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ABSTRACT

Vocational-technical students (n=92) and liberal arts students (n=156) were the subjects of a study conducted to evaluate the effectiveness of four instructional strategies intended to produce mastery. Strategies employed were: traditional instruction with no make-up exams; unlimited make-up exams with end of semester deadline; unlimited make-up exams with two-week deadline; and unlimited make-up exams with two-week deadline and with motivational help from an academic advisor. Vocational students were taught physics while liberal arts students were taught physical science. Effectiveness of each strategy was evaluated according to student achievement, further separated according to the IQ's of the students (high/low). Results of analysis indicated: (1) students with unlimited testing opportunities had better performance than those without such opportunities, in every case; (2) those with two-week deadlines performed better than those with end of semester deadlines; (3) students with advisor input generally performed better than those without advisor input; and (4) IQ was not a significant determinant of student performance. Descriptions of course content are included as are tabular and graphic data reflecting comparative student performance. A bibliography and sample course examinations are appended. (JDS)

TEACHING TO ACHIEVE LEARNING MASTERY BY USING RETESTING TECHNIQUES

DWIGHT F. DECKER, M.S.E.

A MAJOR APPLIED RESEARCH PROJECT PRESENTED
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF EDUCATION

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Abstract of a Major Applied Research Project Presented to Nova University in Partial Fulfillment of the Requirements for the Degree of Doctor of Education

TEACHING TO ACHIEVE LEARNING MASTERY BY

USING RETESTING TECHNIQUES

(DWIGHT F. DECKER)

Recently educational literature has begun to record many studies concerning mastery learning - strategies which assume that virtually all students are capable of mastering a given set of course objectives provided that proper motivation and a sufficient amount of time are provided.

This particular study involved an attempt to have students achieve mastery by using a retesting technique - allowing students an unlimited number of make-up exams for any given unit of instruction. It further provided tutoring sessions before and after each make-up exam.

There were four levels of instructional strategies (the independent variable):

1. conventional instruction with no make-up opportunities.

2. unlimited make-up opportunities with the end of the semester as the deadline.

3. unlimited make-up exams over a two-week period.

4. unlimited make-ups with two-week deadline and weekly booster sessions with academic advisors.

All four strategies were used with Vocational-Technical students in a physics course, and only the first three were used with Liberal Arts students in a Physical Science course. Only the highest score on each unit exam was kept for purposes of calculating a course grade; this provided incentive for students to keep trying until mastery (90% or higher) **was** achieved.

The moderator variable was IQ level (high and low - separated by the median) and the dependent variable was learning performance as measured by mastery tests covering instructional objectives specified prior to the learning activities. The study involved one instructor only, so caution must be used in generalizing the results to the total instructor population and to other fields and disciplines.

A 4 x 2 analysis of variance was performed with the Vocational-Technical groups (a total of 92 community college students from Rhode Island) and a 3 x 2 analysis of variance was used with the Liberal Arts groups (156 students). Scheffé tests were performed to compare two strategies at a time to see if one was significantly better than the other. Chi-square tests showed that all strategy groups were from the same population so far as median IQ was concerned.

Attempts to measure the students' affective response to the retesting process involved asking those who participated if they felt they learned more with the retesting and whether or not they liked retesting better than traditional testing. Except for two students, all those who experienced retesting respond affirmatively to both questions. The primary hypothesis that students who have unlimited retesting opportunities have better performance (at either the .05 or .01 level of significance) than those who do not was supported overwhelmingly by the results of this study. Almost all the test cases (both high and low IQ students) demonstrated this, and in no case was the reverse true. The other hypotheses were also supported for both the high and the low IQ students. For the unlimited testing opportunities, those with two-week deadlines nearly always performed better than those who had the entire semester for make-up exams. Also, in cases when the added motivational input of the advisor was used, these students generally performed better than those without advisor input.

For the strategies using two-week deadlines and advisor input, the performance of high and low IQ students was almost never significantly different. For retesting opportunities with end of semester deadline and for traditional teaching no retesting, the higher performance of high IQ students over those with low IQ usually was significantly different.

For the many interactions which were significant, it was noteworthy that low IQ students with retesting performed better than high IQ students who didn't have retesting. The other interactions which were significant supported the other hypotheses:

(1) Low IQ students who had a two-week deadline for make-up exams did better than high IQ students who did not.

(2) Low IQ students who had the advisor's motivational input did better than high IQ students who did not.

Many of the class averages (particularly in the strategies using two-week deadlines and advisor input) were above the 90% level which was defined as the performance which demonstrated mastery of learning objectives. Even in the strategy using the entire semester for make-up exams, the average was either above 90% or very close to it for most of the students.

The Vocational-Technical students had only one opportunity for the final exam regardless of strategy used prior to the final. In spite of this, the hypotheses were supported for all comparisons in which significant differences existed. For the strategy using advisor input, the average for both high and low IQ students was a lofty 95, as high as any average for either the first or second unit exams.

It was interesting to note that for nearly all students who had all semester to do make-up exams, performance was higher on the second unit exam than on the first. This conclusion held except for the high IQ Vocational-Technical students where the difference was not significant.

This study involved only one teacher. The results were sufficiently successful to warrant the study being replicated for other teachers, other fields, and other colleges.

It is very important in securing success with the retesting procedures that the teacher is enthusiastic about the students mastering the learning objectives and gives high grades indicative of that mastery having been achieved.

If retesting to achieve mastery learning continues to be successful, it should soon achieve widespread use.

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Students often approach college physics courses with a mixture of fear and hopelessness. Some have had direct personal experience with physics courses (or related science courses) in high school in which their success has been limited and their enjoyment almost non-existent. Others have avoided physics courses altogether because of the reputation generated by those who have encountered little success or enjoyment.

Many of these students in their community college work will elect engineering, technology, or vocational-technical major studies, all of which have physics courses as a required part of the program. Others will select the broad Liberal Arts major in which a small number of natural science or mathematics courses are required for the associate's degree; a small number of these will select a physics course in order to meet this obstacle.

It may be argued that if students have unlimited opportunities to be successful, they usually will be successful, and in so doing they will experience enjoyment. Success should breed enjoyment and enjoyment should lead to more success. This is in agreement with Bloom's (1968) thesis that, if given proper motivation and a sufficient amount of time, 95% of all learners can achieve mastery of a set of learning objectives.

Statement of the Problem

This study dealt with the author's personal experience in teaching physics courses at Rhode Island Junior College. It was limited to Liberal Arts students taking a course called Physical Science and Vocational-Technical students taking a physics course emphasizing applications to their particular major.

The independent variable used with the Vocational-Technical students was the method of instruction with four levels:

1. traditional instruction with no attempt at retesting.

2. instruction augmented by allowing all students unlimited test make-up opportunities (tutorial help before and after each make-up exam) with the end of the semester as the final time deadline.

3. instruction allowing all students unlimited make-up opportunities using a two-week period following the initial unit exam as the time deadline.

4. instruction allowing all students unlimited make-up opportunities using a two-week deadline and utilizing the added motivation of the student's academic advisor. The advisor was given a weekly progress report on each student.

For Liberal Arts students, only the first three levels were employed.

The moderator variable used was student IQ.

The dependent variable was student performance in the course work as measured by each student's highest test score on each unit exam used.

The purpose of the study was to determine if retesting techniques have a beneficial effect on student academic performance, and, if so, what modifications could be made to the retesting technique to make it even more effective.

REVIEW OF THE LITERATURE

Reasons for Mastery Learning Strategies

The traditional use for testing of students has been to determine a student's academic performance in relation to the performance of others in the class. In such a norm-referenced approach (Herrscher, 1971), a normal curve is often used to assign grades and student aptitude is considered to be the capacity for learning.

Bloom (1968) disagrees with this definition of aptitude. In his opinion, given the proper motivation and a sufficient amount of time, 95% of all students can master a carefully written set of course objectives. On this basis, aptitude is more properly considered to be an indication of the time necessary to master course objectives. Some students, according to this theory, will take longer than others to learn the material as stated in the course objectives.

Herrscher (1971) recommends an entire process to cause most students to achieve mastery in learning that involves the concept of retesting. The process begins with the student being given a rationale for the course objectives (or unit objectives) which convinces the student that the learning will be worthwhile to him or her. A pretest might be given to see if the student has already met the learning objectives for that unit of study. If so, the student could then proceed to the next unit of study in proper sequence. If not, the student could proceed through a set of learning activities designed to meet the objectives which would be followed by a posttest. If the student achieves a mastery level grade on the posttest, he or she can then proceed to the next unit of study. If not, he or she is given a new set of learning activities designed to meet the same objectives followed by another posttest. This retesting process continues until the student achieves mastery of the objectives.

In this retesting approach, one's performance is not measured relative to other students as in the norm-referenced approach. Performance is measured against criteria established prior to the learning activities. Such an approach is usually referred to as a criterion-referenced approach.

Carroll (1963) states that if students are normally distributed with respect to aptitude in a subject area and are provided with the same amount, quality, and time of instruction, then an achievement test will show a normal distribution of grades. But if instruction is made appropriate to the needs of each student, the relationship between aptitude and achievement will approach a zero correlation coefficient. Aptitude is then found to better correlate with how fast mastery is achieved.

Glaser (1968) points out that the student's experience and background tell more about how long he or she will take to master a new set of course objectives than aptitude as measured by a general IQ test. If a student has mastered objectives that are prerequisite to a new set of course objectives, he or she is likely to proceed more quickly than the student who has not.

Boyer and Walsh (1968) have effectively refuted four different types of evidence typically offered to prove that people are innately different in their capacity to learn.

McNeil (1966) assumes that differences in learning capacity are essentially nonexistent as he sets up a basis for determining teacher effectiveness in which students meet stated learning objectives. Sorenson (1971) also emphasizes that goals be defined in terms of changes in performance, behavior, or actions without assuming that some students can and some cannot meet these goals.

Bruner (1965) endorses the concept of moving the fast learning student ahead as rapidly as possible, but that we should be careful not to ignore the late bloomer, the early rebel, or the child from an educationally indifferent home. These students are also deserving and capable, and with proper motivation they too can achieve whatever goals they select. In a related book, Bruner (1966) states that intellectual mastery is rewarding particularly as it enables students to go on to something that was previously out of their reach. Again Bruner makes no distinction between the ability of fast and slow learners to achieve mastery.

Lansky (1969) reminds us that with students having different "needs, skills, attitudes, interests, and values", the teaching strategy must change. But again the basic assumption is that all can learn. In the same article he emphasizes that "feelings are real, always present, and relevant for learning". If feelings toward learning are positive, goal achievement is more rapid. A teacher's personality can affect the learner's attitude either positively or negatively (Eble, 1972).

Tuckman (1969) produces evidence that justifies the inference that "culturally deprived individuals have less of their intelligence potential developed than do individuals who have not suffered cultural deprivation". Several studies were referred to in which, given a different cultural environment, gains as high as 40 IQ points were experienced, seriously questioning the use of IQ tests to measure learning capacity. In a study of conceptual strategies, Olson (1966) states that while pre-grade school children are more receptive to immediate stimuli, the older child appears more to base problem solving on plans or hypotheses. Different children take different lengths of time to make the transition, but in general all are capable of doing so.

Cohen (1969) points out that when an instructor expects within a given group a "normal distribution" of achievement, he gets it; but if he commits himself to having 90% of his students reach the course objectives, he can achieve that.

Learning is possible, then, for nearly all students if we only dare believe that it is possible.

