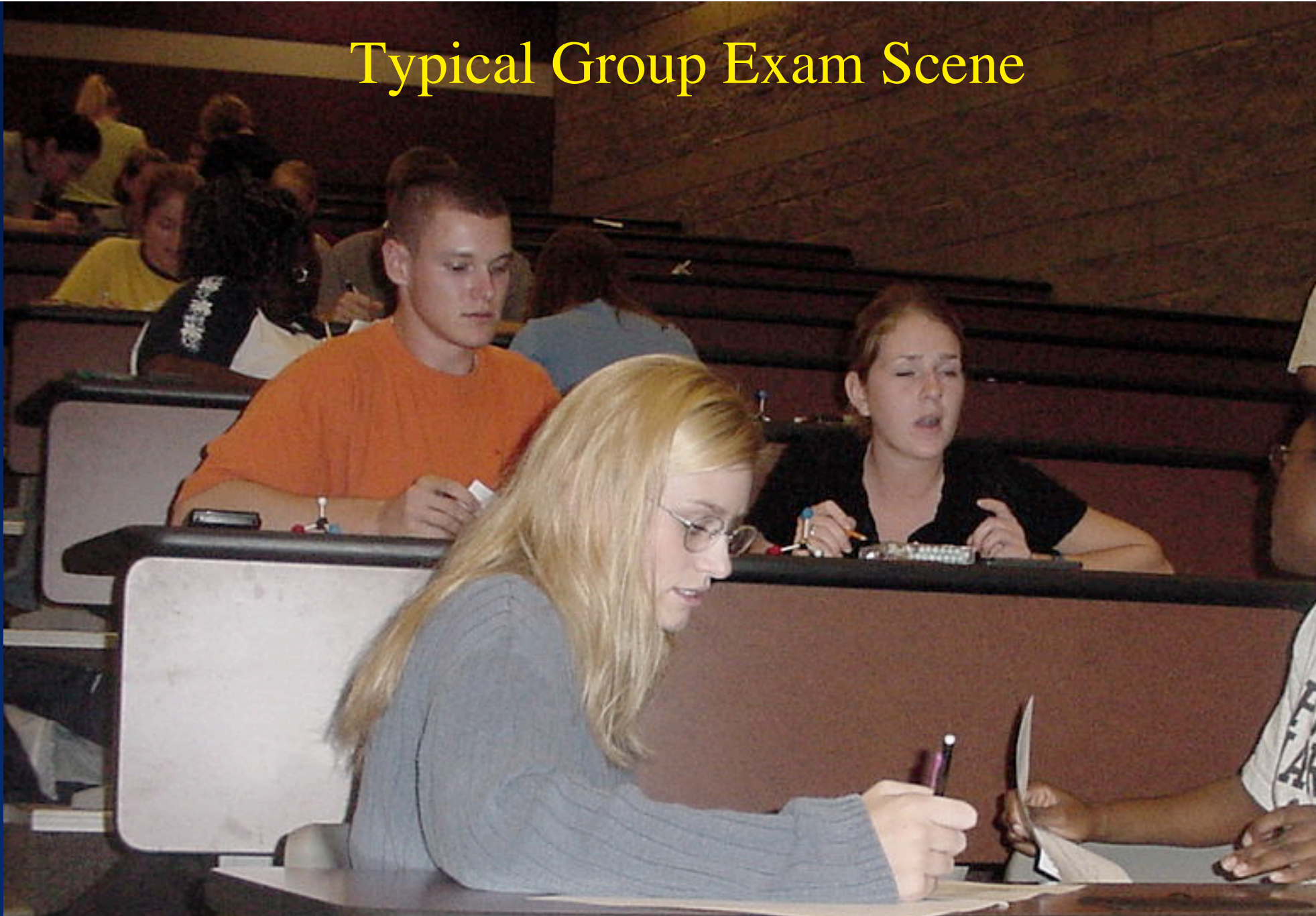
F2002 78% (2.96 \pm 0.70) 22% (2.90 \pm 0.77)

Group-Study Approach: Examinations

Process

- ◆ 30-Minute *open group discussion* of exam
- ◆ 90-Minute individual examination
- ◆ *But note:*
 - Ten 10-pt. weekly quizzes are *individual*
 - Final Exam (150 pts) is *individual*

Typical Group Exam Scene





Group-Study Approach: Examinations

Consequences

- ◆ More informal examination environment
- ◆ Longer examination period necessary
- ◆ Different style for exam questions
- ◆ Consequences for examination grading

◆ Style of exam questions must differ

Short-answer examination:

Which compound is most acidic? (Circle one)

(a) $\text{CH}_3\text{CH}_2\text{OH}$ (b) $\text{CH}_3\text{CH}_2\text{NH}_2$ (c) $\text{CH}_3\text{CH}_2\text{SH}$

Study-group examination:

Arrange the compounds in the list below in order of increasing acidity. Specify the acidic hydrogen in each case. Explain why the order you proposed is the correct one.

