THE EFFECT OF SHORT, FREQUENT REVIEW TESTS ON THE RETENTION OF PREVIOUSLY LEARNED CHEMISTRY CALCULATIONS

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An Abstract

Presented to the

Graduate and Research Council of

Austin Peay State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts in Education

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by

Sharon Blair Freehill

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ABSTRACT

The Effect of Short, Frequent Review Tests on the Retention of Previously Learned Chemistry Calculations

This study was undertaken to determine the effect of short, frequent review quizzes on the retention of previously learned mathematical skills in chemistry calculations among Chemistry I students at Harrison High School.

The design of this study was a nonequivalent pretest-posttest control group. The experiment was repeated twice with the experimental group becoming part of the control group during the second test. The students in the experimental group received short review quizzes approximately twice a week. The review quizzes were administered to the students during the first five minutes of the class period as a "sponge activity." The review quizzes consisted of chemistry calculations requiring mathematical skills that were presented in previous lessons.

All of the students (total = 101) received the same diagnostic pretest and the same quarter examinations (posttests). A Pearson product-moment correlation indicated that the tests were highly related. The pretest versus quarter examination I correlation was $r = 0.7655$; the pretest versus quarter examination II correlation was $r = 0.6703$; and the quarter exam I versus quarter exam II

correlation was r = 0.8234.

An analysis of variance of the final test scores indicated a statistically significant difference ($F(1,99) = 10.528$, $p < .002$) due to the review quizzes first quarter. Second quarter test scores were not significantly different.

A 2 x 2 factorial analysis indicated that females scored significantly better than males in both the experimental and the control groups second quarter ($F(1,97) = 5.602$, $p < .05$). A 2 x 3 factorial analysis (having review quizzes or not having review quizzes versus grade level - tenth, eleventh or twelfth) determined that grade level did not affect the test scores either first quarter ($F(2,95) = 2.192$, $p > .05$) or second quarter ($F(1,97) = 3.993$, $p > .05$).

Nonminority students were found to score significantly higher than minority students first quarter ($F(1,97) = 3.993$, $p < .05$) in a 2 x 2 factorial analysis. The same analysis of variance second quarter did not indicate a significant difference for nonminority students ($F(1,97) = 1.37$, $p > .05$).

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July 1988

To the Graduate and Research Council:

I am submitting herewith a Thesis written by Sharon Blair Freehill entitled "The Effect of Short, Frequent Review Tests on the Retention of Previously Learned Chemistry Calculations." I have examined the final copy of this paper for form and content, and I recommend that it be accepted in partial fulfillment of the requirements for the degree in Master of Arts in Education, with a major in Biology.

B. P. Stone
Major Professor

We have read this thesis
and recommend its
acceptance.

George Rawlins III
Minor Professor

Barbara B. Wilburn
Third Committee Member

Accepted for the Graduate
and Research Council:

William J. Ellis
Dean of the Graduate School

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CHAPTER 1

Introduction

Science teachers today have a common goal of preparing students to be successful in a highly technological world. Today's educators also share many concerns. A review of educational literature indicates the problems being addressed by the majority of researchers involved the learning process. Much less attention is being given to the problem of retention. This is a seriously overlooked factor. From the day a child enters school, he/she is screened, classified, grouped, promoted, and labeled according to his/her performance on tests. Test results affect decisions about the student throughout his/her school career. The student is expected to learn new material and store this information; evaluation occurs at a later date. A typical high school course will require exams that include subject material covered up to eighteen weeks prior to the test. Additionally, the student is expected to take important standardized tests over content he/she may have learned years ago. If the student does poorly on the exam, it is assumed that he/she did not learn the material initially. This may

be an inaccurate assumption; the low test scores may be due to problems in retention. For this reason it is important that, in addition to the development of instructional methods to assist learning, effort is made to develop techniques facilitating the retention of learned material.

