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ABSTRACT

This paper describes the development and implementation of an individualized instruction-evaluation system used in a third-quarter chemistry course at Cuyahoga Community College (Ohio). The system included: (1) 20 performance objectives covering the three modules in the course; (2) an instructional sequence for each objective composed of a variety of learning activities--lectures, readings, discussion, problems, slide-tape modules, and tutoring; (3) criterion-referenced tests with immediate feedback; (4) redirection on objectives not mastered and retesting; (5) grade determination based on number of objectives successfully completed, with no penalty associated with number of attempts. Evaluation of the system was based on the number of students achieving mastery, error rate data, and a student questionnaire. Of the 10 students in the course, 9 achieved mastery of 90% of the objectives, and student responses to the detailed course evaluation questionnaire were very positive. However, error rate data indicated necessity for revision of instruction for 5 of the 20 objectives for which an average of more than 2 attempts were required. Objectives and alternate test questions for the modules are appended. (JDS)

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DESIGN, PRODUCTION, EVALUATION, AND REVISION OF AN INDIVIDUALIZED INSTRUCTION-EVALUATION THIRD QUARTER GENERAL CHEMISTRY COURSE

by

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Cuyahoga Community College, Eastern Campus

A PRACTICUM REPORT PRESENTED TO NOVA UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE
DEGREE OF DOCTOR OF EDUCATION

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ABSTRACT

This practicum report deals with the development of an individualized instruction-evaluation system used with three modules of a course in general chemistry. The report presents the system and supports the different facets of the model with learning theory principles. Basically it is a system that (1) spells out the objectives in concise behavioral terms; (2) suggests learning activities which include lecture, discussions, reading assignments, problems with answers, self-instructional materials, and tutoring; (3) tests by objective with criterion-referenced questions; (4) gives knowledge of results on tests; (5) redirects; (6) determines grades by number of objectives accomplished with no penalty attached to number of attempts. The writing of the three modules was accomplished and was included as part of this practicum in the form of (1) objectives, (2) learning activities, (3) tests, and (4) retests.

The evaluation of the system and the modules was based on the number of students achieving mastery, error rate data, and a post-test questionnaire. Of the ten students enrolled, nine achieved a mastery level of eighteen objectives or 90 percent. Error rate data produced a number of objectives and retests that need to be reqritten, reworked, or the addition of supplementary material. Rate of progress was also examined and found to be too slow. As a result, timelines or deadlines will be established for each module.

The forty-one question post-test questionnaire produced the following conclusions and recommendations: (1) all the students reported they enjoyed learning with the system; (2) all reported it was a "very helpful way of learning"; (3) most facets of the system were helpful to learning and will be kept unchanged; (4) institute timelines with first attempt in class; (5) grade attempts (tests) immediately; (6) the mean predicted anxiety level of students without the system is significantly higher than the reported anxiety level of students with the system; (7) modules and objectives were clearly written; (8) slide-tapes and tutors were only some help; and (9) all students judged the system as an "A" grade.

Additional recommendations were to structure all "hard core" physical science courses at Cuyahoga Community College Eastern Campus with the objective system; and further follow-up and study the future classes with larger enrollments so findings can be further generalized.

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I. INTRODUCTION

This practicum report deals with the development of an individualized instruction-evaluation system used with three modules of a course in general chemistry. The report presents the model of the system and supports the different facets with learning-theory principles. As part of the practicum, three modules were written to include the objectives, learning activities, tests, and retests. The entire enrollment of ten students worked through the modules and completed the post-test questionnaire. The results were analyzed and the system and the modules evaluated so that revisions could be recommended.

II. BACKGROUND AND SIGNIFICANCE

Many two-year students do not possess the academic skills and abilities that one would expect of the traditional entering college student. One of the main causes of the failures of these new students has been an adherence to the standard or traditional methods of instruction. Many of these courses are taught in essentially the same manner as the instructor was taught without any regard to what is known about how people learn. If the needs of the community college student are to be met, curriculum, courses, and modes of instruction have to be structured in a manner which is consistent with theories of learning.

The Eastern Campus of Cuyahoga Community College offers the traditional general chemistry as a three-quarter sequence during each academic year. Although the sequence has a prerequisite of high school chemistry or the equivalent and algebra, the

backgrounds and skills of the students are extremely varied. In an attempt to meet the varied needs of these students, a number of informal pilot studies were performed during the first two quarters of the sequence this year. Based on experience with the pilot studies and a study of learning theory, it was concluded that a formal, more complete developmental study would be conducted during the Spring Quarter on the emerging system of instruction-evaluation.

A brief description of the model, further detailed later in a student handout (see Appendix), is presented at this t e. Basically it is a system that (1) spells out the objectives for the students in concise behavior terms; (2) suggests the learning activities that students should do (which includes lecture, discussions, reading assignment, problems to work, self-instruction tape-slide modules were available and sessions with instructors or tutors); (3) opportunity to show competency in each objective by taking criterion-referenced test questions in the testing center; (4) being given feedback (knowledge of results) as to which objectives were accomplished (90% or better) and which were not; (5) for objectives not accomplished, redirected to activities described in number 2 above and re-taking objectives when it is believed they can be completed; (6) grades are determined by number of objectives accomplished with no penalty or onus attached to second, third, or subsequent attempts.

It was the purpose of this practicum to design, write, evaluate, and recommend revision of an individualized instruction-evaluation approach to general chemistry.

To design a learning system that can allow for all students to learn, it must make provisions for students to work at different rates. D. O. Hebb implies in his writings that there are only two kinds of learners: those who are prepared by early training and those who are not. (3:139) For the student with the appropriate background, new concepts and principles can be learned quickly perhaps in one trial. For the student without a good background, learning may involve many trial and many attempts to show competency. (6:93) This explanation is also consistent with the works of Gagne' especially when dealing with the more complex types of learning. The learning of principles, an emphasis in chemistry, is thought to be the chaining of two or more concepts. (5:52) Accordingly, one condition for learning principles is that the student must have previously learned the concepts or must first take time to learn new concepts. (5:53) Eventhough the chemistry sequence has a prerequisite of high school chemistry, many of the fundamental concepts are not known by the students for many different reasons.

A review of current literature in the field of community college education leads one to a similar conclusion as above when one attacks the problems of providing learning for all students. The essential overall assumption is that all students can learn. They may have different skills, different interests, and different learning rates, but they can learn if the proper conditions are met. Bloom views aptitude to learn as "the amount of time required by the learner to attain mastery of a learning task." (2:97)

Skinner has been bold enough in his beliefs to spell out the significance of his views on learning and expressed it this way: "If the learner fails to learn, it is the teacher's fault. With appropriate instruction, all pupils should get 'A' grades." (3:91) To go further, a teacher of Skinnerian persuasion would say "anyone can learn anything if the proper conditions are met. It might be that some require more time than others (i.e. more care, more experience, more background), but sooner or later, anyone can be brought to the same level of achievement." (3:4)

The system, as described previously, has six basic parts or facets which attempts to allow for different learning rates. As will be seen with the detailing of each facet, there are many other principles of learning theory also accounted for by the system. The first phase is the spelling out of the concepts and principles for the students as what are referred to as behavioral or performance objectives. The importance of well-written objectives cannot be over-stressed. An objective as used here is "a specific, observable student action or product of student action." (4:13) If students are to learn, they must be told what they are expected to learn. If it is important to learn, than it is important that the teacher verify that learning has occurred. This position on learning, of course, stems from the behaviorists camp of learning theory. Many psychologists, and in particular, Guthrie, were obsessed with the observable, understandable, and verifiable. If it is not oservable, it therefore must be excluded. (8:167) This position is further supported by Hilgard

and Bower when they operationally define learning:

> Learning refers to the change in a subject's behavior to a given situation brought about by his repeated experiences in that situation, provided that the behavior change cannot be explained on the basis of native response tendencies, maturation, or temporary states of the subject (e.g., fatigue, drugs, etc.) (6:17)

In order to specify the objectives, the content must first be analyzed to find out what the components are. Learning theorists Hebb and Guthrie both make this suggestion. (3:142) Guthrie goes further by suggesting to "break any unit into its finest units." (3:103) While there is a practical limit of subdivision, the use of objectives, at least in part, accomplishes the task.

The second phase of the system is the formal instructional sequence provided so the students can learn the content specified by the objectives. An attempt has been made to introduce a variety of experiences or activities for the students. The guiding principle was that different people learn different ways. Thorndike suggests that one should avoid rigidity in teaching. Introduce a variety of techniques for solving problems. (3:80) The following is a list of activities available to the students for learning the objectives which are suggested by different learning theorists.

1) Lecture - While it is realized that lecture-discussion has limitations, it is possible for students to learn by ". . . merely sitting, looking, and listening." (1:126) Lecturing, to a large part, is an opportunity to emotionally condition the students. (3:122) If the students feel good about the course (instructor, content, etc.) there is a probability he will feel good when studying the content and therefore spend more time.