Gagne (1965) defines learning as a "change in human condition or capability, which can be retained, and which is not simply ascribable to the process of growth". No mention is made of items that some people can learn and others cannot. Medsker (1960) indicates that at least half of community college teachers feel that selection procedures for students in transfer programs should be made more stringent and very few are aware that many students that don't meet these standards still are accepted and do quite well later in the transfer institution. This is more evidence that those who are considered inadequate are still quite capable of learning.

In summary, the chief reason to employ mastery learning is based on the contention that, with sufficient motivation and time, nearly everyone can successfully meet all the performance criteria which are established prior to the learning activities. It is necessary that students have relearning and retesting opportunities. How long students take to achieve mastery depends on both their learning speeds and their background of knowledge prior to the new learning opportunities.

Use of Mastery Learning Strategies

Many studies of the mastery learning techniques have been done recently, nearly all of which suggest that with motivation, retesting, and a sufficient amount of time, the mastery learning technique results in better student performance than traditional learning approaches. Included are studies in the following course areas:

* elementary economics (Fels, 1974)
* mathematical divisibility rules (Magidson, 1974)
* statistics (Phaff and Schmidt, 1974)
* speech communication (Bassett and Kibler, 1974)
* strictly factual content (Honeycutt, 1974)
* algebra and English (Sheldon and Miller, 1973)
* college mathematics (Wagner and Jones, 1973)
* third and fourth grades (Okey, 1974).

On a broader scale, most of the concepts of teaching for mastery and the retesting approach have been tried successfully (Rouche and Pitman, 1972) by the following colleges:

1. Moraine Valley Community College, Palos Hills, Illinois.
2. Brookdale Community College, Lincroft, New Jersey.
3. Central Piedmont Community College, Charlotte, North Carolina.
4. Mitchell College, Statesville, North Carolina.
5. Kittrell Junior College, Kittrell, North Carolina.

A study by Riviere and Haladyna (1974) showed that when students learn for mastery: (1) test scores have very little variability and are not related to aptitude, and (2) test items which are broken down into high and low cognitive behavior subscales are unrelated to aptitude.

Block (1974) has collected a book of essays on mastery learning which assert that nearly all, rather than some, students can learn most of what they are taught. The first part introduces the theory, practice, and research on mastery learning and the second part sketches the theoretical and practical administrative implications of mastery learning. Warries (1974) points out that "standard mastery curves" for student scores on summative tests are similar to the theoretical and empirical skew curves used in statistics and biology and not at all like a normal distribution curve.

Burke and others (1973) describe a computer-assisted, competency-based instructional model that has been developed for teacher education, based on the concept that humans should control their own lives and that technology should expand one's choices. Students select educational exercises according to their interests, employ a computer to move through the modules, and interact in small groups with an academic counselor. They are encouraged to persist until mastery criteria are achieved, and an improved student self-concept is sought.

Mayo (1970) states that the mastery model calls for informing students about course expectations, setting standards for mastery in advance, using short diagnostic tests for each unit, prescribing additional learning experiences for those who do not achieve mastery on the first try, and providing additional time for those who need it. These strategies are of most benefit to the student who experiences high test anxiety.

Cross (1975) refers to mastery learning strategies (dedicated to all students achieving mastery of course objectives regardless of the time necessary) as the educator's model of education. She emphasizes that in such a strategy educators are increasingly willing to deal with individual differences in learners. This differs from the traditional method of eliminating the slower learners or the poorly prepared by being highly selective.

Carmichael (1973) asserts that five different conditions of readiness determine whether or not innovations such as mastery learning will succeed: (1) desire to change the status quo, (2) systematic management process, (3) effective leadership, (4) a receptive teaching staff, and (5) financial resourcefulness. Even these won't succeed unless teachers, administrators, board members, and students work together.

A study by Thrash and Hapkiewicz (1973) concerning students in educational psychology showed that males reacted more favorably than females to mastery learning. On a negative note, it concluded that graduate students, most of whom were practicing tearchers, rated the course lower than did undergraduate students.

To summarize, mastery learning strategies have been used successfully at five community colleges and in individual programs at many others. Test scores have shown little variability and are not related to student aptitude. The strategy seems most beneficial to students who experience a high level of test anxiety. To be successful, course performance expectations and standards for mastery must be specified in advance of the learning activities. For those who do not meet mastery level criteria the first time an evaluation is made, additional time and learning experiences must be provided.

Problems with Mastery Learning Strategies

For the teacher, attempting to motivate students toward mastery learning within the framework of the conventional A,B,C,D,F grading system presents certain problems. The author in his experience has noted students (who are conditioned by the conventional grading system) say "I'm only a C science student". Such students seem to believe that mastery is not possible for them, and they struggle only hard enough to achieve a minimum mark for passing the course. A primary task of the teacher is to convince students that an "A" mark (mastery learning) is possible for everyone.

The traditional grading system seems also to condition some students to look for ratings relative to other students even after they believe that mastery learning is possible. Those who learn more slowly not only require longer times but a wider variety of learning activities to achieve mastery. Some of the slower learners tend to feel badly about learning slowly although no stigma is attached to them by the instructor. Some who have part-time employment resent using the added time necessary to achieve mastery, and a few even worry about being graded downward on achievement for fear of the grade standard being raised because of those who do achieve mastery. If the conventional grading system continues to be used, the teacher must be vigilant to discern these attitudes and convince these students that any grade represents a level of predetermined achievement and not a relative rating on some type of curve.

A third problem within present structures is the rigid time system (semester, trimester, or quarter) in which courses are supposed to be completed. This does not allow the fast learner to begin a new course before the end of the time block assigned. It also tends to discourage the slow learner from recording an "incomplete" at the end of a time block and continuing the course work until mastery is achieved.

Perhaps all three of the above problems could be solved by abolishing the rigid time system and using a periodic reporting scheme that utilizes a one-point grading system (Flynn, 1973) - a pass or incomplete. The "incompletes" could eventually be changed to pass when the course work is completed. Also, the "incompletes" could be kept confidential between the registrar's office, the teacher, and the student. Such a no-penalty system could produce a favorable attitude from most students, the evidence being their behavior in terms of what they say about the course and the school (Mager, 1968). Further evidence of success in such a system could be seen if the students achieve mastery as demonstrated by properly disigned criterion-referenced tests (McKeachie, 1963). Even these changes could fail to produce favorable attitudes among students if their individual characteristics, desires, and needs are not considered in curriculum decisions (Mayhew and Ford, 1971).

Roueche and Pitman (1972) point out that for the student to persevere until mastery is achieved, he or she must enjoy the task to be performed. Just being convinced that mastery is possible is not enough. The same authors point out that this enterprise cannot succeed unless the college president cooperates. Even if the president chooses not to lead, he or she has the authority to keep others from leading. Usually progress is most rapid when the president supports the legitimate efforts of key members of the faculty to lead. The appointment of an Educational Development Officer to coordinate instructional effectiveness can be helpful when the enterprise becomes sufficiently widespread.

Goodlad (1970) emphasized the importance of preparing teachers to make the changes necessary to meet the very different demands on their time. They must spend much more time with individual students if the retesting is really going to work. If the teacher on the basis of aptitude tests expects certain accomplishments for some students and lesser achievement from others, this expectation becomes a self-fulfilling prophecy (Rosenthal and Jacobson, 1968). This expectation must be eliminated before retesting dedicated to mastery learning can really work.

Instructional objectives must be well defined so that all students know precisely what is expected of them (Herrscher, 1972, and Cohen, 1967). If this is not done, even the best of criterion-referenced tests will not be a good indication of teaching or learning effectiveness (Wittrock, 1969; Popham and Husek, 1969; and Klein, 1970).

A summary of the problems that students encounter with mastery learning includes the following:

(1) a belief by many that mastery is not possible for them.

(2) a conditioned response to look for ratings relative to others even after being told that evaluations are based solely upon meeting learning objectives.

(3) a rigid time schedule (semester, quarter, or trimester) that establishes a final deadline for grades to be submitted.

Teachers who judge students' abilities to learn in advance of the learning activities can prejudice the results and make the opportunity for some to achieve mastery completely meaningless.

Outlook for the Future

Levin (1973) has presented an interesting paper on the economic implications of mastery learning. In it he concludes that mastery learning is very humane in its concern for equalizing outcomes, that society is gradually recognizing and economically rewarding this approach, and that the economic importance of mastery learning will greatly increase in the forseeable future.

The evidence on mastery learning gathered to this date indicates overwhelming success and suggests that it should be tried in many more schools. The basic reason for this success seems to be motivational; the retesting opportunities (with the possibility of reward for mastery) keep the students trying.

Statement of the Hypotheses

The following hypotheses were formulated:

a. Students who have opportunities for unlimited make-up exams and tutorial help have higher academic performance than those who do not.

b. Students who are required to take whatever make-up exams they wish with a two-week deadline have higher academic performance than those who have the entire semester for make-up opportunities.

c. Students who have weekly motivational help from their academic advisor have higher academic performance than those who do not.

Rationale for the Hypotheses

The rationale for attempting to use retesting techniques to motivate students to achieve course mastery was inspired by the writings of Bloom (1968), Herrscher (1971), and Roueche and Pitman (1972). These writers all emphasize that, with the proper motivation and a sufficient amount of time, 95% of all students can master the course objectives.

After one semester's experience with allowing students to take unlimited make-up exams over the entire semester, it was discovered that almost half of the students waited until the last week of the semester to try make-ups. These students stated that, by doing this, they had time for only one make-up exam and were not as well prepared as they would like to have been due to the hectic activities of the last week of the semester. These students requested that a two-week deadline be imposed on the unlimited make-up opportunities to provide them with a measure of external discipline which they felt they did not yet possess internally.

The students in the Vocational-Technical Division are with their advisor in his role as teacher for approximately 10 to 20 hours per week depending upon the program and the semester. The author visited with each advisor at the beginning of the semester to determine what topics should be covered in the physics course. When one advisor was told of the retesting process (chance for unlimited make-up exams), he suggested that a weekly progress report be given to him so that he could help to motivate the students to take advantage of the make-up opportunities. Since this plan was quite feasible to implement with this group, it was incorporated to determine if advisor motivation was helpful.

Operational Definitions of the Variables

The independent variable in this study was four (three in the case of Liberal Arts students) different instructional strategies: (a) traditional instruction, (b) unlimited make-up opportunities - end of semester deadline, (c) unlimited make-up opportunities - two-week deadline, and (d) unlimited make-up opportunities - two-week deadline with advisor input (this last treatment for vocational students only).

They were constructed as follows:

a. traditional instruction. Each student was allowed one opportunity only on each unit exam and his evaluation on that unit was based on that one test score.

b. unlimited make-up opportunities - end of semester deadline. Each student was allowed to take as many make-up exams as he desired. He was told that only the highest mark would be used for his evaluation and he was encouraged to strive for a grade of 90% or higher (an indication of mastery). The only time deadline imposed was the end of the semester when all grades were due.

c. unlimited make-up opportunities - two-week deadline. This strategy was carried out in the same manner as option (b), with the exception that a two-week deadline was imposed for doing make-ups after the initial exam. For extenuating circumstances, the deadline was extended. The primary aim of the two-week deadline was to prevent students from procrastinating until the end of the semester and undergoing panic.

d. unlimited make-up opportunities - two-week deadline with advisor input. This strategy was carried out in the same manner as option (c) but with advisor input into the motivational process. Once each week, the advisor was provided with information about the number of make-ups each student had taken and his scores. The advisor agreed to encourage each student to continue the make-up process until his score reached at least 90%. This meant that the attempted motivation of students to continue make-ups was pursued by both the course instructor and the advisor.