Although not currently stressed, lack of retention is by no means a new issue in the field of education. The earliest research on retention occurred in 1885 by Ebbinghaus. He identified two basic principles of forgetting and suggested that the ability to recall previously learned material diminished with time in a predictable pattern (Smith, 1979). In more recent years, other researchers have supported Ebbinghaus' findings on forgetting (Hovland, 1959 and Hirsch, 1977).

Ebbinghaus also reported in 1885 that reviewing previously learned material improved the ability to recall it (Smith, 1979). Since then a number of retention studies have stressed review as an aid to retention (Bausell and Moody, 1972 and Gay, 1973).

The application of this research to the classroom setting is widespread. Most teachers will provide their students with some means of reviewing material before a major test occurs. However, there is not an abundance of research that indicates which method is most effective for most students. Two studies have

shown that testing can be used to increase retention (Landauer and Ainslie, 1975 and Gay and Gallagher, 1976). Spaced practice has been shown to be more productive than massed practice (Ingle, 1969). There is a need to combine some of these research results into a specific effective review activity that will improve retention.

Purpose of the Study

The author has recently completed the "Training and Application of Clinical Teaching and Supervision" workshop provided to all teachers in the Harrison School District. All Harrison teachers are expected to implement the clinical teaching methods designed by Madeline Hunter (Hunter, 1987). One of these techniques is the use of "sponge activities" in order to make maximum educational use of class time. Sponge activities are supposed to be used at the beginning of the class period so that students will be on task while the teacher is involved with attendance and organizational chores. The importance of implementing sponge activities coupled with the students' need for review of previously presented material resulted in the development of this research project.

Personal teaching experience has indicated that a significant factor affecting student success in high school chemistry is retention of mathematical knowledge. Chemistry instruction is very sequential,

and the student is required to recall and build upon mathematical skills introduced earlier in the school year. Retention is vital. To assist in this retention, the author presented review quizzes for Chemistry I students at Harrison High School. The review quizzes were presented during the first five minutes of class approximately twice a week. Each quiz consisted of a chemistry problem requiring previously presented mathematical skills.

Five sections of Chemistry I students participated in the project. All of the students took the same diagnostic test at the beginning of the experiment. During the first quarter of the study two sections of students received the review quizzes. All of the students took the same comprehensive quarter final examination. The following quarter two different sections of students received review quizzes, and once again all students took the same final examination. One section of students did not receive review quizzes either quarter. The purpose of this research project was to determine if the frequent (spaced practice) review quizzes improved the retention of the learned mathematical skills as determined by the students' scores on the comprehensive final examinations.

Statement of the Hypothesis

The null hypothesis for this study proposes that there is no significant difference among the average

test scores for Harrison High School students scheduled by a computer into five periods of Chemistry I. This study was designed to test the null hypothesis by the administration of frequent review quizzes. The study will further test the null hypothesis by comparing test scores of students who differ by gender, grade level, and minority status.

Terms

retention - the aspect of memory that involves the possession of information.

sponge activities - activities designed for use at the beginning of the class period to maximize the time that students are on task.

Limitations

1. The time period of the study may not have been sufficient to significantly affect the students' retention of chemistry mathematical skills.

2. The author did not have control over student-initiated review outside of the classroom.

3. Assignment of students to classes may not have been entirely random due to scheduling conflicts.

4. Uncontrollable differences among classes may have influenced the results.

5. The instrument used to measure retention was a teacher-prepared comprehensive quarter examination rather than a standarized test.

CHAPTER 2

Review of the Literature

The process of remembering begins with the short term memory system which holds incoming sensory information briefly. Important information is retained longer by the use of two interrelated memory systems that are educationally significant: the declarative system and the procedural system. The declarative system processes explicit facts and symbols that are easy to learn and to forget. The procedural system processes problem-solving skills that are difficult to learn and to forget (Sywlester, 1985).