2) Reading - Each objective specifies the pages to be read

in the text so the student doesn't have to hunt for help. Many learners have become conditioned to printed words and are able to learn through processes similar to the lecture. (3:124)

3) Problems - Each objective specifies questions at the end of each chapter to be answered for practice. The answers to all the questions assigned were distributed for feedback and reinforcement. It is important to determine the relative need for practice and to schedule the reinforcement. (3:81) The answers to the questions serve to inform the student he is probably correct in his problem solving method; and also serve as immediate secondary reinforcement. Most psychologists endorse a principle of immediate reinforcement. Giving correct answers or "knowledge of results" has been adopted by teaching-machine developers (based on Skinner's theoretical development) as a perfectly satisfactory immediate reinforcer. (3:220) Guthrie approaches this idea by suggesting that the answer be specified as well as the question. (3:103) "Homework without answers is a test, not a learning exercise." (1:260)

4) Slide-tape modules - The use of slide-tape instructional packages for groups of objectives has a number of advantages. Along with allowing self-pacing, the packages break the content into even smaller parts and give immediate feedback and reinforcement for each step. This, of course, is consistent with many learning theories as documented previously.

5) Discussions and tutoring - According to cognitive-field theorists, learning is an active or interactive process. (1:199) During discussions and one-to-one tutoring, students interact with the tutors and the content of the course in an attempt to gain new insights or cognitive structures or change old ones. They also have the advantage of receiving immediate feedback and reinforcement from the instructor or the tutor.

The third phase of the system is an opportunity for the students to demonstrate, under test conditions, they have the necessary skills and knowledge to "accomplish" the objectives. Each test question comes directly from one of the objectives and would be referred to as criterion referenced questions. Every attempt has been made to make sure the test questions were specified by the Objectives. Retention depends on the proper

stimulation. Instructors should not give trick questions. Students should be trained to recognize different forms of the "same question." (1:263) The test questions are graded as either "pass" or "not pass" with "A" level being the criterion. Giving partial credit for answers is avoided for if students "get away with" some rough approximations of the proper response, they will actually learn these approximations. (3:63;6:43) The effect of giving partial credit is similar to reinforcing undesirable behavior which will then further strengthen the undesirable response. (3:61) As mentioned previously, Guthrie suggested that the answer as well as the question must be specified and further suggested that the "precise response" be also required. (3:103) If this is not done, the result will be incomplete or inadequate learning. Having the general idea of a concept or principle but not being able to do it, will impede learning later on which is based on those concepts or principles.

In the fourth phase, the tests over the objectives are graded with the students being told which objectives they have mastered and have credit for. At the same time, they are told which answers were not acceptable and exactly what should have been done. Even though the first try and subsequent tries are not graded immediately, this type of feedback is still viewed as having reinforcement value. The support of this practice from learning theory essentially the same as was documented for providing feedback and answers for homework and tape-slide packages. In order to justify the grades earned by the student as well as

to gather feedback and reinforcement for the instructor as to his success or failure, some method of determining what the student learned must be used. "When the student does not learn, the teacher fails the course." (3:92)

During the fifth phase, the student is redirected to activities that will help him learn the objectives not yet accomplished. It is important to note that once the student has shown competency in an objective he/she does not have to retake that objective again. The student restudies and works mainly on the objectives he doesn't know. While the lecture activity is no longer an option at this time, the student still has the learning activities of working with a tutor, slide-tape packages, reading the text and doing more problems, and asking questions during review sessions with the instructor. The unique advantage of this phase is that students continue to work on content they didn't master the first time. It is also possible that the student knew the material the first time or at least to a great degree and simply needed a short review and retesting to show competency. The support of these activities from learning theory is essentially the same as for the second phase, learning activities and the overall system.

The last phase of the system is the determination of the final grade of the student which is based solely by the number of objectives accomplished. While not entirely consistent with learning theory, grades are given for the following performances: 90 percent of objectives accomplished - A; 80 percent - B;

70 percent - C; less than 70 percent - student option of an incomplete (I) or withdrawal (W). This scale was developed as a result of student suggestions during this study. Some students reported at the very beginning they would be satisfied with a grade lower than an "A". This, of course, also was consistent with the present College policy on grading.

As mentioned previously, there is no penalty or onus attached to objectives accomplished during second, third, or subsequent attempts. An objective accomplished on the fifth try has the same value for grade determination as one accomplished on the first try. Giving less than full credit is similar to punishing the student for not knowing the content or for not knowing whether they are ready to take objectives. The practice of giving low grades or penalties apparently stems from the erroneous concept that punishment fosters learning. Or perhaps giving a student an adversive stimuli (a low grade) will cause him to respond to remove that stimuli, which of course in reality he cannot do. Learning theorists are in relative agreement on the role of punishment in learning. Skinner objects to punishment or "adversive control" because he has determined that it is ineffective and is accompanied by undesirable complications. (3:89) He would suggest that one simply not reinforce the undesirable practice and therefore bring about its extinction. (1:90) Thorndike would suggest that one does not punish learners if the intention is to weaken some practice. Only reward is effective in producing learning. (3:61)

The subject area of chemistry by popular reputation stimulates high anxiety reactions in many students. They have heard that chemistry is at the least a very tough subject. Although moderate anxiety (fear) can be an effect method of motivation, higher levels can actually have a detrimental effect on learning. (6:609) The student may perceive the requirements of the course as being impossible for him/her, producing a very high level of anxiety. Under these conditions, the anxiety can function as an adversive stimuli by which the student could drop out in an attempt to remove it. Freud has classified anxiety into a number of categories, two of which are relevant at this point. Objectives Anxiety depends upon real or anticipated danger (failure - V.K.B.) whose source lies in the external world. Neurotic Anxiety is in regard to an unknown danger (chemistry? V.K.B.) (6:351) The conditions of the class must not allow the student to develop neurotic anxieties. Although this may be highly dramatized, the point is clear. The reduction of fear and anxiety improves learning. However, one must cause or allow for a healthy degree of tension.

With no penalties, the student has a better probality of success. The popular phrase, "nothing succeds like success," has its basis in learning theory. When a student experiences a series of successes that student becomes motivated. (3:163) When a student succeeds, he feels good. When he feels good chances are he will continue that activity. It is important to "arrange for the prospective learner to be successful at the activity that is to be learned." (3:163)

The overall purpose of this practicum was to design an individualized instruction-evaluation system that was consistent with the author's synthesis of learning theory. The effectiveness of this system was evaluated by the writing, testing, evaluating, and recommending revision of three modules of a third quarter general chemistry course.

III. PROCEDURES

The initial phase of the practicum was the designing of an individualized instruction-evaluation system for three modules of a general chemistry course. The design was based on the author's synthesis of learning theory as documented in the Background and Significance chapter of this paper. After the system design was formalized, the content was selected and behavioral objectives were written consistent with the course outline and the text. (7) The learning activities were determined based on the objectives and consisted of lectures, available slide-tape modules, problems at end of chapters for each objective, pages to be read in text for each objective, and examples in text for each objective.

The first module consisted of three objectives (see Appendix I) on acid-base theory covered in chapter 15 of the text and was designated "Module 10" for this is the third course in the general chemistry sequence. Module 11 consisted of eight objectives over chapter 16 and covered ionic equilibria of weak electrolytes, pH, common-ion effect, and buffers. (Appendix I) Module 12 had nine objectives for chapter 17 and covered solubility product

constant (K_{sp}), precipitation, complex ions, amphoterism, and hydrolysis. (Appendix I) Tests over each module were then constructed with one question for each objective. (Appendix II) Second, third, fourth, and fifth attempt test questions were constructed for each objective and labeled according to module, objective, and attempt number. (Appendix III)

Class sessions with the ten students were held as normal with a schedule similar to previous quarters. To help introduce students to the system, a handout explaining the procedures, testing, and grading was written and distributed. (Appendix IV) When a module was concluded in class, students were encouraged to take the module test as soon as they were ready in the testing center. When each student finished the test, it was graded within 24 hours with students being given a feedback sheet showing which objectives they had mastered and which objectives required more study and therefore retaking. After students completed more study by working on their own or in sessions with tutors or instructor, they were instructed to sign-up on a "request form" (Appendix V) 24 hours in advance of the time they wished to try again. These objective tests were then graded with feedback to the student similar to the first try. Subsequent attempts followed the same procedure. Throughout the experimental period which extended past the end of the quarter, a record was kept on the students' progress. Information recorded was: the number of the attempt on which the student was successful for each objective; and the dates the student mastered the objective and received credit.

At the end of the quarter, students were asked to give feedback about the system and the modules during a class session. Questions were asked as to how helpful the different facets of the system were for learning chemistry, and how might the system be improved. These responses, along with the author's questions were the basis for writing the post-test questionnaire (Appendix V) that was then distributed to and completed by the students in the class.

