

Use of Conceptests in a Large Lecture Course to Provide Active Student Involvement and Peer Teaching¹

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The purpose of this project was to evaluate the use of Conceptests. Conceptests are used to activate specific misconceptions and cause students to feel uncomfortable with their previous ideas following a lecture addressing the concept. This discomfort is the driving force behind the student's construction of new knowledge. The Conceptest will evaluate the ability of the student to transfer knowledge rather than memorize methods. Through the use of the Conceptest, not only do the students benefit, but also the instructor learns how to more effectively teach concepts to the students. Two or three Conceptests were presented as a part of each one-hour lecture. The students were given a multiple-choice Conceptest and were asked to choose an answer and evaluate the certainty of their response on a scale of one to five. Following fifteen to twenty minutes of lecture, the students were again asked to answer the question and evaluate their confidence in their answer. Then the students were asked to talk with their classmates for one minute about the question and provide a third answer with a level of confidence in their answer. The student outcomes for this exercise are: (i) an active role for each student following every fifteen minutes of lecture; and (ii) empathic peer instruction to complement the instructor's expertise. The project implications are: (i) immediate feedback is provided to the instructor with regard to how the lecture is being received; and (ii) an objective means is provided to determine when principles are not being correctly applied to new situations.

INTRODUCTION

In a large lecture class of 50 or more students it is difficult for all students to become actively involved with the material that is being presented. Multimedia may be incorporated into the lecture so that visual and aural input will be more stimulating, but the student is still passively involved. The instructor's expertise in the field may result in the formulation of a lecture that would be better presented to experts in the field rather than to novices. If the student is overwhelmed by the amount of material, passive involvement in the lecture may lead to no involvement. The use of Conceptests assists in the prevention these problems by providing: (i) an active role for each student following every fifteen minutes of lecture; (ii) empathic peer instruction to complement the instructor's expertise; (iii) immediate feedback to the instructor with regard to how the lecture is being received; (iv) an objective means to determine when principles are not being correctly applied to new situations.

METHODS

The Conceptest questions are provided in Appendix A. The innovation was used in the first half of the first semester of the pharmacy professional program. The course being taught was the first pharmaceuticals course. This course is used to help the students learn how to apply their knowledge obtained from the prerequisites for pharmacy school: inorganic and organic chemistry, statistics, physics, microbiology and calculus to: physical pharmacy, drug delivery and drug disposition. After the first midterm, the termination of

the strategy was planned so that the students and instructor could evaluate the effectiveness of teaching with and without this learning strategy.

Conceptests are multiple choice questions which test the student's ability to apply a concept that has been presented in lecture to a situation which has not yet been encountered. Two or three Conceptests were presented as a part of each one-hour lecture. The students were given a multiple-choice Conceptest and were asked to choose an answer and evaluate the certainty of their response on a scale of one to five. Following fifteen to twenty minutes of lecture, the students were again asked to answer the question and evaluate their confidence in their answer. Then the students were asked to talk with their classmates for one minute about the question and provided a third answer with a level of confidence in their answer. The instructor then collected the questions at the end of the class for computer analysis of the student's understanding of the material. SAS[®] was used for the analysis.

RESULTS

Table I shows how peer teaching affects student learning. The increased percentage of correct answers after learning from the instructor is 23 ± 25 (mean \pm SD) while the increase in percentage of correct after peer teaching is 6.8 ± 8.4 .

Student Evaluations

The average 3.6 ± 0.2 of the numerical evaluations for the Pharmaceutics I course was not significantly above the previous year's average 3.4 ± 0.2 . The average was still significantly below the average 4.1 ± 0.2 of all of the evaluations for all other courses taught at the College.