The three measures that are frequently used in retention experiments are recall, recognition, and relearning (Arzi, Ben-zvi, and Ganiel, 1986). Recall is determined by the student providing the materials he has learned. Recognition is indicated by the student selecting one statement as correct from a set of statements. Multiple-choice tests yield combined measures of recall and recognition. Relearning, or savings, is demonstrated through the savings in time required for relearning previously learned materials when compared to the time required to learn the materials for the first time.

Importance of Retention

Aeschlimann (1980) entitled his article in School and Community, "Retention: the Forgotten Skill." In this article he conveys his belief that schools have been overlooking the importance of retention in the search for better instructional methods to upgrade skills. He points out that the improvements made to help students learn material will be of little use unless someone discovers how to help them remember it. He states, "...it seems a terrible waste of time and an empty gesture to spend the students' and the teacher's time and effort on material that no one is expected to retain..." (Aeschlimann, 1980, p. 42).

Other educators and researchers echo Aeschlimann's regard for the importance of retention.

> "A good memory is essential for intelligence and creativity."
> (Morris, 1979)

> "...designers of instruction should concern themselves not only with providing materials that facilitate original learning, but also with providing techniques for enhancing retention of mastered material..."
> (Smith, 1979, p.195)

> "It is hard to think of any educational goal for which the ability to retain information is unimportant; human memory is crucial for acquiring the knowledge and skill we learn at school."
> (Howe and Ceci, 1979)

> "The importance of retention is shown by the fact that growth or improvement in skills, knowledge, and attitudes is dependent upon the learner's retention of the effects of previous experience."
> (Spitzer, 1939, p. 641)

> "Clearly the goal of educational efforts is the long-term retention of concepts and skills."
> (Gay, 1980, p. 45)

> "...retention is essential in a variety of the skills and achievements that contribute to the process of education..."
> (Howe and Ceci, 1979)

> "The long term retention of information is important for a variety of reasons... retrievable information forms a basis for many cognitive processes, such as comprehension, implementation of intellectual skills, creative thinking, and attitude change."
> (E. Gagne, 1978, p. 629)

Actually, retention would not be a problem if it were not for its companion - forgetting. Studies in forgetting reach back over a period of years. The earliest records on studies in forgetting credit Ebbinghaus as the pioneer. His studies with nonsense syllables in 1885 led him to propose the well-known forgetting curve, a negatively accelerated exponential curve. This curve shows that most forgetting occurs rapidly in the first few hours and thereafter the amount recalled remains fairly constant (Smith, 1979). Hovland (1951) determined that meaningful material is retained better than nonsense syllables, but also clearly showed that retention is likely to decrease with time.

These findings are supported and recounted in many literature reviews of studies dealing with retention. The research of Underwood (1957 and 1983) indicated that after twenty-four hours the retention of the last information learned by heavily practiced subjects was

twenty-five percent or less, whereas with new subjects seventy-five percent was remembered. The loss of twenty-five percent over twenty-four hours is startling. The research of Arzi, Ben-zvi, and Ganiel (1986) showed that approximately half of the initially required knowledge was forgotten from the completion of the instruction in the eighth grade until the beginning of the tenth grade. Even more disturbing is Gay's report (1973) which states that about sixty-six percent of the concepts learned in high school and college courses are forgotten within two years!

Methods for Improving a Student's Ability to Retain Information

It has been noted that research attention has traditionally focused on the instructional methods that facilitate retention, the logic being that retention will improve if the learning of material is improved (Gay, 1980). Many books on learning and instructional design provide guidelines that can help ensure learner mastery of instructional materials, thus increasing retention to some degree (Gagne, 1970). There are further guidelines found in other sources. A study guide produced by Graham and Robinson (1984) lists four processes which aid retention: categorization, association of new information within its context; personalization, association of new information with personal experiences; application, making use of

learned material; and self-recitation, repetition and mneumonics.

Madeline Hunter (1967) provides a list of five factors which she believes assist in retaining information: meaning, feeling tone, degree of original learning, practice, and transfer. Some of these same factors are found in P. E. Morris' (1977) suggestions for improving recall of information. Morris also suggests learning organized, meaningful material, active learning, and self-testing. The use of organizational strategies is also emphasized as a method for enhancing memory by Rohwer and Dempster (1977).