The results of the number of objectives accomplished, number of attempts for each objective, date of completion, and the questionnaire were grouped and entered on a summary sheet to permit ready access. The data was then analyzed to obtain the following information:

1. What percent of the students achieved mastery over 90 percent of the objectives?
2. How many attempts were necessary for students to achieve mastery over individual objectives? (error rate data)
3. What was the rate of progress in completing the objectives?
4. Did students enjoy learning chemistry through this system?
5. How did students describe their feelings about their involvement with the program?
6. According to students' claims, how helpful were the following in learning chemistry?
   a. being able to work more at their own rate
   b. having no penalty or onus attached to repeating attempts over objectives
   c. having slide-tape packages
   d. specifying exactly what they were responsible to learn in the form of behavioral objectives
   e. indicating for each objective the pages to be read in the text

f. indicating for each objective, the problems at the end of the chapter
g. having the answers for ALL problems assigned from the text
h. indicating for each objective the appropriate slide-tape modules
i. the lecture-recitation method used during class
j. the availability of a tutor
k. having no deadlines or time frames for modules
l. being able to take objective trys (tests) at any time the student was ready in the testing center
m. the use of objectives when working on incompleted work
n. the mastery concept (tests are either right or wrong)

7. Overall, how clearly did students feel the objectives were stated?

8. Overall, did students feel the test questions (objective trys) agreed with what was stated in the objective?

9. How appropriate did students believe the content of of the objectives was to a study of general chemistry?

10. Was the content relevant to the students?

11. How helpful did students claim the following methods might be if incorporated into the system:
a. having tests graded immediately
b. having a tutor available when working tape-slide packages
c. having deadlines for each module
d. having first attempt during class time on a specified date
e. having some form of self-instructional material over each (or series of) objective?
f. reducing size of modules but must master the whole module each time
g. being able to give input as to the content covered

12. Did students claim the tests lost their motivational value as a result of the opportunity to retake objectives as many times as necessary?

13. Did students feel they were able to earn higher grades as a result of the system?

14. What level of anxiety did students predict they would have had if the course was structured in a more traditional manner?

15. What level of anxiety did students claim to have had during this course?

16. Did students claim to believe the system activity helped them to learn chemistry better?

17. Did students claim the system encouraged them to "go back" and learn concepts they didn't learn the first time?

18. Did students claim to believe they would remember the concepts longer (greater retention) as a result of the system?

19. Did students claim they were encouraged by the system to learn more for their own knowledge?

20. Did students claim the testing over each objective was a detriment to learning the "big picture?"

21. Did students claim the specific feedback over each objective helpful in learning chemistry?

22. To what extent did students claim to cheat?

23. What was the letter grade assigned by students to the objective-system?

24. To what extent did students recommend the use of the system for use in all other courses they are taking?

25. To what extent did students recommend the use of the system for use in all "hard core" science and math courses?

The procedures for treating the data were to enter the data, in some cases calculate means or percentages, and then summarize. After the data was collected and grouped it was deemed necessary to formally examine the relationship between the two "anxiety" questions. The hypothesis postulated was:

> The mean predicted anxiety level of students learning without the objective system is significantly higher than the mean claimed anxiety level of students learning with the system.

For a study of relationship of mean anxiety levels with and without the system, a t-test is called for. Responses were assigned values from one to five with "a great deal of anxiety"

being the highest. Means were calculated, with a one-tailed test being used for a relationship in a particular direction was sought. Desired level of significance was .01 with degree of freedom being 18. Critical t under these conditions is 2.55.

IV. RESULTS

The results of the number of objectives accomplished, number of attempts for each objective, dates of completion, and the questionnaire were grouped and entered on a summary sheet to permit ready access. The number of objectives accomplished were ranked from high to low as shown in Table 1 and Figure 1. Expected level of performance for each objective was mastery with eighteen objectives (90%) accomplished of the twenty objectives earning an "A." Of the ten students who worked through the modules, 90 percent received an "A" grade with one taking an incomplete.

TABLE 1

FREQUENCY DISTRIBUTION OF NUMBER OF OBJECTIVES EARNED BY TEN STUDENTS

Interval	Frequency
19-20	7*
17-18	2*
15-16	0
13-14	0
11-12	0
9-10	1**
Total	10

* 90% or better: "A" grade
** student still working: "I" incomplete

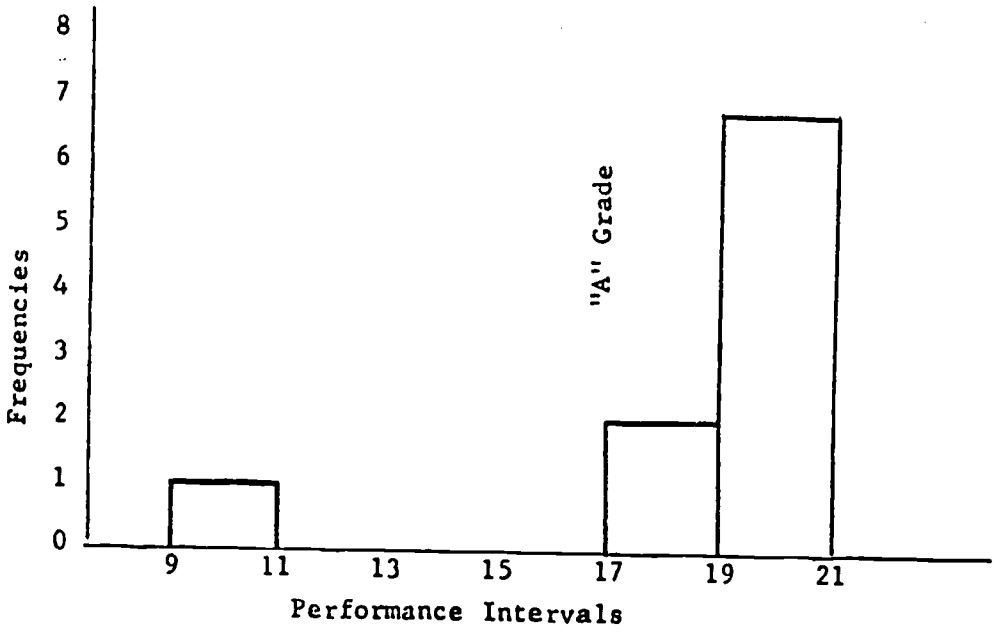

FIGURE 1: Histogram of ten students for performances

An analysis of the number of attempts required to achieve mastery for each objective produced Table 2. The error rate data was grouped to show the number of times students had to try to show competency. As is shown in Table 2, most (75%) of the objective trys were accomplished in the first or second attempt with objectives 11-7, 12-5, 12-6, 12-7, and 12-8 taking the most attempts. This observation was verified by calculating the mean number of attempts for each objective showing that those objectives had means greater than 2.0 attempts. When the total number of students achieving mastery is examined, it is seen that 91 percent of the objectives were accomplished.

Table 3 shows the rate of progress in achieveing the objectives. The mean for all the objectives measured from time of completion of formal class room instruction was 17.3 days with the time ranging from three days to a high of 62 days. The range

TABLE 2

ERROR RATE DATA FOR MODULES (OBJECTIVES)

dule-Objective	Number of Students Completing an Attempt 1	2	3	4	Total Number of Students Achieving Mastery	Average Number of Attempts
10-1	10				10	1.0
10-2	9	1			10	1.1
10-3	10				10	1.0
11-1	7	1	1	1	10	1.6
11-2	6	3			9	1.3
11-3	9	1			10	1.2
11-4	8	2			10	1.2
11-5	5	1	1	1	8	1.8
11-6	4	4	1		9	1.7
11-7	1	4	2	1	8	2.4
11-8	3	7			10	1.7
12-1	1	8			9	1.9
12-2	7	2			9	1.2
12-3	5	4	1		10	1.6
12-4	5	3	1	1	10	1.8
12-5	2	1	1	1	6	2.1
12-6	1	1	5	2	9	3.2
12-7	1	1	5	2	9	3.2
12-8	0	3	2	2	7	2.9
12-9	5	3	1		9	1.6

TABLE 3

RATE OF PROGRESS

Module-Objective	Mean Number of Days	Range (days)
10-1	10.8	5-25
10-2	11.4	5-31
10-3	10.8	5-25
11-1	20.6	3-63
11-2	16.6	3-42
11-3	9.6	3-24
11-4	14.7	3-47
11-5	22.5	3-55
11-6	20.6	4-55
11-7	35.9	3-62
11-8	24.5	3-50
12-1	15.5	6-26
12-2	12.8	6-25
12-3	13.6	6-26
12-4	14.9	6-32
12-5	16.3	6-29
12-6	20.3	6-32
12-7	20.3	6-32
12-8	19.6	13-32
12-9	14.1	6-32
$\bar{X}$	17.3	

for Module 10 was five to 31 days; Module 11 was three to 62 days; and Module 12 was six to 32 days. Although not shown in Table 3, mean days to complete for individual students was 18.4 with a mean range of 8.1 days to 39.8 days.

In response to the post-test question (Appendix V for complete questionnaire) "How much did you enjoy learning chemistry through this system?", 60 percent of the students responded to "very much." As shown in Table 4, the remaining 40 percent responded "to a great extent."

TABLE 4

FREQUENCY DISTRIBUTION OF
STUDENT RESPONSE TO ENJOYMENT

Response	Frequency
Very Much	6
To a great extent	4
Some	0
Very little	0
None	0
Total	10

As shown in Table 5, the response to the question, "Which statements best describe your feelings about your involvement with this objective system?", all of the students responded it was a "very helpful way of learning." The next highest was "sure beats the traditional method," with "a very fair way of grading" being the only other high response.