Written evaluations by the students focused on two problems. First, testing takes time from the lecture, and

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Table I. Preteaching affects

Question	Percent correct (confidence ^a)		
	Pretest	Posttest	Post peer
1	61 (2.96)	66 (2.46)	78 (2.06)
2	88 (3.84)	66 (2.25)	60 (1.81)
3	69 (3.63)	58 (2.21)	57 (1.73)
4	66 (3.32)	85 (1.54)	90 (1.28)
5	19 (4.36)	76 (2.80)	93 (1.63)
6	24 (4.43)	79 (2.53)	86 (1.66)
7	63 (2.97)	99 (1.33)	99 (1.11)
8	24 (3.60)	17 (2.71)	17 (2.42)
9	46 (3.60)	75 (2.03)	78 (1.40)
10	94 (3.10)	87 (1-67)	95 (1.28)
11	65 (3.46)	97 (1.51)	100 (1.10)
12	47 (3.33)	50 (2.97)	70 (2.07)
13	25 (2.83)	60 (1.91)	74 (1.43)
14	4 (2.53)	23 (2.03)	36 (1.76)
15	39 (2.27)	100 (1.46)	96 (1.14)
16	23 (3.35)	62 (2.41)	58 (1.77)
17	0 (3.54)	64 (2.13)	71 (2.01)
18	8 (2.92)	13 (2.34)	18 (1.69)
19	32 (4.24)	52 (3.18)	78 (1.06)

*1=confident, 5=guessing.

explaining concepts takes more time than just presenting facts. Therefore, the students were required to spend additional time reading material outside of class. Second, some students had little experience with becoming actively involved in learning and were not ready to become actively involved in learning at 8:00 AM. The experiment was discontinued after Question 19 when some students strongly requested the immediate return of conventional teaching techniques.

Based upon these responses it was determined that the technique would be evaluated more extensively only after obtaining written consent from all students in a future course. In addition, it is planned that the novel teaching technique will be instituted on alternate weeks with conventional teaching techniques. This will help the students more easily evaluate the innovation. Further, rather than including a section for "comments," specific questions will be posed at the end of the course that will elicit a more detailed evaluation of both the positive and negative aspects of the teaching innovation.

DISCUSSION

"Much goes on in the mind of the learner. Students interpret. They overinterpret. They actively struggle to impose meaning and structure upon new material being presented."

Donald A. Norman

Application of Fundamental Principles. A form of these Conceptests have been used in the field of physics(1) to assist students in their application of principles such as Newton's third law which states that "action is reaction," or "for every force there must be an equal and opposite force." While students accept statements such as this as true during class, outside of class they believe that if "a large truck and a small car collide that the large truck exerts a greater force on the small car than the reverse." The author has found the same problem with fundamental principles taught in the

field of pharmaceuticals. The forces exerted by inactive ingredients such as binders and disintegrants on tablets may be explained, however, following such a lecture the student may propose that the same active ingredient formulated two different ways will have an identical therapeutic effect. This information is understood in lecture and in situations presented in lecture, but is not applied correctly outside of lecture. While some students feel that the Conceptest is "too tricky," if the student is able to figure out the problem, then that student will also be able to figure out a problem on the exam and best of all will be able to figure out similar problems encountered later on in life.

"I have yet to see any problem, however complicated, which when you looked at it the right way, did not become still more complicated."

Paul Anderson

Use of Multiple Choice. Multiple choice questions are often used to determine if material was memorized. Rote-memory questions are easily presented by a multiple-choice format. However, with little more effort than is required to write a concept based essay question, a concept based multiple choice question may be designed for use as a Conceptest. The multiple choice concept question requires an understanding of the backgrounds of the students. The instructor must be able to formulate wrong answers which will be chosen if the concept is not correctly applied. This ability requires some intuition on the part of the instructor and also on some one on one interaction between the instructor and the students. This one-on-one interaction may come during office hours, during review sessions, or following exams in prior years when the course was taught. The time normally spent hand scoring a large number of essay exams may be used to talk over the subject matter with the students. The time spent with the students rather than with the students' exam papers more than compensates for the impersonal regularities of machine scoring(2).

"Supposing is good, but finding out is better."

Mark Twain

Measuring Student Confidence. If a student answers a question correctly but is not confident in the response, that student is not likely to apply that concept when practicing in the profession. On the other hand if the student misunderstands the concept and believes strongly in the misunderstanding, then that student is likely to malpractice the profession. In the health care profession, malpractice may result in death. It is important not only to assist patients but also "to do no harm."

"If you don't know where you are going, you will probably end up somewhere else."