(a) $\text{CH}_3\text{CH}_2\text{OH}$ (b) $\text{CH}_3\text{CH}_2\text{NH}_2$ (c) $\text{CH}_3\text{CH}_2\text{SH}$

Group-Study Approach: Grading

Process

- ◆ Straight-scale grading is used
- ◆ “Resurrection” grading system is used

Consequences

- ◆ One student does not suffer because another does well (essential for group work)
- ◆ Students have Eternal Hope (until the final)

Group-Study Approach: Grading

- ◆ Consequences for examination grading
 - TA grading conferences used
 - Grading takes somewhat longer—but NOT a lot longer!

Assessment: MDCH 204, Fall 1993

- ◆ Control (lecture, 185 students) and study-group (SG) section (40 students) were taught.
- ◆ Students in two sections were cross-paired by three criteria: gender, grade in general chemistry, and pharmacy status
- ◆ Students were integrated into one large lecture course (MDCH 205) in the *following* semester.

Assessment, F1993, contd.

Results in F1993

- ◆ Two “A” students dropped SG section immediately.
- ◆ No “D” or “F” grades in SG section
- ◆ Class was much more responsive and fun to teach.

Assessment, F1993 (contd.)

Results in MDCH 205, S1994

(a standard lecture format taught by others)

Study-Group Students

Other Students

%A	34	16
%B	34	47
%C	29	25
%D	2.9	1.2
%F	0	1.8
Avg. points	402	376
Point difference	26/392 spread	

Assessment, F1993 (contd.)

Results in Biochemistry lecture (F1994)

	%A	%B	%C	%D	%F	Avg.
SG Students (<i>n</i> = 28)	18	28	46	7.1	0	430
Other students (<i>n</i> = 147)	16	31	41	8.2	3.4	426

Study Group (A) vs. Lecture (B) Sections (F2002)

◆ Intrinsic expectation

- $\langle \text{GPA(A)} \rangle = 3.00 \pm 0.57$
 $\langle \text{GPA(B)} \rangle = 3.06 \pm 0.62$

◆ Performance difference (no group help)

- $\langle \text{Final Exam (A)} \rangle = 71.7 \pm 37$
 $\langle \text{Final Exam (B)} \rangle = 75.5 \pm 37$
- $\langle \text{Weekly quizzes (A)} \rangle = 71.3 \pm 21.4$
 $\langle \text{Weekly quizzes (B)} \rangle = 78.5 \pm 19.7$

Effect of Study Group Sociology on Calculated Grades

Assessment: *Was your study group functional/useful?*

(Fall 2002)

Highly (Calc. Grd.)	$N = 27$ (28%)	(2.85 ± 0.77)
Somewhat (Calc. Grd.)	$N = 46$ (47%)	(2.67 ± 0.70)
Not very or not (Calc. Grd.)	$N = 24$ (25%)	(2.50 ± 1.07)

Significance of Highly/Not very = 80%

Significance of (Highly + Somewhat)/Not very = 65%

Study Group Effect on Grades

- ◆ Section A F2002 Survey: “The most important way that my study group helped me in this course was—”
(*N* = 97)
 - (1) Group discussions outside of class 32
 - (2) The discussion part of the hour exams 36
 - (3) In-class group discussions 5
 - (4) Working the extra-credit assignments 12
 - (5) Other 2
 - (6) Group not helpful 10