TABLE 5

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO FEELINGS ABOUT THE SYSTEM

Response	Frequency
Very helpful way of learning	10
Sure beats the traditional method	8
A very fair way of grading	7
Inspiring	3
A real treat	1
All other	0

Table 6 attempts to summarize the responses to questions three through sixteen and thirty-seven which deal with how helpful each facet of the system was to learning chemistry. In response to the question that the system allowed students to work more at their own rate, six of the ten said "very helpful." The mean response was 4.4, slightly above "helpful." Students overwhelmingly responded "very helpful" to the practice of not having any penalty or onus attached to repeating objectives. The response to the slide-tape packages had a distribution that was quite different with a mean of only 2.9. This was slightly less than only "some help."

Question 6 on the questionnaire asked students if they thought it was helpful to have behavioral objectives specifying exactly what they were responsible for. Five students responded "very helpful" and the remaining five, "helpful", producing a mean of 4.5. The practice of indicating the pages to be read in the text for each objective was classified as "very helpful" by

seven of the students with a mean of 4.4. The other students were however spread across the continuim with one student responding "very little help." Indicating for each objective the problems at the end of the chapter ahd a mean response of 4.5 with seven students responding "very helpful." The same response pattern was given for furnishing all the answers to those problems assigned in the text. Indicating particular tape-slide packages for each objectives produced scattered responses. As shown in Table 6, question 10, the mode was 3, "some help," with 3.4 being the mean.

Table 6 continues with the frequency of student responses to the helpfulness of the lecture-recitation method used during class. Seven students responded "helpful" and the remaining three "very helpful." No students responded "very helpful" to the tutor question. The responses ranged from "no help" to Helpful" with a mean of 2.6. A mean of 4.6 was calculated for student responses to question 13, that of having no deadlines or time frames for modules. Five students responded "very helpful" with three others responding "helpful."

Being able to take objective tries (tests) at any time in the testing center resulted in eight of the ten students responding "very helpful." The responses to question 15 were even higher with nine of the ten reporting the objectives would be "very helpful" when working on an incomplete. The mastery concept of showing competence to an "A" level for each objective had seven students respond "helpful" with three responding "very helpful."

TABLE 6

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO QUESTIONS 3 THROUGH 16 AND 37 DEALING WITH
FACETS OF THE SYSTEM AS TO DEGREE OF HELP

Question	No Help	Very Little Help	Some Help	Helpful	Very Helpful
3. Work at own rate	0	0	2	2	6
4. No penalty	0	0	1	0	9
5. Slide-tape packages	1	1	6	2	0
6. Behavioral objectives	0	0	0	5	5
7. Indicating pages	0	1	1	1	7
8. Indicating problems	0	0	2	1	7
9. Answers to problems	0	0	2	1	7
10. Indicating tape-slides	0	1	5	3	1
11. Lecture-recitation	0	0	0	7	3
12. Tutors	2	2	4	2	0
13. No deadlines	0	0	2	3	5
14. Variable testing	0	0	0	2	8
15. Objectives when "I"	0	0	0	1	9
16. Mastery concept	0	0	0	7	3
37. Specific feedback	0	0	1	3	6

Question 37 was placed in Table 6 for it dealt specifically with a facet of the system. Six students responded "very helpful" to the practice of giving specific feedback over attempts that were not correct. The mean response was 4.5, midway between "helpful" and "very helpful."

Questions 17 through 20 were constructed to assess student reactions to the content and writing of the Objectives. Table 7 shows the frequency distribution of student response to how clear the objectives were stated. Three students responded "very clear," six responded "clear," and one responded "some." This was a mean response of 4.1.

TABLE 7

FREQUENCY DISTRIBUTION OF STUDENT RESPONSE TO CLARITY OF OBJECTIVES

Response	Frequency
Very Clear	3
Clear	6
Some	1
Very Little Clarity	0
Ambiguous	0
Total	10

In response to the question "Did test questions agree with what was stated in the objective?", eight students responded "agree." As shown in Table 8, the remaining two students selected responses on either side resulting in a mean response of 4.0.

TABLE 8

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO OBJECTIVE AND TEST QUESTION RELATIONSHIP

Response	Frequency
Greatly Agree	1
Agree	8
Some	1
Very Little	0
No relationship	0
Total	10

As shown in Table 9, six students responded "very appropriate" to the content selected for the objectives. The other four students responded "appropriate." These responses produced a mean response of 4.6.

TABLE 9

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO APPROPRIATENESS OF CONTENT

Response	Frequency
Very appropriate	6
Appropriate	4
Some	0
Very little	0
Not appropriate	0
Total	10

Student response was mixed on the question of relevancy of the content. They ranged from "some relevance" to "very relevant" with a mean of 4.1. Table 10 shows the distribution of student responses.

TABLE 10

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES TO RELEVANCY

Response	Frequency
Very relevant	4
Relevant	3
Some relevance	3
Very little relevance	0
Not relevant	0
Total	10

Questions 21 through 27 were listed under the section of "Revision and Improvement" in the questionnaire. For this reason, all the responses were summarized in Table 11. In response to the suggestion fo having attempts graded immediately, eight of the ten students responded "very helpful." The remaining two students responded "helpful" which produced a mean response of 4.8. Student response to Question 22, that of having a tutor available when working slide-tape packages, produced far different results. Seven students responded "very little help" or"some help." This produced a mean response of only 2.6.

Table 11 continues with the listing of student responses to the suggestion to have deadlines for each module when work

has to be completed. Responses were scattered from "no help" to "helpful" with a mean response of 2.5. Question 24 is actually another timeline question, for students were asked if it would be helpful to have the first try (test) in class on a specific date. The response pattern was noticeably moved toward the more helpful end, with four students responding "very helpful." Response to the suggestion of having a self-instructional unit available for each (or series) of objectives, student responses produced a mean of 3.6. Six students responded "some help" with only two responding "very helpful."

Question 26 addressed the idea of reducing module sizes but having mastery tests over the complete module. This approach is used in other systems, noteably the "keller approach." Student responses had a mean of 1.7 with nine of the ten students responding "very little help" or "no help." As shown in Table 11, student responses to the suggestion of having student input as to the content produced a wide range of responses. While five students said "very little help," three students responded at least "helpful."

The "Final Section" in the questionnaire attempted to assess student perceptions and attitudes about their involvement with the system. In response to the question, "Did the tests lose their motivational value as a result of the opportunity to retake objectives as many times as necessary without penalty?", 50 percent of the students responded "not at all." As shown in Table 12, two students responded "very little", with three responding "some."

TABLE 11

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO QUESTIONS 21 THROUGH 27 DEALING WITH
REVISION AND IMPROVEMENT

Question	No Help	Very Little Help	Some Help	Helpful	Very Helpful
21. Immediate grading	0	0	0	2	8
22. Tutor present S/T	0	4	3	1	1
23. Imposing deadlines	2	3	3	2	0
24. First Try in class	0	2	2	2	4
25. More A/T	0	0	6	2	2
26. Module mastery	4	5	1	0	0
27. Content input	0	5	2	1	2

TABLE 12

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO MOTIVATIONAL LOSS AS A RESULT OF NO PENALTY

Response	Frequency
Almost completely	0
A good amount	0
Some	3
Very little	2
Not at all	5
Total	10

As shown in Table 13, 90 percent of the students responded they felt they earned at least one letter grade higher as a result of the system. However, one "A" student felt his grade would have been the same.

TABLE 13

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES TO GRADE EARNED WITH SYSTEM

Response	Frequency
At least one letter or maybe more	2
Definitely one letter grade	7
Perhaps one letter grade	0
Same grade but easier	0
The same	1
Total	10

Table 14 attempts to summarize the responses of questions 30 and 31, which deal with anxiety level. Question 30 asked the question, "If this course were structured in a more traditional manner with the same content, what degree of anxiety would you have had?". Eight of the ten students responded "a great deal of anxiety," with the other two students responding "a good deal of anxiety." The mean produced was 4.8 with 5.0 being maximum. In response to the level of anxiety experience during the course structure with the system, eight students responded "some anxiety," with one student responding on either side; the mean response was 3.0.

TABLE 14

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO ANXIETY LEVEL WITH AND WITHOUT SYSTEM

Response	Frequency without	with
A great deal of anxiety	8	0
A good deal of anxiety	2	1
Some anxiety	0	8
Very little anxiety	0	1
No anxiety	0	0
Total	10	10

As shown in Table 15, 90 percent of the students responded "very helpful" when asked if they believed the system actually helped them learn chemistry better. This skewed response produced a mean of 4.9.

TABLE 15

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO HELPFULNESS OF OVERALL SYSTEM

Response	Frequency
Very helpful	9
Helpful	1
Some help	0
Very little help	0
No help	0
Total	10

Did the system encourage students to "go back" and learn concepts they didn't know? Table 16 shows that five students responded "most of the time," with four others responding "all of the time." Mean response for question 33 was 4.3.