In all four strategies, course and unit objectives were predetermined and all exams (initial and make-up) were designed to test for these objectives. Attempts were made to provide equal difficulty on all exams. The exams were used to determine level of learning, the dependent variable.

Student IQ was used as the moderator variable.

Tutorial help was provided before and following each make-up exam for all students.

The study involved only one instructor, so caution must be used in generalizing the results to the total instructor population and to other fields and disciplines. However, the inclusion of students in two diverse fields of study (viz., liberal arts and vocational-technical education) does lend generality to the study.

Significance of the Study

The retesting process involves using make-up exams that have different questions than previous tests. The make-ups involve different applications of the same physical principles as previous tests. Therefore, the student cannot improve his mark by merely seeking answers to previously used test questions. To improve his mark, real learning must take place.

If the retesting process results in increased student learning, it should have benefits not only to the student but also to the college, to society, and to the taxpayers.

If students learn more, they should do better when transferring to four-year colleges or do better in the job market, whichever is selected. This could mean that taxpayers get a better return on their investment, the two-year college gains in stature, and society benefits from more productive citizens.

An added benefit to the college is the student attitude toward learning. If it improves, the student stays in school longer and retrenchment of teachers does not become a problem.

But the greatest benefit to the teacher can occur in the learning process itself. If students considers the teacher a partner (dedicated to their learning) rather than an adversary, both students and teacher can enjoy their association with each other and achieve mutual satisfaction. Mastery learning becomes the goal and the achievement for both.

METHOD

Subjects

All students in this study were Rhode Island residents and each teaching strategy sample included all the students using that particular strategy (the sample in each case was the total population). The students were either in the first or second year of a two year community college program (at Rhode Island Junior College) and most ranged in age from 18 to 22 although some went up to age 28.

There were two separate experiments - four instructional strategies for the Vocational-Technical students (all men) and three for the Liberal Arts students (both men and women). The numbers of students using each strategy, further separated by IQ level (high and low), are shown in the tables that follow on the next two pages. The teaching strategies used were:

I - traditional instruction - no make-up exams.

II - unlimited make-up exams - end of semester deadline.

III - unlimited make-up exams - two-week deadline.

IV - unlimited make-up exams - two-week deadline, with motivational help from academic advisor.

Table 1

Vocational-Technical Students

Teaching Strategy

	I	II	III	IV	Total*
High IQ	5	17	19	5	46
Low IQ	7	14	18	7	46
Total	12	31	37	12	92

Key:

I - traditional instruction with no make-up examinations.

II - unlimited make-up examinations using the end of the semester as a final deadline.

III - unlimited make-up examinations with a two-week deadline.

IV - unlimited make-up examinations, two-week deadline, and weekly input from academic advisor.

* - The numbers of students are slightly less than specified in the proposal because of those who left the program or left the school.

Table 2

Liberal Arts Students

Teaching Strategy

	I	II	III	Total*
High IQ	24	14	40**	78
Low IQ	23	16	39**	78
Total	47	30	79**	156

Key:

I - traditional instruction with no make-up examinations.

II - unlimited make-up examinations using the end of the semester as a final deadline.

III - unlimited make-up examinations with a two-week deadline.

* - The number of students are slightly less than specified in the proposal because of those who left the program or left the school.

** - This number covers two semesters.

The Liberal Arts students were not included in teaching strategy IV because far too many academic advisors were involved and the students in general do not have their academic advisors as teachers.

Tasks

For both courses (Vocational-Technical Physics and Liberal Arts Physical Science), the content was subdivided into several units. This study involved the first two of those units for each course. Objectives were written for each unit and the exams (initial and make-ups) were designed to test for the accomplishment of these objectives. A description of some sample objectives, exam problems to test for these objectives, and solutions (which prove the relationship of test problem to the objective) are shown in Appendix A (Vocational-Technical Physics) and Appendix B (Liberal Arts Physical Science).

The content of the first two units of the Vocational-Technical Physics includes:

First Unit

* Definitions - length, mass, time, weight, area, volume, and density.

* English and metric units of measure.

* Distinction between scalars and vectors.

* Vector sum of forces.

* Translation Equilibrium...Newton's First Law of Motion.

* Rotational Equilibruim...Moment arms and torques.

Second Unit

* Rectilinear motion...speed, velocity, acceleration, projectiles, freely falling bodies.

* Newton's Second Law of Motion.

* Work, kinetic energy, potential energy, and power.

* Impulse and momentum.

* Conditions of conservation of momentum and energy.

For the Physical Science course, the first two units involve:

First Unit

* Speed, velocity and acceleration - definitions.

* Introduction to the metric system.

* Distinction between weight and mass.

* Newton's Laws of Motion.

* Circular motion.

* Kepler's laws of planetary motion.

* Work and power.

* Potential and kinetic energy.

* Momentum in linear and circular motion.

Second Unit

* Distinction between temperature and heat.
* Latent heats.
* Fluids at rest and in motion.
* Wave Motion.
    * Transverse and longitudinal.
    * Relation of wave length, frequency, and velocity.
    * Reflection, refraction, diffraction, and interference.
* Standing waves.
* Intensity and loudness.
* The Doppler Effect.
* Principles of electricity and magnetism.

Independent Variable

The independent variable involved four different levels of instructional strategies.

Strategy I - The traditional approach.

The first two units of the course (whether Vocational-Technical Physics or Physical Science) were taught in such a way that the students were made aware of the content and the behavioral objectives prior to each unit.

In addition to class sessions, tutorial help by the teacher on an individual basis was recommended but not required. At the end of each unit, a single exam was given which was designed to meet the unit's objectives and content (sufficient objectives were stated so that all content was included), and the student was permitted to take the exam only once. Each unit covered about a four week time interval. The evaluation of the student's performance on that unit was based solely on that one exam, and it was assumed that this one score accurately reflected the student's achievement in meeting the objectives. Each exam was designed to be completed in one hour or less and was given in one of the class room sessions.

Strategy II - Unlimited make-up opportunities - end of semester deadline.

The first two units of each course (given in the second semester) were again taught by informing the students of the content and objectives before each unit was begun. At the end of each unit, a single exam was given in one of the class room sessions. This exam was designed to meet the unit's content and performance objectives. Following this, students could take as many make-up exams as they wished throughout the rest of the semester. These make-ups were administered in the teacher's office with a tutorial session before and after each make-up exam. Students were encouraged to keep trying until they achieved mastery (a grade of 90% or higher). In the testing and retesting procedure, only the highest mark was kept for purposes of evaluating performance and assigning a grade. Students had the option of taking make-ups or ignoring them, but if they chose to participate, then a tutorial session before and after each make-up was mandatory. (They were told about the make-up process at the beginning of the semester). The make-ups were similar in form to the first exam (designed to meet the same content and objectives), but did not include the same questions.

Strategy III - Unlimited make-up opportunities - two week deadline.

This strategy was used in the third and fourth semesters of the study for the Physical Science students and only in the third semester for the Vocational-Technical students. It differed from Strategy II in only one respect; the students were allowed only two weeks to complete as many make-up exams as they wished. In extenuating circumstances, that two week limit was extended. The intent here was to eliminate the tendency of most students to wait until the end of the semester when crowded schedules mean an insufficient amount of preparation time for best results.

Strategy IV - Unlimited make-up opportunities - two week deadline - advisor input.

This strategy was used only with the Vocational-Technical students in the fourth semester of the study. It differs from Strategy III only with regard to the input from the student's academic advisor. The students in this program met with their advisor (as a teacher) for about 10 to 20 hours per week. At the end of each week, the teacher of the physics course met with the academic advisor to give him a progress report on each student. By knowing how many make-ups had been taken and what scores were obtained, the advisor could encourage each student to continue taking make-ups until he achieved a mastery grade (90% or higher). In this manner, both the teacher and the advisor participated in the motivational process.

Only one teacher (the author) was involved in the four instructional strategies used in this study.

Moderator Variable

High vs. low IQ level. Students were classified as having high or low academic ability based on IQ test scores. Those above the median were classified as high IQ and those below the median as low IQ.

Rhode Island high school students have for several years taken the Otis-Lennon Mental Ability Test in their sophomore year, using the advanced form designed for grades 10 to 12. Although two major divisions of mental ability are widely recognized (verbal-educational and practical-mechanical), the Otis-Lennon covers only verbal-educational. Its mean IQ score is based on students in the country's educational system, not the United States' total population for all age groups.

In 1966, a total of 14,380 students in Grade 10 (used as the norm group) obtained a mean raw score of 40.01 (standard deviation of 15.98) on the 80 item test. Translated into IQ, the mean was 100 with a standard error of 4.0. The test reliability is quite high as indicated by a split-half correlation of .95 and a Kuder-Richardson correlation of .95 in 1966 and an alternate-forms correlation of .94 obtained in 1967 using 1,002 students.

The test purports to measure verbal, numerical and symbolic reasoning ability. Its validity has been verified in terms of content and also by criterion-referenced and construct categories.

Although the test correlates well with educational criteria and other measures of scholastic aptitude, no claim is made that it measures innate learning potential for all students. In the Otis-Lennon manuals, special caution is advised in interpreting results for children who come from backgrounds which are not normal and those where motivation is quite low.

The Otis-Lennon IQ scores for students in the present study were obtained from student personnel files at the college.

Dependent Variable

The dependent variable, level of learning, was measured by using cognitive achievement tests, designed to measure primarily the first three levels of learning (knowledge, comprehension, and application) in Bloom's (1956) taxonomy of cognitive learning.

The Physical Science tests consisted of 30 multiple choice questions and a separate written section. The written section gave students a choice of problems that they could solve, some of which could be written as paragraph answers and others which could be expressed as computations.

The Vocational-Technical Physics exams each consisted of four problems to be solved by computations. Care was taken again to establish that knowledge, comprehension, and application were necessary if the student was to successfully solve all four problems.

For those strategies involving make-up exams, the make-ups were of the alternate-form type. The questions used were different, but the physical principles and problem types were parallel to the previous tests used for that particular unit of study. Because the forms used were different, memory carry-over effects were minimized. Two other members of the Physics Department at Rhode Island Junior College were informally consulted to verify that the exams (to be best of their knowledge) were parallel in content and equal in difficulty, thus establishing reliability. For the student's evaluation, only his or her highest score among the original and the make-ups was used.

The content validity of the original exam and all make-ups was verified by making sure that all unit content areas were sampled and by having questions that met the performances specified by the behavioral objectives. As a further check on validity, two other members of the Physics Department verified that the tests measured the content of the course's first two units. A description of some sample objectives, exam problems to test for these objectives, and solutions (which prove the relationship of test problem to objective) are shown in Appendix A (Vocational-Technical Physics) and Appendix B (Liberal Arts Physical Science).

The material covered and the learning objectives of the first two units of the Vocational-Technical Physics course constituted about two-thirds of the questions on the semester final exam. All students (including those using retesting strategies on the first two unit exams) were allowed only one attempt on the final exam. To determine whether the students using any of the three retesting strategies on the first two units were able to do better on the final exam than those who did not have retesting, the final exam was also included in this study as a dependent variable for the Vocational-Technical students.

A check on the final exam was not possible for the Physical Science students because those using Strategy I did not take a final exam due to the energy crisis of the winter of 1973-74; and those in Strategies II, III, and IV had a final exam which covered only the third unit (final one-third) of the course; thus the Physical Science final exams which were given did not include items from the first two units on which retesting took place.