Study-Group Benefit vs. Calculated Grades

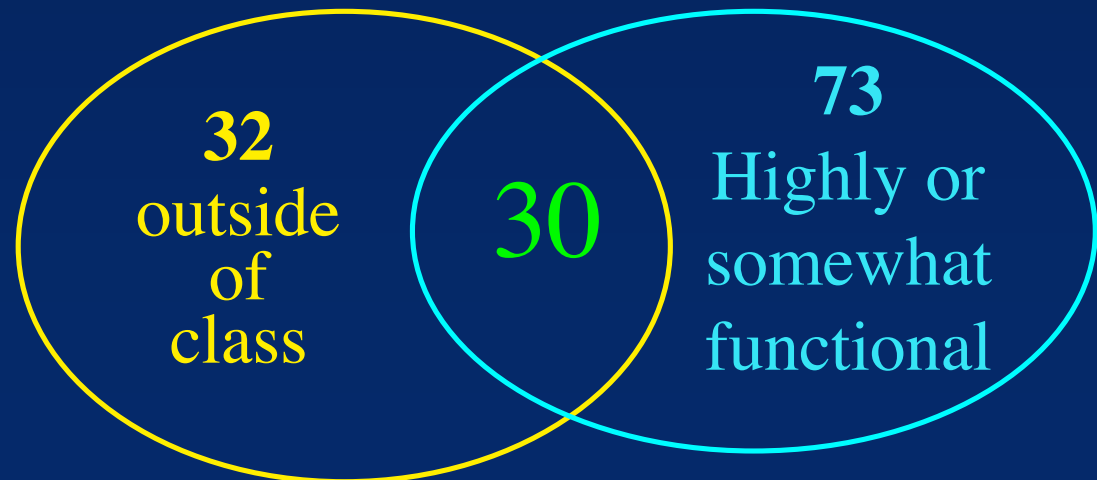
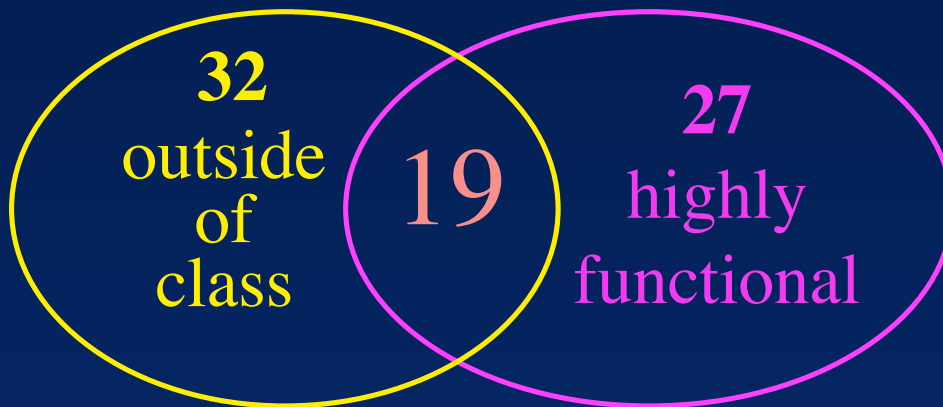
(1) Outside of class study	32	(3.00±0.76)
(2) Answers on exams	36	(2.58±0.65)
(3) Group work in class	5	(2.40±0.55)
(4) Answers on extra credit	12	(2.17±0.94)
(2) + (4)	48	(2.48±0.74)
(6) Group not helpful	10	(2.60±1.17)
(2) + (3) + (4) + (6)	63	(2.49±0.80)

(1) vs. (2): 98.1% probability of significance
(1) vs. (2 + 4): 99.6% probability of significance
(1) vs. (2 + 3 + 4 + 6):
99.6% probability of significance

Profile of Opinions of the 32 Students in Category 1 about Their Groups

- ◆ 19 students (63% female) said their groups were highly functional and useful. (Q28 vs. Q22)
- ◆ 11 students (82% female) said their groups were functional and somewhat useful; 70% females in these two categories; 65% in class as a whole.
- ◆ 1 student said her group was functional but not very useful
- ◆ 1 student (Calc. Grd. = B) said her group was dysfunctional and useless. (This student also agreed that “studying in groups has value for me,” but that “before this class I generally studied in groups.”)

Study-Group Relationships



Explanations

- ◆ Groups, when used properly, help students to improve performance. (Cause & Effect)
- ◆ Better students naturally use groups to best advantage, *i.e.*, out-of-class study. (Correlation)
- ◆ Better students tend to be the “teachers” in groups; learning by teaching others is the main value of the group; and this principally occurs in out-of-class work.

Probation and Dismissal Data

In Spring 2001—

- ◆ Of the 42 students placed on probation
 - 13 (31%) took prepharmacy at Purdue;
 - 29 (69%) took prepharmacy elsewhere
- ◆ Of the 13 students dismissed from program
 - 2 (15%) took prepharmacy at Purdue;
 - 11 (85%) took prepharmacy elsewhere

Study-Group Sociology

- (a) I became closer friends with my group members during the semester.
- (b) I like the people in my group less than I did at the start of the semester.
- (c) The study group had no major effect on my relationship with the members of my group.