TABLE 16

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO ENCOURAGEMENT TO RESTUDY UNLEARNED CONCEPTS

Response	Frequency
All the time	4
Most of the time	5
Some	1
Very little	0
Not at all	0
Total	10

Table 17 shows the distribution of responses to the question of greater retention as a result of the system. The mean response was 4.0 with 100 percent of the students responding at least "some."

In response to the question, "Did the system encourage you to learn more for your <u>own</u> knowledge rather than just learning for test?" Student responses were widely diverse. As shown in Table 18, student responses ranged from "for tests only" all the way to "for own knowledge." The mean response, however, was 3.5.

TABLE 17

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO DEGREE OF RETENTION UNDER THIS SYSTEM

Response	Frequency
Much longer	3
Longer	4
Some	3
A little longer	0
No difference	0
Total	10

TABLE 18

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO SYSTEMS EFFECT OF LEARNING
FOR THEIR OWN KNOWLEDGE

Response	Frequency
For own knowledge	3
To a good degree	2
Some	3
Very little	1
For tests only	1
Total	10

Student response to the practice of giving the content in "small bits" in objective form as being a detriment to learning the "big picture" was again scattered. Table 19 shows, however, that 50 percent responded they learned concepts "to a good degree" with a mean of 3.8.

TABLE 19

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO LEARNING CONCEPTS

Response	Frequency
Learned Concepts	2
To a good degree	5
Some	2
Very little	1
Learned only pieces	0
Total	10

As shown in Table 20, 90 percent of the students responded "no cheating" under the system. Only one student responded that he/she cheated "a little." The mean response of 1.1 was the lowest of the questionnaire.

TABLE 20

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO DEGREE OF CHEATING WITH SYSTEM

Response	Frequency
To a great extent	0
Cheat	0
Some	0
A little	1
No cheating	9
Total	10

When students were asked to assign a letter grade to the "system," 100 percent responded "A" as shown in Table 21. The mean response was, of course, 5.0 which was the highest of the

questionnaire.

TABLE 21

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO ASSIGNING LETTER GRADE TO SYSTEM

Response	Frequency
A	10
B	0
C	0
D	0
F	0
Total	10

As shown in table 22, the most often used student response to recommending the system for all courses was "many." Four students responded "some" with only one responding "most."

TABLE 22

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
TO RECOMMENDING THE SYSTEM
FOR ALL OTHER COURSES

Response	Frequency
Most	1
Many	5
Some	4
Very few	0
None	0
Total	10

Eight of the ten students recommended using the system for "most" science and math courses. Table 23 shows the other two students responded "many," with mean of 4.8.

TABLE 23

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES TO RECOMMENDING THE SYSTEM FOR ALL SCIENCE AND MATH COURSES

Response	Frequency
Most	8
Many	2
Some	0
Very few	0
None	0
Total	10

For the relationship of mean anxiety level predicted without the system and the mean claimed anxiety level with the system, a null hypothesis of $\bar{X}_1 = \bar{X}_2$ was postulated. As shown in Table 24, a t-ratio of +9.03 was obtained and found to be significant at the .005 level. In view of this finding, the above null hypothesis was rejected. Therefore, it was concluded that the mean predicted anxiety level of a student learning without the objective system is significantly higher than the mean claimed anxiety level of students learning with the system.

TABLE 24

CALCULATION OF t-RATIO FOR MEAN CLAIMED ANXIETY LEVELS WITH AND WITHOUT THE OBJECTIVE SYSTEM

	Without System		With System	
n	10		10	
mean	4.8		3.0	
S.D.	.42		.47	
$\bar{X}_1 - \bar{X}_2$		+1.80		
t-ratio				+9.03*

* significant at .005 level

V. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this practicum was to design, produce, evaluate, and recommend revision of an individualized instruction-evaluation approach for three modules of a general chemistry course. The design and production of the system and materials were accomplished and included in this practicum in the form of (1) objectives for three modules, (2) one whole module test for each module, (3) four additional attempts for each objective, and (4) an instruction sheet.

The evaluation of the system was based on the number of students who achieved mastery, error rate data, and the post-test questionnaire. Of the ten students who started the course, nine completed at least eighteen objectives (90%), and earned an "A" for that part of the course. The one student who did not reach an "A" level was still, at the time of writing, working on

completing the modules. Based on the above statistic, the overall program was judged to be successful.

Error rate data produced some areas that need rewritting, reworking, or the addition of supplementary material. In particular, objectives 11-7, 12-5, 12-6, 12-7, and 12-8 required many more attempts to complete than other objectives. Objectives 12-5 and 12-8 had very poor results with only six and seven students, respectively, achieving mastery. Based on student feedback and a close examination of the objectives and the tests, it was concluded that: (1) objective 11-7 was appropriate and attempts (tests) were consisten, therefore supplementary material will be written; (2) objective 12-5 was written in a confusing manner with attempts not particularly consistent (especially the third try), therefore the objective with its tests will be rewritten; Objective 12-6&7 was appropriate and attempts consistent, however it was over a very difficult concept, therefore supplementary material will be written; Objective 12-8 was appropriate and attempts consistent, however it assumed competency over concepts in objective 11-7 (see above) and therefore no action was taken. Other attempts (tests) that are in need of rewriting because of inconsistency with objectives were: first module 10 attempt, 10-3-4, 10-3-5, 12-3-5, 12-5-3, and 12-5-5.

Rate of progress in achieving objectives was judged too slow for some students. Module 10 completion rate was good, however, most students mastered the objectives on the first try. Module 11 completion rate was the longest with the range being 3 to 62 days. This is in part explained by the fact that module 11 was

presented early in the quarter with plenty of time to retake the objectives. Module 12 completion rate was still high, but was judged adequate. It is interesting to note that the 55 days for module 11 and the 32 days for module 12 both fell into the last week of the quarter. Based on this information, time lines are recommended for each module. ~~This recommendation will be~~ will be reviewed again when the post-test questionnaire is summarized.

Most students reported that they enjoyed the experience of learning chemistry with the system. Overall feelings toward the system were very good. Not one neutral or negative response was given by any student. All students reported that it was a "very helpful way of learning."

The facets of the system judged helpful to learning were: (1) able to work more at own rate; (2) no penalty or onus attached to retakes; (3) specifying content with behavioral objectives; (4) for each objective, indicating the text pages, problems, and the answers; (5) the lecture-recitation format; (6) taking tests at any time; (7) the mastery concept; and the use of specific feedback on retakes. All of the above facets will be retained and effort will be made to continually improve each one.

The facets of the system which were questionable as to the degree of help were: (1) slide-tape packages; (2) for each objective, indicating slide-tapes; (3) the tutors; and (4) having no deadlines. It is not known at this time if the students were evaluating the particular tape-slides used or

tape-slides in general. Further study is recommended to answer this question. The practice of indicating for each objective the tape-slides will be continued even though it was judged less than helpful. This will be done for it does not deter any student, is helpful to some, and doesn't cost anything. The usefulness of the tutors is questioned because of the poor student usage and the response, "some help." Further study is recommended to find out what problems are involved.

As mentioned above, timelines for each module will be instituted by on the completion rate data. Knowingly, this decision was made in opposition to 80 percent of students who responded it was at least helpful not to have deadlines. Students did respond to a later question to deadlines in a morefavorable fashion. A compromise solution was made in an attempt to stop procrastination by students. Each module will have a reasonable deadline in which all objectives must be completed. Only students opting for an incomplete (I) may work on objectives not accomplished, but only after the end of the quarter. This policy will be instituted and evaluated this next quarter.

Most students reported the objectives were clearly written and that the tests agreed with those objectives. Most of the students reported the content to be appropriate for a study of general chemistry but thought it could be more relevant. It is recommended that all the objectives be studied and many be revised based on the above data and the now greater experience of the author.

Only one suggestion from the revision and improvement section was strongly supported by all students. A mean response of 4.6 indicates students believe that grading attempts (tests) "immediately" after working would be "very helpful." Steps are already in progress to institute a testing center person who will have the knowledge, expertise, and authority to grade objective trys. It is interesting to note however, that this service was offered on a limited basis during the experimental period and not one student asked to take objectives tries during the specified hours. It is, of course, possible that the limited hours did not coincide with the student needs.

One other suggestion somewhat supported by students was the practice of having the first test on a specific date and held in class. It was interpreted that this was "helpful" to students by keeping them on schedule. It is therefore recommended that all first attempts be held on a specific date and during class time.

The need for more self-instructional materials was indicated to some extent by a mean student response of 3.6. It is recommended that more materials be written and purchased consistent with other budget priorities.

The suggestion of having a tutor present while working on slide-tapes was not considered very helpful by most students. This, however, will be accomplished under the above testing program for the testing center has A/T carrels.

Students do not want the size of the modules reduced and

be tested over the entire module. Even though the present system of testing over each objective is time consuming, it will continue.

According to students, removing penalties for missing test questions results in very little, if any, loss of motivation. They also believe they earned higher grades as a result of the system.