Data Analysis

Two-factor analyses of variance were used. For the Vocational-Technical students, the independent variable (teaching strategy) was subdivided into four levels and the moderator variable (IQ) into two levels, producing a 4 x 2 analysis of variance as outlined by Tuckman (1972). The Liberal Arts students were involved in only three teaching strategies, so for them a 3 x 2 analysis of variance was used. Thus, the study was divided into two experiments.

The effects of both variables separately and any possible interaction of the two on learning level (the dependent variable) were studied. Because teaching strategy was significant, any two strategies compared against each other were tested using the Scheffé test (Winer, 1962; Ferguson, 1971).

A chi-square analysis (Tuckman, 1972) was also performed to determine whether or not all the treatment groups had effectively the same mean IQ.

Attempts to measure the student's affective response to the retesting process involved asking those who participated in any of the retesting techniques two questions:

1. Do you believe that you learned more by having unlimited opportunities for make-up exams than you would if these opportunities did not exist?
2. Did you like the retesting process (unlimited make-up exams) better than the traditional approach with which you are accustomed (only one opportunity for each unit exam - no make-up test)?

Looking backward, it would have been preferable to construct a single affective measure that could have been used with all the treatment groups including the groups who did not have make-up exam opportunities. Unfortunately, most of the students involved in this study are no longer available to respond to any newly constructed affective questionaire instrument.

RESULTS

Hypothesis One

The hypothesis that students who have opportunities for unlimited make-up exams and tutorial help have higher academic performance than those who do not, was accepted in all cases where significant differences were found. In this study, the number of significant differences between Strategy I (traditional teaching with no make-up exams) and the strategies with make-up exams (II, III, and IV) far outnumbered those which did not show significant differences.

Beyond this point, the coding shown in Table 3 will be used. The four teaching strategies will be considered as independent variable A with four levels, and referred to as follows:

1. Strategy I (traditional teaching with no make-up exams) will be named A_1.
2. Strategy II (unlimited make-up exams with end of semester deadline) will be called A_2.
3. Strategy III (unlimited make-up exams with two week deadline) will be renamed A_3.
4. Strategy IV (unlimited make-ups-two week deadline with advisor input) will be referred to as A_4.

Also, the moderator variable IQ will be coded B_1 for high IQ and B_2 for low IQ; IQ was split at the median value of 101.5 for both the Vocational-Technical students and the Physical Science students.

<u>Vocational-Technical Students</u>

<u>First Exam</u>

Concerning the first hypothesis, Table 5 shows a main effect for treatments (A) with an F ratio of 61.67, significant beyond the 0.01 level. Tables 4 and 6 show that for the Vocational-Technical students the A_2 and A_3 high IQ first exam averages (90.41 and 95.95) are each significantly better than the A_1 high IQ group (73.60 exam average) at the .05 level and .01 level, respectively, using the Scheffé test. The exam averages are also shown in Figure 1. The same tables and graph also establish more emphatic differences for the A_2, A_3, and A_4 low IQ groups (83.43, 89.94, and 92.29) over the A_1 low IQ group (41.29 average) all at the .01 level of significance.

<u>Second Exam</u>

For the second exam with the Vocational-Technical students, Table 7 shows a highly significant treatment (A) effect (F = 16.81). Tables 4 and 8 along with Figure 2 indicate that the A_2, A_3, and A_4 low IQ exam averages

Table 3

Educational Strategies

A_1: traditional teaching - only one attempt allowed for each unit exam.

A_2: unlimited make-up exams - end of the semester deadline.

A_3: unlimited make-up exams - two week deadline.

A_4: unlimited make-up exams - two week deadline with motivational input from program advisor.

B_1: High IQ = those above 101.5 IQ.

B_2: Low IQ = those below 101.5 IQ.

101.5 = Median IQ for both Vocational-Technical and Physical Science Students.

Table 4

Vocational-Technical Students

Exam Averages

I. First Exam.

	Educational Treatment			
IQ Level	A_1	A_2	A_3	A_4
B_1 - High	73.60	90.41	95.95	86.60
B_2 - Low	41.29	83.43	89.94	92.29

II. Second Exam.

	Educational Treatment			
IQ Level	A_1	A_2	A_3	A_4
B_1 - High	72.40	92.94	92.05	90.40
B_2 - Low	49.14	89.71	87.22	87.43

III. Final Exam.

	Educational Treatment			
IQ Level	A_1	A_2	A_3	A_4
B_1 - High	77.40	76.18	84.74	95.40
B_2 - Low	47.70	64.14	67.44	94.70

A_1: traditional teaching.

A_2: unlimited make-up exams - end of semester deadline.

A_3: unlimited make-up exams - two-week deadline.

A_4: unlimited make-up exams - two-week deadline with advisor input.

Table 5

Vocational-Technical Students

Analysis of Variance (First Exam)

A = educational strategy .... p = 4

B = IQ level ..... q = 2

N = number of students = 92

Source	df	MS	F	Critical F .05	Critical F .01
A	p-1=3	7,514	61.67**	2.72	4.03
B	q-1=1	1,698	13.93**	3.96	6.95
AB	(p-1)(q-1)=3	853	7.00**	2.72	4.03
error	N-pq = 84	122			

** $p < .01$

Table 6

Vocational-Technical Students

Scheffé Test (First Exam)

	Comparison	F	Comparison Interaction	F
B_1	A_1-A_2	8.96*	$\underline{B_1}$ - $\underline{B_2}$	
	A_1-A_3	16.23**		
	A_1-A_4	3.47	A_1 - A_2	2.92
	A_2-A_3	2.26	A_1 - A_3	8.58*
	A_2-A_4	0.46	A_1 - A_4	8.36*
	A_3-A_4	2.84	A_2 - A_1	98.19**
			A_2 - A_3	0.02
B_2	A_1-A_2	68.01**	A_2 - A_4	0.14
	A_1-A_3	97.89**	A_3 - A_1	125.43**
	A_1-A_4	74.72**	A_3 - A_2	10.37*
	A_2-A_3	2.74	A_3 - A_4	0.56
	A_2-A_4	3.01	A_4 - A_1	49.15**
	A_3-A_4	0.23	A_4 - A_2	0.30
			A_4 - A_3	0.36
	A_1 — B_1-B_2	24.99**		
	A_2 — B_1-B_2	3.08		
	A_3 — B_1-B_2	2.74		
	A_4 — B_1-B_2	0.77		

*$p < .05$
**$p < .01$

*$p < .05$
**$p < .01$

Figure 1
VOCATIONAL-TECHNICAL STUDENTS
FIRST EXAM SCORE AVERAGES

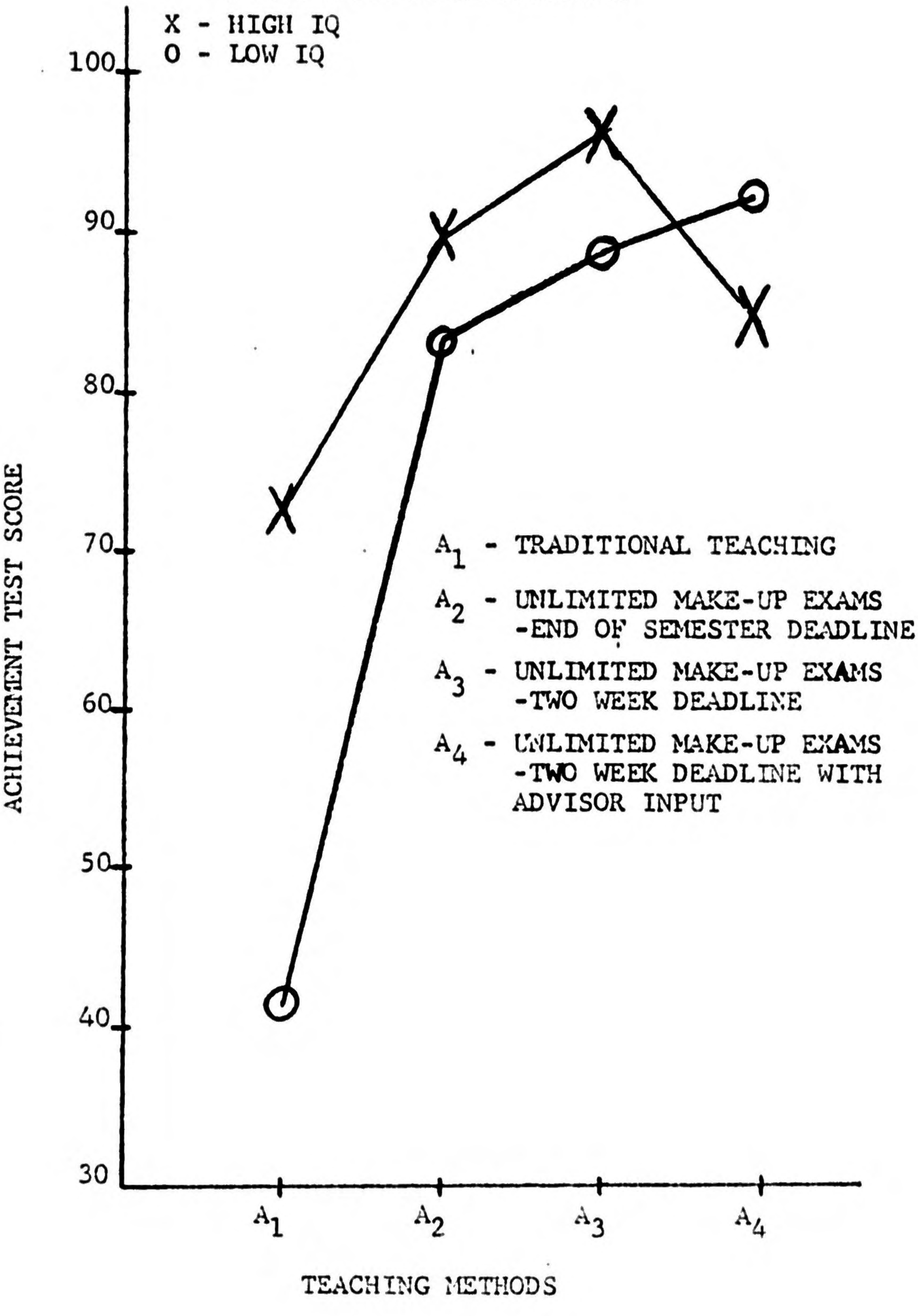


Table 7

Vocational-Technical Students

Analysis of Variance (Second Exam)

A = educational strategy ..... p = 4

B = IQ level ..... q = 2

N = number of students = 92

Source	df	MS	F	Critical F .05	Critical F .01
A	p-1=3	3,705	16.81**	2.72	4.03
B	q-1=1	1,272	5.77*	3.96	6.95
AB	(p-1)(q-1)=3	418	1.90	2.72	4.03
error	N-pq = 84	220			