Laurence Peter

Absolute Grading System. To insure that students are enthusiastic about peer instruction the grades should not be based on a curve (the norm). Under an absolute standard the instructor is a resource who helps the students accomplish the objectives(3). The instructor and students struggle to eliminate ignorance and master the objectives. Absolute grading systems assist with and encourage the introduction

of new teaching techniques and provide the rewards of overall better grades. New teaching methods such as the Conceptests work best with an absolute grading system because the emphasis is placed on assisting the slower students without a compromise in the standards. No one wants to see a pharmacist or other health care professional who has obtained their degree by "riding the curve" rather than mastering the objectives.

*"The true art of memory is the art of attention."
Samuel Johnson*

Active Involvement. Lecturing provides aural stimulation. The chalkboard is used to provide visual stimulation both in the form of pictures and written words. Feelings and sensations may even be stimulated by a dynamic speaker thus providing a third means for perception of the material presented. However, without active participation by the audience, the student will eventually lose interest and may miss a point which is critically important to the understanding of the global concept. The global concept may be presented at the beginning of the lecture to entice the student to remain attentive as all of the parts of the concept are presented, but this may not be enough to keep the students attention. Conceptests provide a means for the students to become actively involved, both with the instructor, and with their peers. Students receive immediate feedback with regards to their understanding of lecture material and are able to immediately share their new knowledge with their peers as well as the instructor. The instructor is able to present material which will address any lack of understanding prior to the midterm and final exams. The students are able to practice answering questions so that they can approach exams with more confidence. Teaching no longer becomes just telling but is a learning experience which students share with their peers.

"The human learning process is not only stranger than we suppose but stranger than we can suppose"

J. B. S. Haldane

Peer Instruction. The paradox of expertise in teaching is explained by students as the inability of the expert instructor to present knowledge at an introductory level (Hankins, 1987). Lecture material presented by experts is often unable to capture the novice viewpoint. While course material may be presented in a concise manner and develop logically from the perspective of the expert, students may find it difficult to comprehend. Peer instruction provides a chance for the students to share their perspective of the concept with other novices and enables a patient and empathic interaction to take place. In this manner some of the connections which are not emphasized because they are instinctive to the instructor may be reinforced by peer instruction.

"It is best to make things as simple as possible but not simpler."

Albert Einstein

Objective Results of the Use of Conceptests. The initial results obtained from the use of the Conceptest in Pharmaceutics I, demonstrate the successes and failures of

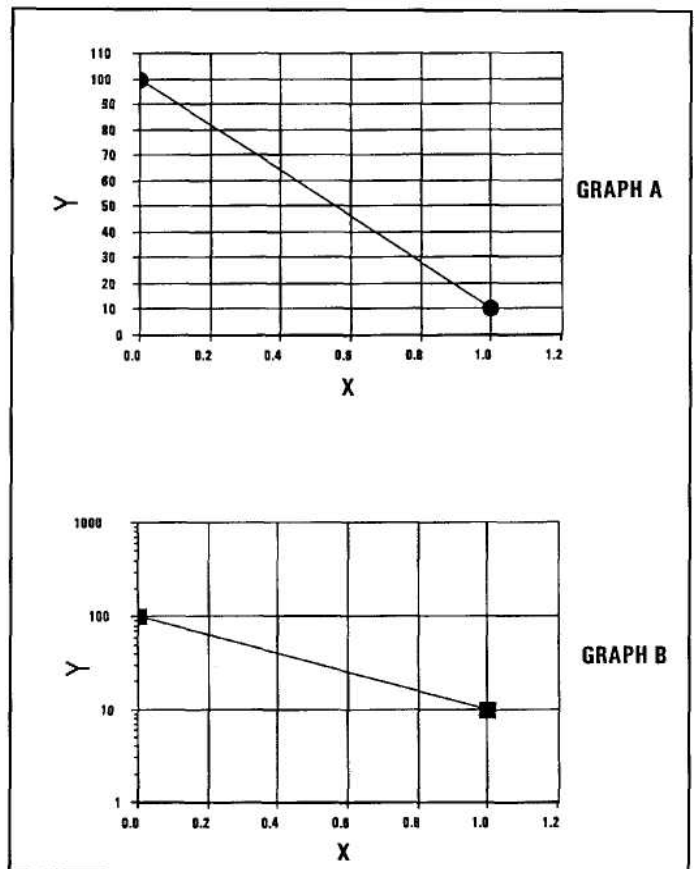
the instructor to overcome students' beliefs in pharmaceutical fallacies. Without exception, the students were more confident in their answers following the lecture and again following the peer instruction segment. In four out of 19 questions the students misapplied the concept to the test more frequently following the lecture than prior to the lecture and in four out of nineteen questions, the students misapplied the concept more frequently following peer instruction than prior to peer instruction. One possible explanation for this result is that in several questions more than one concept was used to solve the problem. If one concept was understood and the other was not then an appropriate alternative wrong answer was available to the students.