The mean predicted anxiety level without the system is significantly higher than the mean claimed anxiety level of students with the system. There are short-comings to this conclusion for it is realized that in one case, responses were "predicted" on an "if" basis and recalled or remembered in the other case. It is however supportive evidence in favor of the system because the students believe their anxiety level is lower.

Overall students believe the system is (1) helpful in learning chemistry; (2) encourages them to study unlearned concepts; (3) increases their retention of chemical concepts; (4) to some extent, encourages them to learn for their own knowledge; (5) eliminates the necessity to cheat; (6) but does not deter them from learning the concepts or "big picture."

The students overwhelmingly gave the system an "A" and recommended that it be used for many other courses. They went further in their recommendations by suggesting "most" science and math courses be structured in with the objective system format.

It is recommended that the previously stated revisions and modifications and additions be carried out. Due to the success

of this experiment, it was recommended and adopted that Chemistry 111, 112, and the rest of 113 be structured with an objective system approach. It was also recommended that Principles of Medical Science, Biology 121, be written and taught during this summer utilizing the objective system. (At the time of writing, all objectives and most test had been written). The last recommendation is to continue to evaluate and revise each course and the system beginning with Biology 121 this summer.

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Mr Vernon Burger

Module 10

1. You should be able to define the following terms based on the (1) Arrhenius concept (2) general solvent systems (3) Bronsted Lowery (4) Lewis. 1, 15

2. Given an equation, you should be able to identify the Bronsted acids and bases and the conjugate pairs; be able to describe the difference between strong and weak acids and bases; be able to describe Amphiprotic, Amphoteric, and Hyprolysis and give examples. 3, 4, 5, 6, 7, 8, 10

3. Given a list of equations, you should be able to arrange all the Bronsted acids according to decreasing acid (or base) strenght; and on the basis of the above state whether you would expect an appricible reaction between species that will given. 11, 12, 13, 14

10-1-2

Give an example and explain:

a. Arrenius acid and base
b. General solvent system acid
c. Bronsted-Lowery Neutralization
d. GSS Neutralization

10-1-3

Give an example and explain:

a. Arrhenius acid and base
b. general solvent system base
c. Bronsted-Lowery acid
d. General solvent system acid and base

10-1-4

Give an example and explain:

a. Arrhenius neutralization
b. General solvent system neutralization
c. Bronsted-Lowery base
d. Arrhenius acid and base

10-1-5

Give an example and explain the differing concepts as to acids and bases.

10-2-2

In the following equations, identify the Bronsted Acid, base and the conjugate acid and base.

a. $NH_2^- + H_2O \quad NH_3 + OH^-$

b. $H_3O^+ + OH^- \quad 2\ H_2O$

Describe the difference between strong and weak acids and bases.

10-2-3

1. In the following equations, identify the Brosdted Acid, base and the conjugate acid and base.

   a. $NH_3 + H_2O \quad NH_4^+ + OH^-$

   b. $CO_2 + H_2O \quad H^+ + HCO^-_3$

2. Describe Amphiprotic and hydrolsyis (give an example).

10-2-4

1. In the following equations, identify the Bronsted Acid, base and the conjugate acid and base

   a. $SO_2 + H2O \quad H^+ + HSO_3^-$

   b. $Pb^{2+}(aq) + H\ O \quad Pb(OH)^+(aq) + H^+(aq)$

2. Describe Amphoteric and Hydrolysis (give an example)

10-2-5

Describe the difference between strong and weak acids and bases and also amphoteric, amphiprotic, and hydrolysis

NAME _____

TEST - MODULE 10

1. Define the following terms based on (A) Arrhenius (B) GSS (C) Bronsted-Lowery

erm	Arrhenius	GSS	Bronsted-Lowery
cid			
ase			
eutralization Reaction			

2. Arrange all the Bronsted Acids that appear in these equations according to decreasing acid strength.

a. $H_3O^+ + H_2PO_4^-$ $H_3PO_4 + H_2O$

b. $HCN + OF^-$ $H_2O + CN^-$

c. $H_3PO_4 + CN^-$ $HCN + H_2PO_4^-$

d. $H_2O + NH_2^-$ $NH_3 + OH^-$

3. Identify the Bronsted Acid-Base conjugate pairs.

a. $NH_3 + H_2O$ $NH_4^+ + OH^-$

b. $NH_3 + HCl$ $NH_4^+ + Cl^-$

c. $H_3O^+ + HS^-$ $H_2S + H_2O$

d. $HS^- + H_2O$ $H_3O^+ + S^=$

What is the difference between the terms amphiprotic and amphoteric?

Chemistry 113

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Assistant Professor

Module 11

1. Given the concentration of an acid or base and the degree of dissociation (%) or ionization , you should be able to calculate the equillibrum concentrations and the ionization constant. Combos E-1, 4, 5, 8a, 9a, 9b

2. Given the ionization constant (or from table) and the concentration of an acid or base, you should be able to calculate the concentration of the acid and base and their ions and the degree of ionization. Combos E-2, E-3, E-4, 1, 2, 3, 6, 8b

3. Given (or having previously calculated) the $(H)^{+}$, you should be able to calculate the (OH^{-}) and the pH and pOH. Combos E-5, E-6, E-7, E-8, E-9, 12, 13, 14

4. Given the concentration (amount) of a weak acid or base and the ionization constant (from the table), you should be able to calcualte the pH and pOH, (H^{+}), (OH^{-}) degree ionization. Combos E-11, 15, 16, 17

5. Given the concentration of a weak acid, a base, and salt of the weak acid or base, you should be able to calculate the (H^{+}), (OH^{-}), pH and degree of ionization pOH of the solution (Common-ion effect). Combos 24, 25, 26, 27, 28

6. You should be able to define a buffer system; be able to explain in items of a model or theory; given the amounts of a buffer system, be able to calculate the concentration and pH. Combos E-15, E-16, E-17, 29, 30, 31, 32

7. Given the concentration of a polyprotic acid and the ionization constants of the ionization steps (from the table), you should be able to calculate the concentration of all ions present and the pH. E-18, E-19, 34, 35.

8. Given the pH or(H^{+}) of a saturated solution of H_2S, you should be able to calculate the sulfide concentration. Combos E-20, 38, 39, 40

Main reference for Module 11 is Chapter 16 in "Chemistry- A Conceptual Approach". Mortimer

11-1-2

What is the ionization constant of a monoprotic acid which ionizes 2.0×10^{-3} % in a .5M solution?

11-1-3

Calculate the ionization constant for acid HA which ionizes 4.5×10^{-20}% in a 0.25M solution

11-1-4

If ionization constant of HA is 5.62×10^{-8}, what is the degree and % of ionization in a .100M solution?

11-1-5

What are the equilibrium concentrations of a Monoprotic acid which ionizes

3.62×10^{-4}% in a .8M solution?

11-2-2

a. What are the concentrations of H^+, $C_7H_5O_2^-$ and $HC_7H_5O_2$ in a .02M solution of Benzoic acid?

b. What is the degree of ionization?

11-2-3

a. What are the concentrations of H^+, ClO_2^-, and $HClO_2$ in a .3M solution of chlorous acid?

b. What is the degree of ionization?
(K for $HClO_2$=1.1 x 10^{-2})

11-2-4

a. What are the concentrations of C_sH_sN, H_2O, $C_sH_sNH^+$, and OH^- in a .08M solution of pyridine? (basic)

b. What is the degree of ionization?
(K for C_sH_sN= 1.5 x 10^{-9})

11-2-5

a. What are the concentrations of $C_6H_sNH_2$, H_2O, $C_6H_sNH_{3g}^+$, OH^- in a .16 solution of aniline? (basic)

b. What is the degree of ionization?
(K for $C_6H_sNH_2$= 4.6 x 10^{-10})

11-3-2

a. What is the pH of a solution that is 2.8×10^{-5} in OH^-?

b. What is $(\dot{\ddot{O}}H^-)$ of a solution with a pH of 10.3?

c. Define pH

11-3-3

a. What is the pOH of a solution that is 3.75×10^{-6} in H^+?

b. What is the (H^+) of a solution with a pOH of 2.5?

c. Define pOH.

11-3-4

a. Define pH and pOH.

b. Find the pH and pOH of solutions that have the following concentrations of H^+

1. 6.2×10^{-3}
2. 5.8×10^{5}
3. 9.2×10^{0}

11-3-5

a. Define pH and pOH.

b. Find the pH and pOH of solutions that have the following concentrations of OH^-

1. 5.32×10^{-7}
2. $.631 \times 10^{3}$
3. $.001 \times 10^{0}$

11-4-2

What concentration of HNO_2 would you mix to adjust the pH to 2.7?

11-4-3

Given a .1M solution of benzoic acid, find the pH and the degree of ionization.

11-4-4

Given a .02M solution of ammonia, find the pOH and degree of ionization.

11-4-5

What concentration of $NH_3 + H_2O$ would you mix to adjust the pH to 2.7?

11-5-2

A solution is prepared by adding .0010 mole of sodium formate (NaCOOH) to 100. ml of a .035M formic acid (HCOOH). Assume no volume change. Calculate the pH.