* $p < .05$

** $p < .01$

Table 8

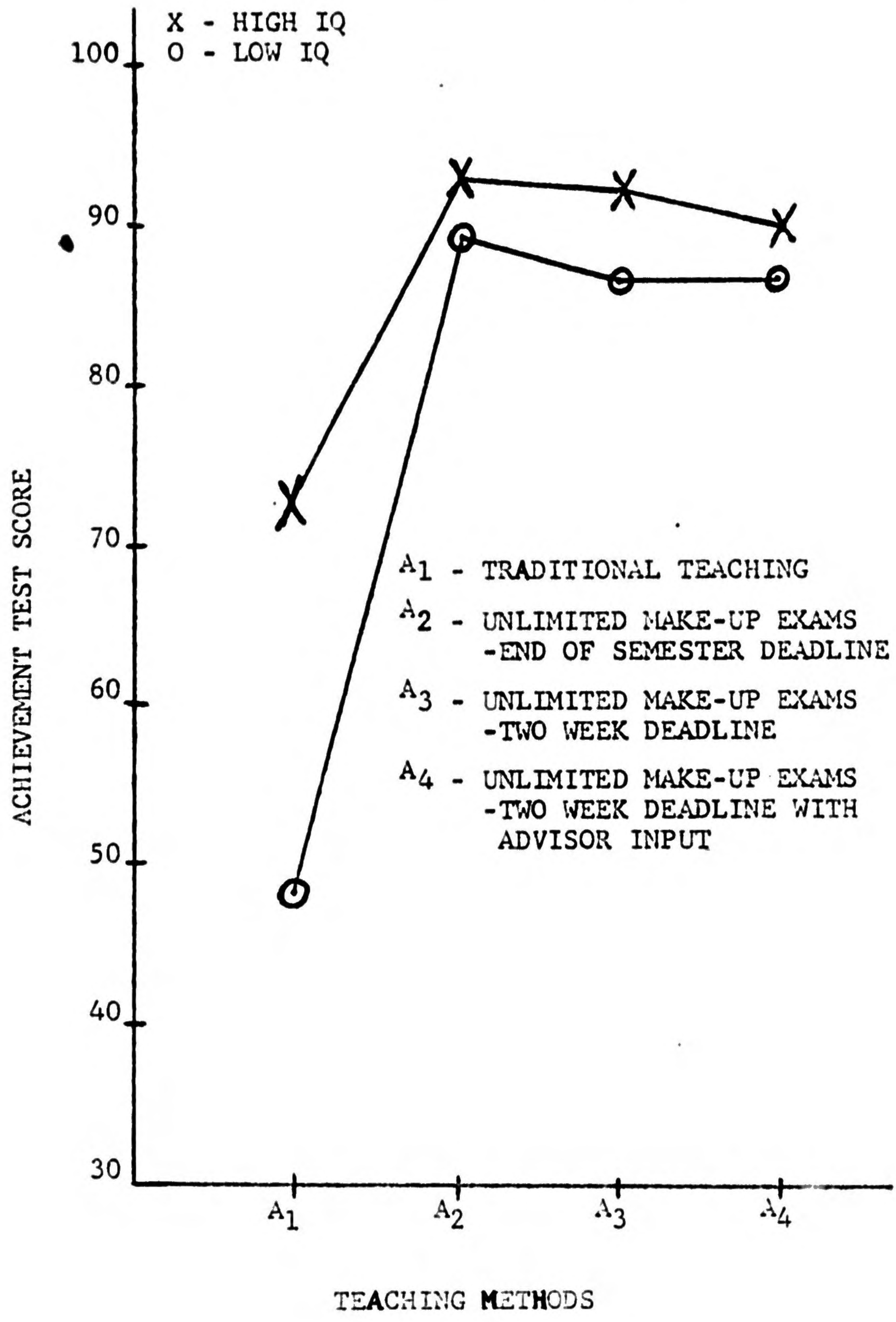
Vocational-Technical Students

Scheffé Test (Second Exam)

Comparison	F	Comparison Interaction	F
B_1: A_1-A_2	7.39	B_1 - B_2	
A_1-A_3	6.93		
A_1-A_4	3.67		
A_2-A_3	0.03	A_1 - A_2	5.01
A_2-A_4	0.11	A_1 - A_3	3.90
A_3-A_4	0.05	A_1 - A_4	2.99
		A_2 - A_1	43.15**
B_2: A_1-A_2	34.84**	A_2 - A_3	1.30
A_1-A_3	33.15**	A_2 - A_4	0.68
A_1-A_4	23.28**	A_3 - A_1	42.72**
A_2-A_3	0.22	A_3 - A_2	0.20
A_2-A_4	0.11	A_3 - A_4	0.49
A_3-A_4	0.00	A_4 - A_1	22.52**
		A_4 - A_2	0.01
A_1-B_1-B_2	7.16**	A_4 - A_3	0.18
A_2-B_1-B_2	0.36		
A_3-B_1-B_2	0.98		
A_4-B_1-B_2	0.12		

**$p < .01$ **$p < .01$

FIGURE 2
VOCATIONAL-TECHNICAL STUDENTS
SECOND EXAM SCORE AVERAGES



(87.71, 87.22, and 87.43) are each significantly higher than the A_1 low IQ group (49.14) at the .01 level of significance.

Final Exam

The final exam statistics with the Vocational-Technical students are shown in Tables 4, 9, and 10 in addition to Figure 3. A significant main effect for treatments (A) with F = 11.61 was obtained. For this exam (none of the four strategy groups had make-up opportunities on this final exam), the A_4 low IQ group average (94.70) was higher than the A_1 low IQ group average (49.70) at the .01 level of significance.

Physical Science Students

First Exam

For the Physical Science students on the first exam, a significant main effect (F = 38.52) was obtained. Tables 11, 12, and 13 along with Figure 4 demonstrate that the A_3 high IQ group average (91.90) was higher than the A_1 high IQ group (76.42) with a significance level of .01. The same .01 level also holds for the difference between the A_3 low IQ group (89.31) over the A_1 low IQ group (60.26).

Second Exam

The second exam for the Physical Science students showed a significant main effect (F = 104.13). Tables 11, 14, and 15 along with Figure 5 show several striking differences for teaching strategies.

The A_2 and A_3 high IQ averages (84.07 and 92.45) were both significantly higher than the A_1 high IQ group (63.83) at the .01 level. Similar results occurred for the A_2 and A_3 low IQ groups (77.25 and 89.64) over the A_1 low IQ group (56.39) also at the .01 level.

A check on the final exam was not possible for the Physical Science students because those using Strategy A_1 (traditional teaching with no retesting) did not take a final exam. This A_1 strategy took place during the fall semester of the school year 1973-74; during the normal final exam period in January the school was closed due to the energy crisis of that winter.

Those Physical Science students using Strategies A_2, A_3, and A_4 had a final exam but it covered only the third unit (final one-third) of the course; thus those Physical Science final exams which were given did not include items from the first two units on which retesting took place.

Table 9

Vocational-Technical Students

Analysis of Variance (Final Exam)

A = educational strategy ..... p = 4

B = IQ level ..... q = 2

N = number of students = 92

Source	df	MS	F	Critical F .05	Critical F .01
A	p-1=3	3,335	11.61**	2.72	4.03
B	q-1=1	3,862	13.44**	3.96	6.95
AB	(p-1)(q-1)=3	627	2.18	2.72	4.03
error	N-pq = 84	237			

**$p < .01$

Table 10

Vocational-Technical Students

Scheffé Test (Final Exam)

Comparison	F	Comparison Interaction	F
B_1: A_1-A_2	0.02		
B_1: A_1-A_3	0.74	B_1 - B_2	
B_1: A_1-A_4	2.82		
B_1: A_2-A_3	2.29	A_1 - A_2	2.25
B_1: A_2-A_4	4.97	A_1 - A_3	1.35
B_1: A_3-A_4	1.57	A_1 - A_4	3.04
		A_2 - A_1	13.99^{**}
B_2: A_1-A_2	4.39	A_2 - A_3	2.32
B_2: A_1-A_3	6.83	A_2 - A_4	5.92
B_2: A_1-A_4	26.90^{**}	A_3 - A_1	24.42^{**}
B_2: A_2-A_3	0.26	A_3 - A_2	11.90^{*}
B_2: A_2-A_4	15.16^{**}	A_3 - A_4	1.77
B_2: A_3-A_4	13.03^{**}	A_4 - A_1	23.09^{**}
		A_4 - A_2	12.53^{**}
A_1—B_1-B_2	8.95	A_4 - A_3	10.64^{**}
A_2—B_1-B_2	3.87		
A_3—B_1-B_2	9.63^{**}		
A_4—B_1-B_2	0.00		

$^{*}p < .05$

$^{**}p < .01$

$^{**}p < .01$

FIGURE 3
VOCATIONAL-TECHNICAL STUDENTS
FINAL EXAM SCORE AVERAGES

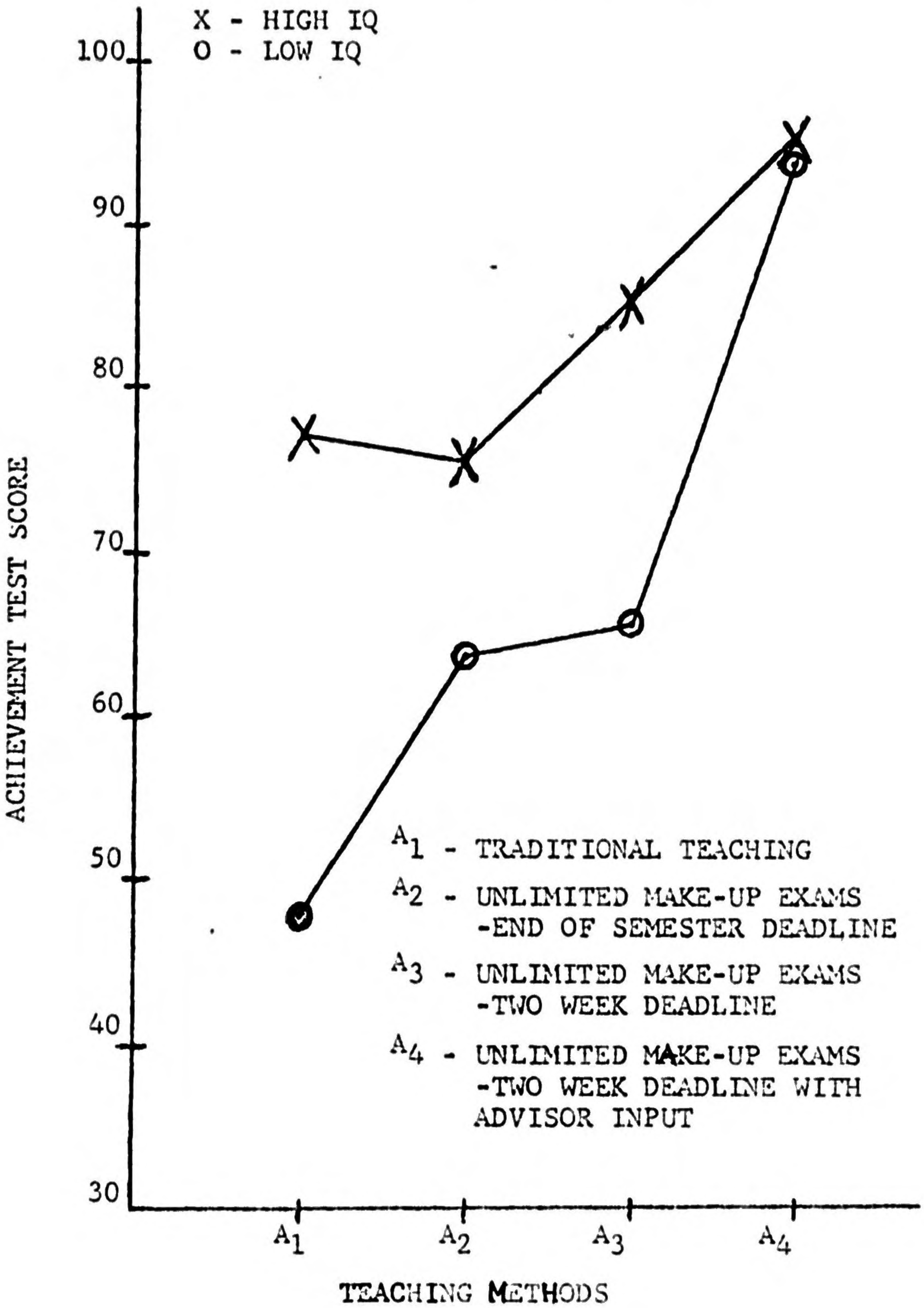


Table 11

Physical Science Students

Exam Averages

I. First Exam.

IQ Level	Educational Treatment A_1	A_2	A_3
B_1 - High	76.42	75.79	91.90
B_2 - Low	60.26	67.88	89.31

II. Second Exam.

IQ Level	Educational Treatment A_1	A_2	A_3
B_1 - High	63.83	84.07	92.45
B_2 - Low	56.39	77.25	89.64

A_1: traditional teaching.