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References

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APPENDIX A. CONCEPTEST QUESTIONS

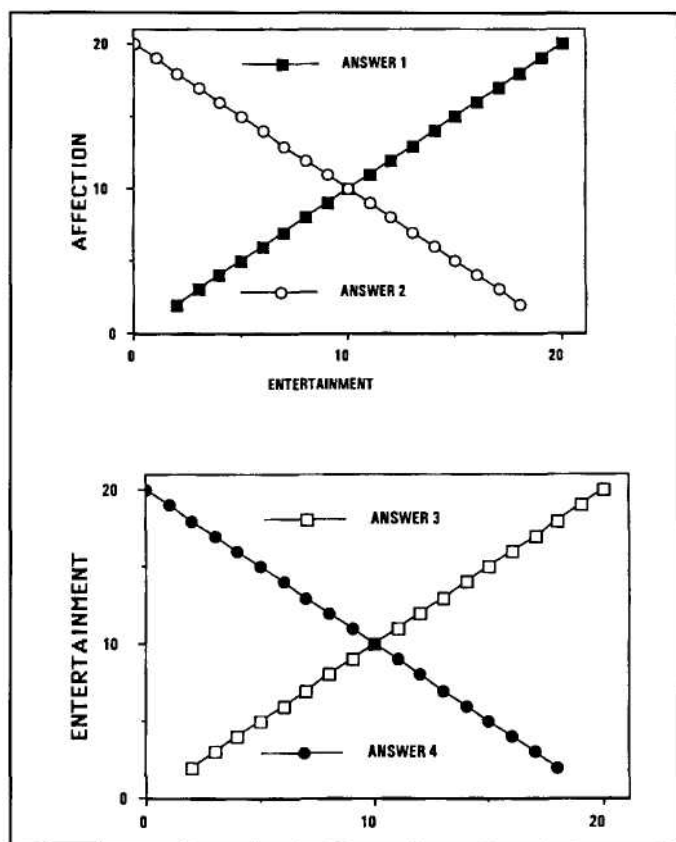


1. Choose one:
 - a. Graph A is a better fit of the points than Graph B
 - b. Graph B is a better fit of the points than Graph A
 - c. Graph A is equal to Graph B with regards to best fit
2. A patient complains to you that every time an OTC liquid sinus medication is taken, drowsiness is a side effect. The

- patient has switched to a liquid dosage form because surgery has made swallowing difficult. This side effect was not a problem when the patient used a tablet dosage form of the same active ingredient. You conclude that the problem is due to the dosage form. Is the problem associated with?
- Accuracy
 - Precision
- After talking with the patient you learn that the patient is legally blind and/or illiterate and that he can not identify the markings on the cup used to dispense the liquid dosage form. This is an example of an error that is
 - Determinate
 - Indeterminate
 - A drug representative tells you that the values obtained for the generic product are not significantly different than the values for the brand name product. The representative states that; "when comparing the two products, the t-value is very low, therefore the p-value is very high." Does this provide substantial support to his claim of no difference between values associated with each product.
 - yes
 - no
 - On the back of your answer sheet explain how the t-value is associated with the null hypothesis.
 - A patient received an injection of a drug. Lab values were taken over a period of time and a curve was drawn which represented the concentration of drug at various timepoints. The same patient returned two weeks later and received another injection of the same drug. Again a curve was drawn as before. Your computer has identified an equation for each of the two curves. The physician administering the drug calls you on the telephone and tells you that on one of the two occasions a larger dose was given. To identify which time a larger dose was given you should
 - integrate once
 - differentiate once
 - integrate twice
 - differentiate twice
 - differentiate thrice
 - The physician asks for the peak concentrations. You should:
 - integrate once
 - differentiate once
 - integrate twice
 - differentiate twice
 - differentiate thrice
 - A USP Monograph gives appropriate information if you are trying to:
 - identify the best active ingredient for a disease state
 - identify the chemical structure of the drug
 - identify packaging and storage requirements for the drug
 - two of the above
 - all of the above
 - Which of the following is a subset of the others:
 - Biological equivalent
 - Chemical equivalent
 - Pharmaceutical equivalent
 - Therapeutic equivalent
 - None of the above is a subset of the others
 - For a drug to have activity, it is most important that it first be
 - Absorbed
 - Adsorbed
 - Which of the following may be used to prevent bacterial growth?
 - sugar
 - alcohol
 - both
 - neither
 - One reason that tablets are so expensive is that the ingredients must be broken up into small particles. The small particles are then formed into larger particles. Why is this done?
 - To increase the cost of the drug
 - To make the particles uniform in size
 - To purify the particles
 - To make the particles irregular in size
 - none of the above
 - A suppository should be formulated so that the active ingredient is;
 - soluble
 - insoluble
 - partly soluble
 - it depends on the drug
 - it doesn't matter
 - Miss Manners states:

"There are three possible parts to a date, of which at least two must be offered: entertainment, food and affection. It is customary to begin a series of dates with a great deal of entertainment and the merest suggestion of affection. As the amount of affection increases, the entertainment can be reduced proportionately. When the affection has replaced the entertainment, we no longer call it dating. Under no circumstances can the food be omitted.

Draw a graph which represents this situation.



ANSWER 5-NONE OF THE ABOVE

- Drug degradation and drug elimination can follow zero order and first order kinetics
 - true
 - false
- Choose the best answer
 - undissolved drug particle - zero order degradation
 - undissolved drug particle - first order degradation

III. saturated transport mechanism - zero order

IV. saturated transport mechanism - first order

- a. I & III
- b. I & IV
- c. II & III
- d. II & IV

16. The concentration of soluble drug remains constant for a
A. suspension
B. solution
C. both A & B
D. neither A nor B
17. Which of the following is least likely to exhibit nonlinear pharmacokinetics
a. active transport
b. facilitated diffusion
c. pinocytosis
d. passive diffusion
e. ionic diffusion
18. The dissolution rate of drug from a tablet will depend on;
a. the surface area
b. the concentration of the drug in the surrounding solution
c. the concentration of a saturated solution of the drug
d. none of the above
e. all of the above
19. The amount of time which is required for a tablet to disintegrate is a predictor of the time it takes for the drug to be absorbed.
a. true
b. false
20. Which of the following result in the greatest increase in time that the food spends in the stomach?
a. fats
b. proteins
c. carbohydrates
21. Food has a greater effect on
a. rate of absorption
b. extent of absorption
22. Food may increase the extent of absorption for drugs whose predominant route of absorption is
a. first order
b. zero order
23. No one will apply for an NDA for apples because
a. apples are not a drug
b. apples entered the marketplace between 1938 and 1962 and so like aspirin it is not necessary to file an NDA
c. they are not patentable
d. apples are not efficacious in the treatment of any disease state
e. none of the above
24. Attractive and repulsive forces operate to:
a. prevent us from imploding
b. hold our bodies together
c. provide a minimum net energy at certain distance
d. all of the above
e. none of the above
25. Radioactive decay of a single isotope is
a. zero order
b. first order
c. second order
d. none of the above
26. The Clausius Clapeyron Equation demonstrates that a one degree temperature increase at a low temperature relative to a one degree temperature change at a high temperature will have an effect on the vapor pressure which is
a. greater
b. less
c. the same
27. If the volume of the liquid is greater than the volume of the solid then
a. it is water
b. increased pressure will decrease the melting temperature
c. increased pressure will increase the melting temperature
d. more than one of the above
e. none of the above
28. If there are three phases and two components, how many variables must be fixed to identify the system? ($F=C-P+2$)
a. zero
b. one
c. two
d. three
e. four
29. Three formulations contain pharmaceutical equivalents one in the crystal form and the other two in the amorphous form.
a. None of these are therapeutically equivalent
b. The two in amorphous form are therapeutically equivalent
c. All three are therapeutically equivalent
d. Not enough information given
e. Too much information given
30. If the temperature increases, a solute's solubility will
a. increase
b. decrease
31. Drugs should be prescribed and dispensed with regard for;
I. race
II. gender
III. religion.
a. I
b. II
c. III
d. I & II
e. I & II & III