11-5-3

How many moles of the salt NaA are needed (per liter) to produce a pH of 5 in a 0.25M HA solution.

$$K_{HA} = 1.6 \times 10^{-5}$$

11-5-4

What is the pH of a solution prepared by mixing 100. ml of a .05M of $NaC_2H_3O_2$ and 100. ml of a .10M solution of $HC_2H_3O_2$. Assume a total volume when mixed of 200. ml.

11-5-5

A solution prepared from 0.060 mole of a weak acid, HX, diluted to 250. ml has a pH of 2.89. What is the pH of the solution after 0.030 mole of solid NaX is dissolved in it? Assume that no significant volume change occurs when NaX is dissolved in the solution.

11-6-2

How does a buffer work?

What concentrations should be used to prepare an ammonia-ammonium chloride buffer with a pH of 11.2?

11-6-3

How much of each reagent would be needed to make a buffer with a pH of 5.3 from $HC_2H_3O_2$ (acetic acid) and $NaC_2H_2O_2$ (sodium acetate)?
(K for $HC_2H_3O_2$* 1.8×10^{-5})

11-6-4

How many grams of NH_4Cl are needed to make one liter of a solution with a pH of 10.9?

11-6-5

How many moles of sodium benzoate, $NaC_7H_5O_2$, should be added to 250ml of .3M benzoic acid, $HC_7H_5O_2$, to prepare a buffer with a pH of 5? Assume that no volume change occurs when the sodium benzoate is added to the solution.

11-7-4

What are the concentrations of <u>all</u> particles in a .50M solution of carbonic acid (H_2CO_3 or $CO_2 + H_2O$)

11-7-4

What are the concentrations of all particles in a .5M solution of oxalic acid, ($H_2C_2O_4$)?

($K_1 = 5.9 \times 10^{-2}$)

($K_2 = 6.4 \times 10^{-5}$)

11-7-5

What are the concentrations of all the species in a .16M solution of sulfurous acid ($SO_2 + H_2O$)?

($K_1 = 1.3 \times 10^{-2}$)

($K_2 = 5.6 \times 10^{-8}$).

11-8-2

What is the $(S^{=})$ in a saturated solution of H_2S with a pH of 7.2?

11-8-3

What is the (S^{-2}) concentration in a saturated H_2S solution with a pOH of 8.8?

11-8-4

Whfat is the (S^{--}) in a solution saturated of H_2S with a pH of 6.8?

11-8-5

What is the (S^{+2}) in a saturated solution of H_2S with a pOH of 6.8?

Name_____

...

1. A .25M Methanoic acid ionizes .005%, what is the ionization constant? HCOOH

2. What are the (OH^-) and ($C_6H_5NH_3^+$) concentrations in a .50M solution of analine ($C_6H_5NH_2$)? see page 769

3. a) What is the pH of a solution that is 3.5×10^{-3}M in (H^+)?

   b) What is (H^+) of a solution with a pH of 5.3?

   c) What is pOH of a solution b) above?

   d) What is (OH^-) of solution a) above?

4. What is the pH of a 1.0M solution of hypobromous acid (HOBr)?

5. What is the pH of a 1.0M hypobromous acid solution if .20 mole of sodium hypobromite (NaOBr) is added to .500 liters of the acid. Asume no change in volume.

6. a) Define a buffer

b) Calculate and then describe how you would buffer a solution to a pH of 4.3 using acetic acid ($HC_2H_3O_2$) and sodium acetate ($NaC_2H_3O_2$). Do work on next page.

...

7. What are the concentrations of all the particles present in a .01M solution of sulfurous acid (H_2SO_3) or ($SO_2 + H_2O$)?

$(SO_2) = (H_2SO_3) =$

$(H^+) =$

$(HSO_3^-) =$

$(SO_3^{=}) =$

6. What is the sulfide ion concentration ($S^{=}$) in a saturated solution of H_2S that has a pH of 10.0?

V. K. Burger
Instructor

1. Given the solubility of a compound or it's ions (in grams or moles perliters), you should be able to calculate the solubility product constant (K_{sp}) Combos E-1, E-3

2. Given the solubility product constant (K_{sp}) of any compound, you should be able to calculate the concentrations of the ions present and calculate the solubility in moles per liter or grams/liter. Combos E-4, 2, 6, 7,

3. Given the concentration and amounts (ml) of the solt solutions and the relevant K, you should be able to calculate the ion production and predict whether or not precipitation will result. Combos E-5, 14, 15, 16, 18, 19.

4. Given K_{sp} (from three) and concentration of a salt and the concentration of another compound with an ion which is common (or pH), you should be able to predict whether or not ppt will result Combos E-6, 21, 22, 23, 24, 25.

5. Given the K_{sp} (from table) of a particular salt and the concentration of another compound with an ion which is common (or pH), you should be able to calculate the concentration of all ions and the solublity in g/l or moles/l. Combos E-7, 3, 4, 12, 13.

-7. Given the concentration and name of a salt, you should be able to predict acid-base properties of the solution (hydrolysis) and the pH. Combos E-17, 18, 34, 35, 36, 37.

8. Given the formula and the concentration of a solt derived from a polyprotic acid, you should be able to calculate the pH. Combos E-20, 42.

9, You should be able to state the principles involving complex ions and amphoterism and be able to write one example of each

Main reference is Chapter 17

12-1-2

4.16 grams of SrC_2O_4 will dissolve in one liter of water. What is the Ksp of SrC_2O_4.

Define solubility product.

12-1-3

HCN is soluble to 2.21×10^{-5} moles/1 . Calculate the Ksp of HCN.

Define solubility product.

12-1-4

The molar solubility of $BaCO_3$ is 4×10^{-5} moles/1. Calculate the Ksp.

Define the solublility product.

12-1-5

Define solubility product.

At 25° c, 4.3×10^{-6} mole of $Ni(OH)_2$ dissolves in 1 liter of water. Calculate the Ksp of $Ni(OH)_2$.

12-2-2

Ksp of $Ba(IO_3)_2 = 1.5 \times 10^{-3}$. What is the solubility in moles/liter.

12-2-3

How many grams of $PbCO_3$ will dissolve in 500ml of water?

($Ksp_{PbCO_3} = 1.5 \times 10^{-15}$)

12-2-4

Ksp= 4.6×10^{-6} for lead Bromide. What are the concentrations of the ions present.

12-2-5

How many grams of AgI will dissolve in one liter of water?
(Ksp of AgI= 8.5×10^{-17})

12-3-2

Will a 0.000001M solution of $Cu(OH)_2$ ppt?

($Ksp_{Cu(OH)_2} = 1.6 \times 10^{-19}$)

12-3-3

Using .010M HCl as a reagent, what is the minimum concentration (M) of Ag^+ that must be present. Assume 10.0ml of each solution is present for a total volume of 20.0ml.

(Ksp for AgCl= 1.7×10^{-10})

12-3-4

What concentration of F^- is necessary to start the precipitation of SrF_2 from a saturated solution of $SrSO_4$?

(Ksp of $SrF_2 = 7.9 \times 10^{-10}$; Ksp of $SrSO_4 = 7.6 \times 10^{-7}$)

12-3-5

A solution is .015M in Mn^{+2} and .025M in NH^+. What should the concentration of NH_3 be in order to cause $Mn(OH)_2$ to start to precipitate?

12-4-2

Will a solution of 0.0002M AgCl ppt. in an HCl solution with a pH of 4.6?
(Ksp AgCl= 1.7×10^{-10})

12-4-3

What should (H^+) in M be in a solution that is .25M in Co^{+2} to prevent ppt. of CoS when the solution is saturated with H_2S?

(Ksp of CoS= 5×10^{-22}; K for .10M H_2S= 1.1×10^{-22})

12-4-4

A solution that is 0.3CM in H^+ and 0.15M in Ni^{+2} ; aturated with H_2S. Should NiS precipitate?

(Ksp of NiS = 3×10^{-21}; K for .10M H_2S 1.1×10^{-22})

12-4-5

A. Will a precipate of MnS form when a solution that is .1M in acetic acid, $HC_2H_3O_2$ and .1M in Mn^{+2} is saturated with H_2S:?

B. If .1M in sodium acetate, $NaC_2H_3O_2$, will MnS precipitate?

NAME_____

A. A solution is .02M with $Pb(NO_3)_2$ and .01M with NaF. Will a ppt of PbF_2 form?
Show calculations for the ion product. (K_{sp} PbF_2 is 4×10^{-8})

B. The molar solubility of $Ag_2C_2O_4$ is $2.22 \times 10^{-4}M$. What is the K_{sp}?

C. Will a ppt of $Al(OH)_3$ form in a solution of .000010M $Al(NO_3)_3$ and a pH of 8.0?

D. State the principle of amphoterism and give an example of ampoteric substances and how it functions.

E. A saturated solution of $CaCO_3$ is 6.86×10^{-5}M; the K_{sp} of $CaCO_3$ is 4.7×10^{-9}. What is the molar solubility of $CaCO_3$ in a .050M solution of $(NH_4)_2CO_3$?