	% (a)	(b)	(c)		% (a)	(b)	(c)
S1995	69	2	29	F1997	87	<1	13
S1996	78	3	20	F1998	82	3	16
S1997	64	3	33				

Study-Group Sociology: Relative Effort of Group Members

%—>	Same effort	Someone else made more	I made more	None apply
S1995	64	11	8	21
S1996	64	10	6	21
S1997	56	17	7	20
F1997	64	11	5	20
F1998	61	13	7	19

Study-Group Sociology: Relative Effort of Group Members

%—>	Someone else made less	I made less	None apply
S1995	15	6	79
S1996	12	9	79
S1997	19	8	73
F1997	22	12	67
F1998	28	5	68

Study-Group Sociology: Goldbricker Perception

I think it is possible for someone who has not studied to pass this course merely by relying on other group members.

	% A (Ex. Gr.)	%D (Ex. Gr.)	%U	Avg. Ex. Gr.
S1996	20 (2.55)	67 (2.34)	13	2.39
S1997	30 (2.19)	59 (2.11)	11	2.14
F1997	17 (2.70)	71 (2.50)	12	2.55
F1998	16 (2.52)	70 (2.57)	14	2.61
F1999	18 (2.52)	65 (2.29)	17	2.50
F2001	19 (2.95)	65 (2.90)	16 (3.33)	2.95
F2002	26 (2.87)	48 (3.12)	16 (3.00)	2.95

Assessment: Student Attitudes

The study-group organization of this course helped me to learn the material more effectively.

	% A (Ex. Gr.)	%D (Ex. Gr.)	%U	Avg. Ex. Gr.
S1995	53 (2.63)	16 (2.11)	31	2.49
S1996	53 (2.39)	20 (2.45)	27	2.39
S1997	47 (2.13)	24 (2.33)	30	2.14
F1997	75 (2.59)	7 (2.50)	18	2.55
F1998	78 (2.73)	7 (2.57)	15	2.61
F1999	67 (2.47)	7 (2.78)	26	2.50
F2001	67 (2.96)	13 (2.87)	19	2.95
F2002	59 (3.02)	26 (2.71)	15	2.95

Assessment: Student Attitudes

I prefer the study-group method of teaching to the traditional lecture method.

	% A (Ex. Gr.)	%D (Ex. Gr.)	%U	Avg. Ex. Gr.
S1995	63 (2.69)	25 (1.89)	12	2.49
S1996	74 (2.43)	15 (2.24)	11	2.39
S1997	63 (2.11)	13 (2.33)	23	2.14
F1997	74 (2.66)	8 (1.92)	18	2.55
F1998	70 (2.72)	9 (2.40)	20	2.61
F1999	70 (2.44)	13 (2.44)	17	2.50
F2000	77 (2.95)	10 (2.60)	13	3.00
F2001	69 (2.95)	12 (3.00)	19	2.95

Assessment: Student Attitudes

I would like to have more classes that use the study-group approach.

	% A (Ex. Gr.)	%D (Ex. Gr.)	%U	Avg. Ex. Gr.
S1995	57 (2.73)	23 (2.16)	26	2.49
S1996	63 (2.43)	17 (2.36)	20	2.39
S1997	49 (2.07)	16 (2.27)	35	2.14
F1997	73 (2.58)	9 (2.47)	18	2.55
F1998	72 (2.70)	11 (2.35)	18	2.61
F1999	74 (2.45)	11(2.64)	15	2.50
F2000	73 (2.91)	10 (2.94)	17	2.94
F2001	69 (2.96)	15 (2.94)	16	2.95

Assessment: Student Attitudes

I believe that this course requires thinking about principles and applying them.

	% A (Ex. Gr.)	%D (Ex. Gr.)	%U	Avg. Ex. Gr.
S1996	92 (2.44)	3 (2.75)	6	2.39
S1997	95 (2.15)	2 (1.67)	2	2.14
F1997	99 (2.56)	0	1	2.55
F1998	100 (2.61)	0	0	2.61

Assessment: Student Attitudes

I understand the importance of this course to the profession of pharmacy.

	% A (Ex. Gr.)	%D (Ex. Gr.)	%U	Avg. Ex. Gr.
S1995	63 (2.60)	14 (1.85)	23	2.49
S1996	51 (2.51)	19 (2.41)	30	2.39
S1997	63 (2.22)	20 (2.04)	17	2.14
F1997	67 (2.68)	21 (2.15)	12	2.55
F1998	75 (2.70)	11 (2.35)	15	2.61
F1999	71 (2.64)	9 (2.10)	20	2.50
F2000	79 (2.97)	7 (2.64)	14	2.94
F2002A	86 (3.00)	7 (2.86)	7	2.95
F2002B	78 (2.82)	10 (1.91)	11	2.75