A_2: unlimited make-up exams - end of semester deadline.

A_3: unlimited make-up exams - two-week deadline.

Table 12

Physical Science Students

Analysis of Variance (First Exam)

A = educational strategy ..... p = 3

B = IQ level ..... q = 2

N = number of students = 156

				Critical F	
Source	df	MS	F	.05	.01
A	p-1=2	6,379	38.52**	3.06	4.75
B	q-1=1	2,635	15.91**	3.91	6.81
AB	(p-1)(q-1)=2	520	3.14*	3.06	4.75
error	N-pq = 150	166			

*p < .05

**p < .01

Table 13

Physical Science Students

Scheffé Test (First Exam)

Comparison		F
B_1	$A_1 - A_2$	0.02
	$A_1 - A_3$	21.71**
	$A_2 - A_3$	16.25**
B_2	$A_1 - A_2$	3.31
	$A_1 - A_3$	73.73**
	$A_2 - A_3$	31.46**
A_1 — $B_1 - B_2$		18.52**
A_2 — $B_1 - B_2$		2.82
A_3 — $B_1 - B_2$		0.80

** $p < .01$

Comparison Interaction ($B_1 - B_2$)	F
$A_1 - A_2$	4.23
$A_1 - A_3$	14.91**
$A_2 - A_1$	12.67**
$A_2 - A_3$	11.44**
$A_3 - A_1$	87.82**
$A_3 - A_2$	39.82**

** $p < .01$

FIGURE 4
PHYSICAL SCIENCE STUDENTS
FIRST EXAM SCORE AVERAGES

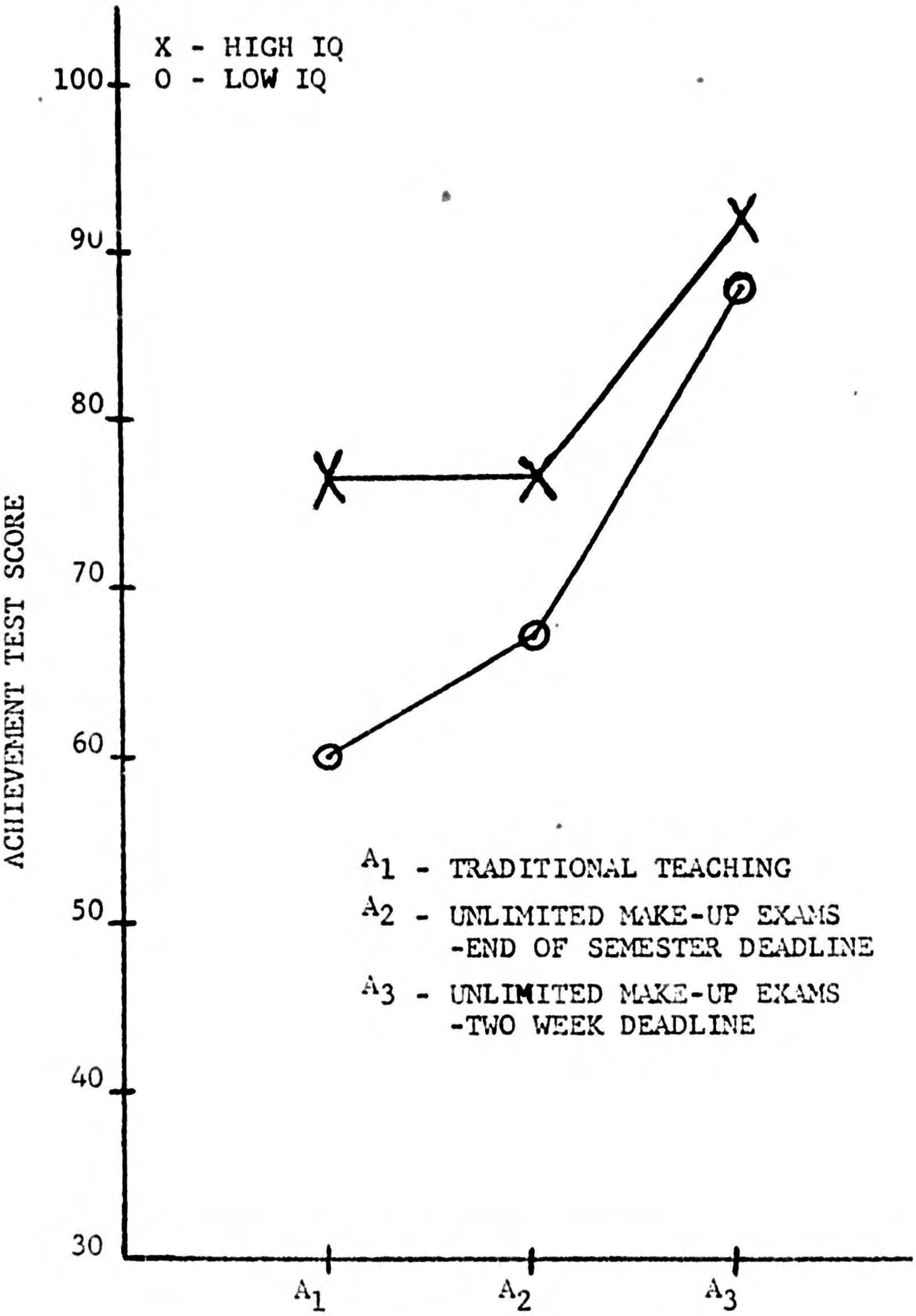


Table 14

Physical Science Students

Analysis of Variance (Second Exam)

A = educational strategy ..... p = 3

B = IQ level ..... q = 2

N = number of students = 156

Source	df	MS	F	Critical F .05	Critical F .01
A	p-1=2	10,987	104.13**	3.06	4.75
B	q-1=1	1,076	10.20**	3.91	6.81
AB	(p-1)(q-1)=2	70	0.66	3.06	4.75
error	N-pq = 150	106			

** $p < .01$

Table 15

Physical Science Students

Scheffé Test (Second Exam)

Comparison		F
B_1	$A_1 - A_2$	34.33**
	$A_1 - A_3$	116.47**
	$A_2 - A_3$	6.90*
B_2	$A_1 - A_2$	38.92**
	$A_1 - A_3$	151.61**
	$A_2 - A_3$	16.51**
A_1 — $B_1 - B_2$		6.16*
A_2 — $B_1 - B_2$		3.29
A_3 — $B_1 - B_2$		1.48

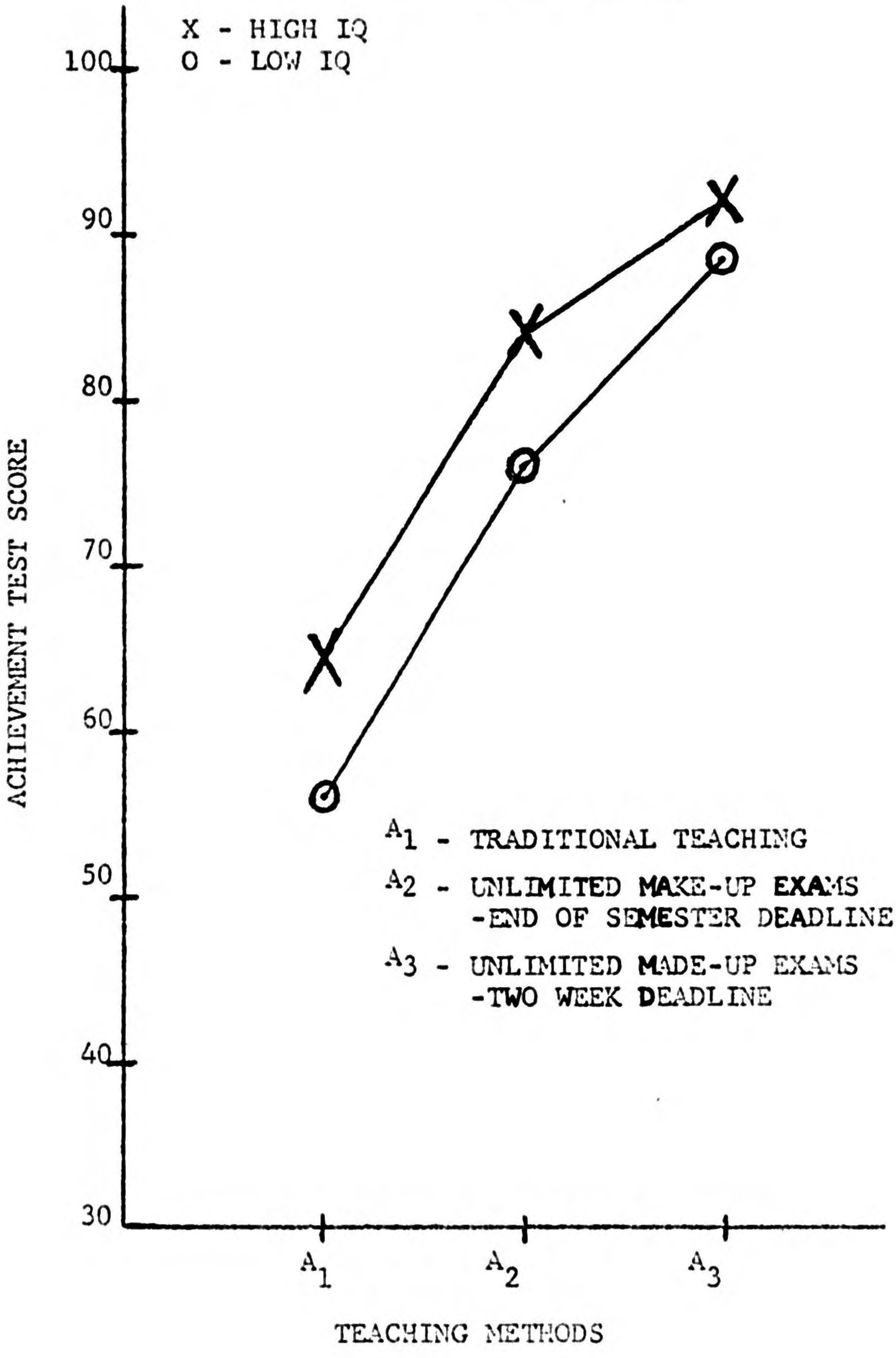
*$p < .05$

**$p < .01$

Comparison Interaction	F
B_1 - B_2	
A_1 - A_2	16.39**
A_1 - A_3	93.81**
A_2 - A_1	63.20**
A_2 - A_3	3.03
A_3 - A_1	180.46**
A_3 - A_2	25.03**

**$p < .01$

FIGURE 5
PHYSICAL SCIENCE STUDENTS
SECOND EXAM SCORE AVERAGES



Hypothesis Two

The hypothesis that students who are required to take whatever make-up exams they wish within two weeks after the initial exam have higher academic performance than those who have the entire semester for make-up opportunities has also been established in all cases where a significant difference exists using the Scheffé test.