F. What is the solubility of AgBr in grams/liter?
(K_{sp} of AgBr is 5.0×10^{-13})

G. What is the pH of a .010M solution of K_2S?

H. What is the pH of a .0015M solution of KOBr?

What is the pH of a .00015M solution of aniline nitrate, $C_6H_5NH_3NO_3$?

THE SYSTEM

Based on your experience with the Objective System of Instructional evaluation, please respond to the following questions:

1. How much did you enjoy learning chemistry through this system (circle one)

1	2	3	4	5
none	very little	some	to a great extent	very much

2. Which statements best describe your feelings about your involvement with this Objective System? (you may select more than one)

____too easy
____inspiring
____a waste of time
____just another course
____OK
____sure beats the traditional method
_____can take or leave it
_____a real treat
_____too time consuming
_____did it to please the instructor
_____a very fair way of grading
_____very helpful way of learning

Please indicate how helpful each of the facets of the system were in learning chemistry. (circle one)

V. K. Burger
Eastern Campus CCC

THE BURGER OBJECTIVE SYSTEM (BOS)

EXPLANATION OF THE OBJECTIVES

The statements on the following pages are objectives you are expected to accomplish (learn) during this course. Each objective states a specific skill or behavior you must be able to do to prove you "know" the concept or principle covered. You will be expected to prove you know these principles and concepts "under usual written examination conditions" and to a level of understanding equivalent to "A" (90% or above) work. There are also laboratory objectives which require completing experiments and handing in complete and adequate lab reports. You do not have to accomplish all of the objectives, but the more you do accomplish, the higher your grade will be.

TESTING

Your first chance to accomplish objectives (i.e. prove you know the concepts) is on a regularly scheduled exam day. If you miss any of the objectives you may sign-up to reattempt those objectives missed at a later date. Lab objective may be accomplished by handing in lab report within one week of completing the experiment.

2nd, 3rd, 4th, and 5th Tries

To accomplish an objective missed during the first try, you must fill out an "Objective Request Form" found outside of my office, Room 209. These forms must be turned in 24 hours in advance of testing time and must contain the following information: (subsequent tries follow same procedure)

1. Name
2. Day and Date (you want to be tested)
3. Time (of testing)
4. Course title
5. 3 numbers separated by dashes representing the particular objective you want to try. Each objective must be listed separately.

It is recommended that you study just a few objectives and sign-up for retake. Only retake objectives you know you can accomplish. Don't just sign-up for all you missed. There are time limits for each module(unit).

FEEDBACK (REPORTING BACK TO YOU)

Results of first try will be handed back in class and will be a listing of only the objectives you have credit for. Keep an accurate record for yourself. Results of subsequent tries will be in an envelope outside my office marked "Feedback for (your course)"

GRADES

Your grade will be determined by the number of objectives you accomplish as applied to the following scale and not the number of tries.

Grade	No. of Objectives Accomplished
A	More than 90% plus superior performance on a comprehensive final exam.
B	More than 80% or 90% and less than superior performance on a comprehensive final exam.
C	More than 70%
D	More than 60%
F	Less than 60% - (This grade is not used if effort and attendance are good. See instructor in case of trouble)
I	Gives student an additional time to work on objectives.
W	Withdraw - For student not wishing to have earned grade appear in records and not wishing credit.

ATTENDANCE

As per college policy "A student may be dropped from a course by his instructor whenever total absences exceed three hours in any quarter_____". Please see me for any exceptions before the absences occur.

HOW TO LEARN THE OBJECTIVES (Hints for making it within the system).

1. Read objectives and know what you're responsible for.
2. Attend class and participate.
3. Complete labs and lab reports on time.
4. Read text.
5. Attempt recommended questions and problems in text.
6. Use slide or slide-tape presentations (available from your instructor or from library).
7. Buy and use paperback reviews and problem books.
8. Read other versions of same topic in texts and other books in library.
9. Read with care any handouts given in class.
10. Meet with a tutor (go to Room 151 to make arrangements for the cost-free service)
11. Spend time but spend it as efficiently as possible organize.
12. Set a schedule for accomplishing missed objectives.
13. This system allows for varied rates of learning the materia' but it also makes it possible to procrastinate.
    DON'T DO IT TOMORROW, DO IT NOW! KEEP ON SCHEDULE.

QUESTIONNAIRE

THE SYSTEM

Based on your experience with the Objective System of instructional evaluation, please respond to the following questions:

1. How much did you enjoy learning chemistry through this system (circle one)

1	2	3	4	5
none	very little	some	to a great extent	very much

2.. Which statements best describe your feelings about your involvement with this Objective System? (you may select more than one)

_____too easy
_____inspiring
_____a waste of time
_____just another course requirement
_____OK
_____sure beats the traditional method
_____can take or leave it
_____a real treat
_____too time consuming
_____did it to please the instructor
_____a very fair way of grading
_____very helpful way of learning

Please indicate how helpful each of the facets of the system were in learning chemistry. (circle one)

3. Able to work more at your own rate.

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

4. No penalty or onus attached to repeating objectives

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

5. The slide/tape self-instructional packages

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

6. Specifying exactly what you were responsible for in the form of behavior objectives. (no surprises or tricks)

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

7. Indicating for each objective, the pages to be read in the text

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

8. Indicating for each objective, the problems at the end of the chapter that are covered by that objective

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

9. Having the answers for <u>all</u> the problems assigned from the text

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

10. Indicating for each objective, the tape/slide packages

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

11. The lecture-recitation method used during class

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

12. When available, the tutors

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

13. Having no deadlines or time frames for modules

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

14. Being able to take the objective tries (tests) at any time you were ready, in the testing center

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

15. The use of objectives when working on an incomplete. (Predict in you did not have an "I")

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

16. The mastery concept (showing competence to an "A" level for each objective) (It's either right or wrong) and therefore retaking the objectives

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

THE OBJECTIVES

17. Were the objectives clearly stated as to what you were responsible to know?

1	2	3	4	5
ambiguous	very little clarity	some	clear	very clear

18. Did test questions over each objective agree with what was stated in the objective?

1	2	3	4	5
no relationship	very little	some	agree	greatly agree

19. Based on your reading, viewing tape-slides, and other experiences, would you say the objectives were appropriate to a study of general chemistry?

1	2	3	4	5
not appropriate	very little	some	appropriate	very appropriate

20. Do you feel the material dealt with within the objectives is relevant to your present or future needs?

1	2	3	4	5
not relevant	very little relevance	some relevance	relevant	very relevant

REVISION AND IMPROVEMENT

Please indicate how helpful the following methods might be if incorporated into the system.

21. Being able to take objectives tries (tests) and have them graded at that time.

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

22. Having the instructor or a tutor readily available (in same room) when working slide/tape packages or other self-instructional materials

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

23. Having deadlines for each module when work has to be completed.

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

24. Having 1st try (test) in class on a specific date

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

25. Having a self-instructional unit (written, tape, or slide/tape) available for each (or series of) objectives.

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

26. Reducing the size of each module (to 3 or 4 objectives) tests (mastery) over the whole module rather than each objective.

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

27. Being able to give input as to the [illegible]nt covered by the objectives

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

FINAL SECTION

28. Did the tests lose their motivational value as a result of the opportunity to retake objectives as many times as necessary?

1	2	3	4	5
not at all	very little	some	a good amount	almost completely

29. Do you feel your grade earned with this system will be higher than the grade you would have earned if course were structured in a more traditional fashion?

1	2	3	4	5
the same	same grade but easier	perhaps one letter grade	definitly one letter grade	at least one letter or maybe more

30. If this course were structured in a more traditional manner with the same content, what degree of anxiety would you have had?

1	2	3	4	5
no anxiety	very little anxiety	some anxiety	a good deal anxiety	a great deal anxiety

31. What was your overall level of anxiety during this course.

1	2	3	4	5
no anxiety	very little anxiety	some anxiety	a good deal anxiety	a great deal anxiety

32. Do you believe this system actually helps you learn chemistry better?

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

33. Did the system encourage you to "go back" and learn concepts you didn't know?

1	2	3	4	5
not at all	very little	some	most of the time	all the time

34. Do you believe that you will remember the concepts longer (greater retention) as a result of this system?

1	2	3	4	5
no difference	little longer	some	longer	much longer

35. Did the system encourage you to learn mo[illegible] your own knowledge rather than just learning for the tests?

1	2	3	4	5
for tests only	very little	some	to a good degree	for own knowledge

36. Was the testing over the small "bits" (objectives) of the concepts a detriment to learning the "big picture"?

1	2	3	4	5
learned only pieces	very little	some	to a good degree	learned concepts

37. Was the specific feedback over each objective helpful in learning chemistry?

1	2	3	4	5
no help	very little help	some help	helpful	very helpful

38. Did you have a tendency to cheat to a greater or lesser degree?

1	2	3	4	5
no cheating	a little	some	cheat	to a great extent

39. If you could assign a letter grade to the objective system it would be

1	2	3	4	5
F	D	C	B	A

40. Would you recommend the use of this system for all courses you presently are taking?

1	2	3	4	5
no courses	very few	some	many	most

41. Would you recommend the use of this system for all "hard Core" (nuts and Bolts) science and math courses?

1	2	3	4	5
no courses	very few	some	many	most