Pharmacy Outcome Abilities

- ◆1. Conceptual competence
- ◆2. Scientific comprehension
- ◆3. Mathematical competence
- ◆4. Integrative competence
- ◆5. Critical thinking and decision-making abilities

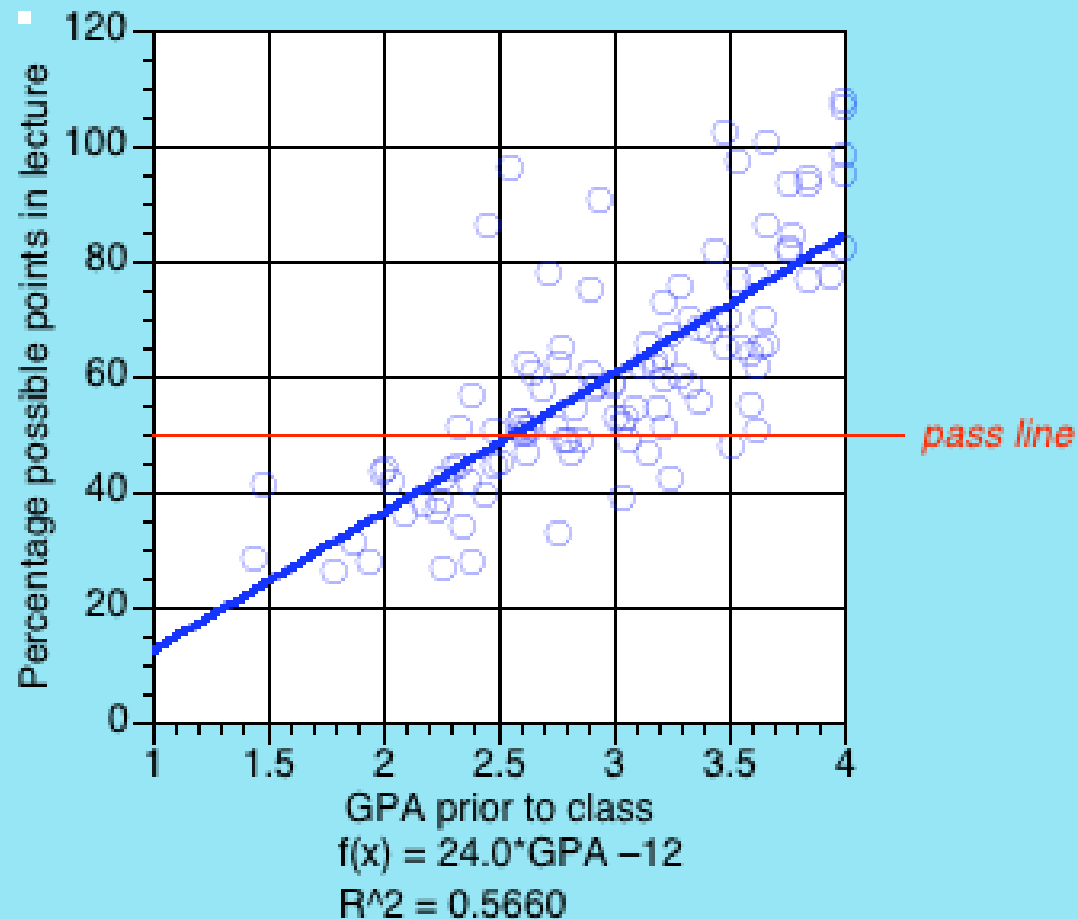
Pharmacy Outcome Abilities, contd.

- ◆ 6. Communications abilities
- ◆ 7. Responsible use of values and ethical principles
- ◆ 8. Social awareness and social responsibility
- ◆ 9. Self-learning abilities and habits
- ◆ 10. Group interaction and citizenship

Teaching at the Margins

- ◆ “Profits are made at the margins...”
- ◆ Some students can’t be prevented from learning.
- ◆ Other students refuse to learn.
- ◆ Much effective teaching is done at the margins and is therefore difficult to document with quantitative data.

Teaching at the Margins



Summary

- ◆ It is possible to use an active-learning study-group approach with a large organic chemistry class.
- ◆ Students who use study groups for active learning outside of class appear to have a significant performance advantage.
- ◆ Good students are not penalized by this approach.
- ◆ Student attitudes towards this approach are highly favorable.
- ◆ The approach can be a lot more fun for the instructor.

Joel Hildebrand said....

“Good teaching is primarily an art, and can neither be defined or standardized. Good teachers are born *and* made; neither part of the process can be omitted.”

Acknowledgements

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