Such a difference was established for the Vocational-Technical students only on the final exam and only for low IQ students. The A_4 group (average = 94.70) was significantly higher (.01 level) than the A_2 group (average = 64.14). (See Tables 4, 9, and 10 and Figure 3.)

Many more verifications for Hypothesis Two were discovered for the Physical Science students. On the first exam, the A_3 high IQ group (average = 91.90) was higher than the A_2 high IQ group (average = 75.79) at the .01 level. The low IQ A_3 group (average = 89.31) was also significantly higher (.01 level) than the low IQ A_2 group (average = 67.83). (See Tables 11, 12, and 13 and Figure 4 for these results.)

The second exam for the Physical Science students showed similar findings. The A_3 high IQ group had an average of 92.45 compared with the A_2 high IQ group's average of 84.07 (.05 level of significance). There was a difference between the A_3 low IQ group (89.64) and the A_2 low IQ group (77.25)-level of significance = .01. (See Tables 11, 14, and 15 and Figure 5.)

Hypothesis Three

The hypothesis that students who have motivational help each week from their academic advisor have higher academic performance than those who do not (all other factors being equal) was verified using the Scheffé test for the final exam only and for the low IQ students only. (Recall that the input of the academic advisor was used only with the Vocational-Technical students.) The difference in exam scores - A_4 group = 94.70 and A_3 group = 67.44 - was significant at the .01 level. (See Tables 4, 9, and 10 in addition to Figure 3.)

Effect of the Moderator Variable (IQ)

Vocational-Technical Students

Tables 5, 7, and 9 which summarize the analyses of variance indicate a strong effect (.01 level) for IQ level for all students on all exams with the exception of the Vocational-Technical students' second exam where the IQ effect was significant at the .05 level.

This difference between the performance of high IQ students and low IQ students was most obvious for teaching strategy A_1 in which the students encountered traditional teaching with no make-up exam opportunities. The cases where this was true at the .01 level of significance (Scheffé test) are as follows:

* Vocational-Technical students first exam (high IQ average = 73.60 over low IQ average = 41.29). See Tables 4 and 6.

* Vocational-Technical students second exam (high IQ average = 72.40 compared with low IQ average = 49.14). See Tables 4 and 8.

* Vocational-Technical students final exam (high IQ average of 77.40 with low IQ average = = 47.70). See Tables 4 and 10.

In another comparison where IQ alone had a demonstrably significant effect on exam scores, the Vocational-Technical final exam averages were different for high IQ (84.74) and low IQ (67.44) at the .01 level using Strategy A_3.

Physical Science Students

A .01 level significant difference existed for the A_1 Physical Science students first exam (high IQ 76.42 and low IQ 60.26). (See Tables 11 and 13.)

For the Physical Science second exam, students using the A_1 strategy demonstrated a significant difference between high IQ (average = 63.83) and low IQ (average = 56.39) at the .05 level. For these results, see Tables 11 and 15.

Interaction of Teaching Strategy With IQ

Vocational-Technical Students

Analyses of variance (Tables 5, 7, and 9) show a strong interaction (p less than .01) between teaching strategy and IQ level for the first Vocational-Technical exam.

Comparing any two cells for interaction of teaching strategy with IQ using the Scheffé test demonstrates for the first Vocational-Technical exam (Tables 4 and 6) the following interactions:

* High IQ A_1 group (avg. = 73.60) vs. low IQ A_3 group (avg. = 89.94) with p less than .05.
* High IQ A_1 group (avg. = 73.60) vs. low IQ A_4 group (avg. = 92.29) with p less than .05.
* High IQ A_2 group (avg. = 90.41) vs. low IQ A_1 group (avg. = 41.28) with p less than .01.

* High IQ A_3 group (avg. = 95.95) vs. low IQ A_1 group (avg. = 41.29) with p less than .01.

* High IQ A_3 group (avg. = 95.95) vs. low IQ A_2 group (avg. = 83.43) with p less than .05.

* High IQ A_4 group (avg. = 86.60) vs. low IQ A_1 group (avg. = 41.29) with p less than .01.

The second exam of the Vocational-Technical students (Scheffé test, Tables 4 and 8) showed the following interactions:

* High IQ A_2 group (avg. = 92.94) vs. low IQ A_1 group (avg. = 49.14) where p is less than .01.

* High IQ A_3 group (avg. = 92.05) vs. low IQ A_1 group (avg. = 49.14) where p is less than .01.

* High IQ A_4 group (avg. = 90.40) vs. low IQ A_1 group (avg. = 49.14) where p is less than .01.

The final exam for the Vocational-Technical students (in which none of the cell groups had make-up opportunities) showed similar results (Scheffé test, Tables 4 and 10) as follows:

* High IQ A_2 group (avg. = 76.18) vs. low IQ A_1 group (avg. = 47.70) at p less than .01.

* High IQ A_3 group (avg. = 84.74) vs. low IQ A_1 group (avg. = 47.70) at p less than .01.

* High IQ A_3 group (avg. = 84.74) vs. low IQ A_2 group (avg. = 64.14) with p less than .05.

* High IQ A_4 group (avg. = 95.40) vs. low IQ A_1 group (avg. = 47.70) where p is less than .01.

* High IQ A_4 group (avg. = 95.40) vs. low IQ A_2 group (avg. = 64.14) where p is less than .01.

* High IQ A_4 group (avg. = 95.40) vs. low IQ A_3 group (avg. = 67.44) at p less than .05.

Physical Science Students

In the first exam of the Physical Science students, the following interactions are all significant at the .01 level (See Tables 11 and 13) as determined by the use of the Scheffé test:

* High IQ A_1 group (avg. = 76.42) vs. low IQ A_3 group (avg. = 89.31).

* High IQ A_2 group (avg. = 75.79) vs. low IQ A_1 group (avg. = 60.26).

* High IQ A_2 group (avg. = 75.79) vs. low IQ A_3 group (avg. = 89.31).

* High IQ A_3 group (avg. = 91.90) vs. low IQ A_1 group (avg. = 60.26).

* High IQ A_3 group (avg. = 91.90) vs. low IQ A_2 group (avg. = 67.88).

The second Physical Science exam also demonstrated similar significant interactions (Tables 11 and 15) at the .01 level as follows:

* High IQ A_1 group (avg. = 63.83) vs. low IQ A_2 group (avg. = 77.25).

* High IQ A_1 group (avg. = 63.83) vs. low IQ A_3 group (avg. = 89.64).

* High IQ A_2 group (avg. = 84.07) vs. low IQ A_1 group (avg. = 56.39).

* High IQ A_3 group (avg. = 92.45) vs. low IQ A_1 group (avg. = 56.39).

* High IQ A_3 group (avg. = 92.45) vs. low IQ A_2 group (avg. = 77.25).

Chi-Square Test

The number of students for each educational strategy divided nearly equally so far as high IQ versus low IQ was concerned. The overall IQ median for both the Vocational-Technical students and the Physical Science students was 101.5.

The Vocational-Technical students divide above and below median IQ as follows:

* the high IQ students using the A_1 strategy numbered 5 and there were 7 students in the low IQ group.

* for the A_2 strategy, 17 high IQ students and 14 low IQ students.

* for the A_3 strategy, 19 high IQ students and 13 low IQ students.

* for the A_4 strategy, 5 high IQ students and 7 low IQ students.

The Physical Science students were even closer to being divided equally by median IQ as shown below:

* the high IQ students using the A_1 strategy numbered 24 and the low IQ group 23.

* for the A_2 strategy, 14 high IQ students and 16 low IQ.

* for the A_3 strategy, 40 high IQ students and 39 low IQ.

Chi-square tests for both the Vocational-Technical students and the Physical Science students revealed no significant difference between the observed frequencies and the expected frequencies for each cell, so it was concluded that all the educational strategy groups came from the same population so far as median IQ level was concerned. (See Tables 16 and 17 for the results of the Chi-square tests.)

Responses to Affective Questionaire

Starting with the first group to use any of the make-up examination strategies, an attempt was made to obtain the students' feelings concerning having make-up exam opportunities compared with no chances for make-up. (The questionaire responses were written, unsigned, and not done in the presence of the instructor.)

All eighty Vocational-Technical students responding indicated that they felt they learned more and enjoyed the course more with make-up exams than they would if make-up opportunities were not available. For the Physical Science students, 109 said they felt they learned more with make-up exams and 107 liked the retesting process better. Two students actually responded negatively to preferring the retesting process; one felt that with his or her part-time employment he or she did not have time for make-ups and feared being downgraded relative to other students (this in spite of the assurance by the instructor early in the semester that the grade was not determined relative to others in the class). Another student felt that he or she always did well on the initial exam and preferred the exhilaration of looking accomplished relative to others who had lower performance on the first exam; this student further stated that the opportunity for others to "catch up" seemed unfair.

The results of this affective questionaire are summarized in Table 13. The totals are less than 92 for the Vocational-Technical students and less than 156 for the Physical Science students because the students in the traditional strategy (A_1 - no make-up exams) were not given the questionaire.

Table 16

Vocational-Technical Students

Chi-Square Test

	Educational Strategy								Total
	A_1		A_2		A_3		A_4		
	o	e	o	e	o	e	o	e	
B_1- High IQ	5	6	17	15.5	19	18.5	5	6	46
B_2- Low IQ	7	6	14	15.5	18	18.5	7	6	46
Total	12		31		37		12		92

Median IQ = 101.5

0 = observed frequency

e = expected frequency

B_1 = High IQ = those above 101.5 IQ

B_2 = Low IQ = those below 101.5 IQ

$$\chi^2 = 0.9838 \qquad \chi^2 = \sum_{A=1}^{4} \sum_{B=1}^{2} \frac{(o-e)^2}{e}$$

Critical Values of Chi-Square

χ^2	.20	.10	.05
	4.64	6.25	7.82

Conclusion: The four educational strategy groups come from the same population so far as median IQ level is concerned.

Table 17

Physical Science Students

Chi-Square Test

	Educational Strategy						Total
	A_1		A_2		A_3		
	o	e	o	e	o	e	
B_1 - High IQ	24	23.5	14	15	40	39.5	78
B_2 - Low IQ	23	23.5	16	15	39	39.5	78
Total	47		30		79		156

Median IQ = 101.5

0 = observed frequency

e = expected frequency

B_1 = High IQ = those above 101.5 IQ

B_2 = Low IQ = those below 101.5 IQ

$\chi^2 = 0.0673$ $\qquad \chi^2 = \sum_{A=1}^{3} \sum_{B=1}^{2} \frac{(o-e)^2}{e}$

Critical Values of Chi-Square

χ^2	.20	.10	.05
	3.22	4.60	5.99

Conclusion: The three educational strategy groups come from the same population so far as median IQ level is concerned.

Table 18

Responses to Affective Questionaire Regarding Opportunities for Make-up Examinations

Question	Vocational-Technical Students		Physical Science Students	
	Yes	No	Yes	No
1. Do you believe that you learned more by having unlimited opportunities for make-up exams than you would if these opportunities did not exist?	80	0	109	0
2. Do you like the retesting process (unlimited make-up exams) better than the traditional approach with which you are accustomed (only one opportunity for each exam-no make-up test)?	80	0	107	2

DISCUSSION

Conclusions

The primary hypothesis that students who have unlimited retesting opportunities have better performance than those who do not was supported overwhelmingly by the results of this study. Almost all the test cases (both high and low IQ students) demonstrated this, and in no case did the reverse hold. The other hypotheses were also supported for high and low IQ students. For the unlimited testing opportunities, those with two-week deadlines nearly always performed better than those who had the entire semester for make-up exams. Also, in cases where the added motivational input of the advisor was used, these students generally performed better than those without advisor input.

For the strategies using two-week deadlines and advisor input, the performance of high and low IQ students was almost never significantly different. For retesting opportunities with end of semester deadline and for traditional teaching with no retesting, the higher performance of high IQ students over those with low IQ usually was significantly different.

For the many interactions which were significant, it was noteworthy that low IQ students with retesting performed better than high IQ students who did not have retesting. The other interactions which were significant supported the other hypotheses:

(1) Low IQ students who had two-week deadlines for make-up exams did better than high IQ students who did not.

(2) Low IQ students who had the advisor's motivational input did better than high IQ students who did not.

Many of the class averages (particularly in the strategies using two-week deadlines and advisor input) were above the 90% level which was defined as the performance which demonstrated mastery of learning objectives. Even in the strategy using the entire semester for make-up exams, the average was either above 90% or very cl-se to it for most of the students.

The Vocational-Technical students had only one opportunity for the final exam regardless of strategy used prior to the final. In spite of this, the hypotheses held for all comparisons in which significant differences existed. For the strategy using advisor input, the average for both high and low IQ students was a lofty 95 - as high as any average for either the first or second unit exams.

It was interesting to note that for nearly all students who had all semester to do make-up exams, performance was higher on the second unit exam than on the first. This conclusion held except for the high IQ Vocational-Technical students where the difference was not significant.

Interpretations

A careful reading of the results and conclusions of this study leads to the following conservative interpretations:

(1) Retesting probably promotes both learning and motivation.

The student has the opportunity to receive a better mark as motivation to continue the testing process. Because of the structure of the make-up exams, real learning must take place to achieve a higher mark. Gradually the student's goal (a higher grade) and the teacher's goal for the student (increased learning) both become goals for the student.

(2) Retesting seems to be particularly effective if augmented by realistic time deadlines and the added help of the advisor's motivational input.

It appears that most students, if given the opportunity to put off taking make-up exams until the end of the semester, will do so. In the hectic activity of end of semester deadlines for other courses, academic achievement suffers. Realistic deadlines promote additional learning before that which has been learned has a chance to be forgotten.

The student's advisor who provided added motivational input (to encourage the student to participate in make-up exams) was also the student's teacher in his academic major. Such association seems to cause so much respect for the advisor by the student that the student follows the suggestions of the advisor.

(3) Low IQ students improve more dramatically with retesting than do high IQ students.

Evidently low IQ students with retesting can eventually perform as well as high IQ students. Without retesting, the performance of high IQ students is much superior to that of low IQ students. Therefore, low IQ students have higher gains possible by using retesting, and by fully utilizing the retesting process take full advantage of these higher gains.

(4) With retesting, an overwhelming majority of students are able to achieve mastery (a grade of 90% or higher) of the learning objectives. Of those who do not achieve 90%, most are quite close.

The student is required to receive additional tutoring before taking the first make-up exam. The result of this is usually a performance far superior to that achieved on the initial exam. This event causes most students to continue trying until a mastery performance (a grade of 90% or better) is achieved.

(5) With only one opportunity to take the final exam, those groups which spend the semester using retesting do much better on the final than those who do not experience retesting.

It seems that by having the retesting experience for an entire semester, the student gains confidence and tackles new learning experiences with an attitude that mastery level success can be achieved on the first attempt. When an announcement is made that only one opportunity will be provided for the final exam, the student responds to the challenge. This indicates that the students who have used the retesting undergo significant growth in personal responsibility that has lasting impact.

(6) Better results on the second unit exam (for many of the students) indicate that students must be convinced that the teacher's desire for students to achieve learning mastery is real. Perhaps once this is achieved, students then seem able to learn to take fuller advantage of the retesting opportunities.

During the first class session of the semester, the students are told about the retesting opportunities and the possibility that they can receive "A" marks if they take full advantage of the process. The general reaction seems to be disbelief because having all or nearly all of a given class receive "A" marks "just isn't done". An often heard question is "Where is the catch?".

After participating in the process for the first unit of the course, the student realizes that mastery learning is possible, that much additional effort is necessary to achieve it, and that the teacher is serious about giving "A" marks to all who earn them.

Recommendations

It is hoped that many teachers who read this study will desire to adopt the retesting techniques in order for their students to achieve learning mastery. For these teachers, it is recommended that realistic time deadlines for make-up exams be employed to prevent students from procrastinating. Also, should it be feasible, the learning will be helped if the students' academic advisor can provide input on a weekly basis.

Needless to say, the teacher must inform the students of these opportunities at the beginning of the course and convince them that he or she is serious about mastery learning. In addition, the academic mark to be given should be indicative of mastery so that the student will be motivated to keep trying. This also means writing the learning objectives so clearly and specifically that both teacher and student know what is expected and how the task is to be done. In this learning process, the teacher will be seen by the student as a partner, not as an adversary.

Because low IQ students seem to gain more by retesting opportunities than high IQ students, it will be helpful if the teacher can provide for more follow-up and encouragement for the low IQ student. If the low IQ students can be identified from school records soon after the course begins, this will be beneficial. This encouragement will be effective if the student is reminded often that only the highest exam score on any unit of the course will be kept for the purposes of assigning a grade.

The make-up exams and the added tutoring sessions held in teacher's office can be very time consuming. The process will be much more efficient if a paraprofessional is hired to keep records of student progress, proctor and grade make-up exams, suggest added study in areas where the student needs more help, and refer students to the teacher for tutorial help when necessary. This will ensure that cheating does not take place and free the teacher to teach.

Because this study involved only one teacher, it would be useful to replicate part or all of this experiment using other teachers, other fields, and other colleges. Should this be done, it is important that the retesting strategies be conducted in such a way that the student will be motivated to take full advantage of the opportunities. If the student perceives that the teacher appears to be skeptical or unenthusiastic or even negative concerning the retesting techniques, the student will either fail to take make-ups or fail to study sufficiently in preparation. To summarize, a successful replication of this study must involve proper teacher expressions of attitude as well as proper teacher administration of procedures. Should this be done, it is hoped that the replication will be as highly successful as this study; if so, mastery learning could achieve widespread use.

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APPENDIX A

SAMPLE PROBLEM ON VOCATIONAL-TECHNICAL PHYSICS EXAM

Content areas: Mechanical forces, Newton's First Law of Motion, and coefficient of friction.

Objectives: All mechanical forces can be divided into two categories:

1. gravitational...commonly known as weight.
2. direct contact...between the object which is acted upon and the object doing the acting.

A corollary of Newton's First Law states that for objects moving at constant velocity, the vector sum of forces adds up to zero.

The coefficient of friction is by definition the friction force divided by the normal force.

After completing this unit of study, the student will be able to draw a complete force diagram on an object at constant velocity. Using Newton's First Law, the student will then be able to calculate the normal force and friction force and from knowing these also calculate the coefficient of friction.

Problem: A 50 lb. medicine ball is pushed across the floor at a steady velocity with a push force of 10 lb.

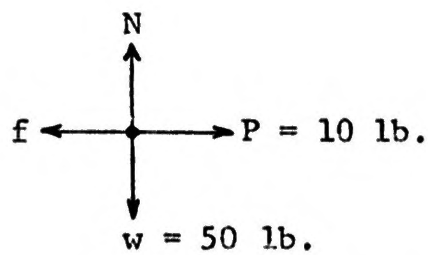
a. Draw a <u>complete</u> force diagram on the medicine ball.

b. Calculate the normal force and the friction force.

c. Calculate the coefficient of friction.

Solution:

a.



gravitational force = w = weight of medicine ball

direct contact forces ....
- N = normal force of floor pushing up
- P = push force to keep ball moving
- f = friction force opposite direction of motion

b. Sum of vertical forces = 0, so N = w = 50 lb.

Sum of horizontal forces = 0, so f = P = 10 lb.

c. Coefficient of friction = $\frac{f}{N} = \frac{10 \text{ lb.}}{50 \text{ lb.}} = 0.2$

APPENDIX B

SAMPLE MULTIPLE CHOICE QUESTION FOR

PHYSICAL SCIENCE EXAM

Content areas: Potential energy, kinetic energy, and heat energy.

Objectives: After completing this unit of study, the student will be able to predict whether an object moves faster or slower as a function of its change in height and whether it increases or decreases in temperature by using the concept that energy (in everyday processes) is converted from one from to another, but total energy is neither increased nor decreased.

Question: How does the temperature at the bottom of Niagara Falls compare with the temperature at the top?

a. Bottom temperature is higher.

b. Bottom temperature is lower.

c. Both temperatures are the same..

Answer: a. Bottom temperature is higher.

Reason: As the water falls, it loses potential energy (energy due to its elevation) and gains an equal amount of kinetic energy (energy of motion). The water moves faster and faster until it reaches the bottom At the bottom, it joins a pool of water and slows down considerably (losing most of the kinetic energy that it gained on the way down). This loss of kinetic energy is not converted back into potential energy, for we know that the water does not bounce back up to the top of Niagara Falls. The loss of kinetic energy in falling must therefore go into another form of energy. When the water which has fallen reaches the bottom, it undergoes multiple collisions with the pool of water already there. These collisions cause friction producing heat. The added heat energy raises the temperature of the water, causing the bottom temperature to be higher than that at the top.

v

Note: To feel assured that the correct answer has been selected, the student will probably go through the reasoning process described above.

APPENDIX B (CONTINUED)

SAMPLE ESSAY QUESTION FOR

PHYSICAL SCIENCE EXAM

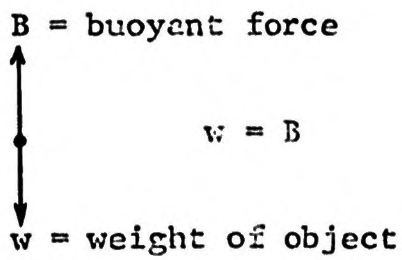
Content area: Archimedes' Principle and Newton's First Law of Motion.

Objective: Archimedes' Principle states that when an object is placed in a liquid, the liquid exerts an upward (buoyant) force on that object which is equal to the weight of liquid displaced by that object. Newton's First Law of Motion states that if an object is at rest and all the forces acting on that object add up to zero, the object will remain at rest. If the forces don't add up to zero, it will move and accelerate. After completing this unit of study, the student will be able to predict the future motion of an object in a liquid such as water by using Archimedes' Principle and Newton's First Law of Motion.

Question: Suppose an object with the same density as water is placed at rest completely below the surface of water with enough room to either rise or fall and is then released. What movement will it have after release? Why?

Essay Answer: It will remain at rest, neither rising nor falling.

Reason: The object has the same density as water, so the weight of water that it displaces has the same weight as the object. By Archimedes' Principle, the buoyant force upward will be the weight of water displaced. Thus the buoyant force upward and the weight of the object downward are the same.



When the weight and the buoyant force are added properly as vectors, the total force is zero. For a total force of zero on an object initially at rest, the object will remain at rest (Newton's First Law of Motion).