In Sywlester's (1985) review of research on memory, a number of techniques for increasing memory have been proven effective through research. These techniques include novelty and multiple storage, as used in mnemonics; visualization and imagery, mentally locating objects in space; and observation of experts. Research also shows that students who have prior knowledge of learning outcomes before instruction achieve and retain significantly more than students without the prior knowledge (Raghubir, 1979). Some studies indicate that instruction about text organization immediately prior to reading can facilitate recall of textual information. Barnett (1984) determined that the instruction on text

structure helped the student to establish coherence among the ideas contained in the text.

However, research also shows that students need help in learning to retain what they comprehend (Graham and Robinson, 1984). Hirsh (1977) studied the effect of three instructional math formats on the retention of high school students. He found that the six-week retention test scores were one-half of the original scores on the original lesson test regardless of the instructional format used. This may indicate that simply improving instructional methods will not improve retention.

What can educators do to improve retention after the original learning has been mastered? In her review of research, Elene Gagne (1978) identifies review as a facilitating condition between the initial learning and testing. She acknowledges that review can take a number of forms: a quiz, questions asked by the teacher, or practice of the to-be-retained information. The review can improve long-term retention by strenthening links in memory (practice makes perfect), or by encouraging the formation of new links which reinforce memory by establishing relationships between learned information.

Review classes are typically described as fact-oriented, teacher-centered, and poorly planned (Moynihan and Carroll, 1974). However, the variety of

methods for review found in the literature include: repetition of the original learning (Rohwer and Hagen, 1977; Petros and Hoving, 1980); general practice (Hunter,1967); review of notes (Graham and Robinson, 1984); audiotutorial (Smith, 1979); oral review (Ross and DiVesta, 1976); games (Suydam, 1985; Cheek, 1980; Ludwig, 1979); outlines (Suydam, 1985; Windsor, 1979); categorization and ranking of key terms and names (Moynihan and Carroll, 1974); summary study sheet (Godfrey, 1979); and student-conducted reviews (Huska, 1980). It is evident that effort has been directed by some educators toward planning interesting reviews. Studies have also shown that review is effective. Ingle et al. (1969) found that repeated review and practice can be a positive motivating factor by becoming a new task each day and varying the classroom procedure. Peterson et al. (1935) proved that groups having review performed significantly better than groups having no review, and two review sessions work better than only one session. After eighteen weeks the one-review group showed a superiority of eighteen per cent over the no-review control group, and the two review group improved fifty-seven per cent over the control group. Bausell and Moody (1972) studied the effect of review on the retention of an arithmetic lesson by fourth and fifth grade pupils. Although the two groups (control and review) had similar scores on the original

lesson test, the review group scored much higher than the control group on the eight-week retention test.

Ross and DiVesta (1976) found that there was a twenty-five percent advantage in recall of concepts and facts when an oral review of textual material was required compared to no oral review requirement. Thus, their data indicated that oral review of material studied is an effective strategy for improving recall. Oral review activity requires processing which not only helps the student store information in memory, but it also makes the information more retrievable. Gay's study using computer instruction and review for eighth grade students also showed that groups having review retained significantly more than the group which received no review (1973).

The Effects of Timing and the Use of Testing as a Means of Review

Research does provide some insight into timing and the use of testing as a review. Timing can be viewed from different angles. For example, information about timing can be studied by comparing spaced or distributed review with blocked or massed review. Reynolds and Glaser (1964) researched the effects of spaced review upon the retention of science topics using programmed instruction. The spacing of the review sequences had a definite facilitating effect on retention. Ausubel and Youssef (1965) showed that practice in the form of spaced reviews rather than

massed repetitions was effective in promoting retention. Scanlon and Tom (1967) also recommended that teachers employ spaced review instead of block review. Hunter (1967) recommended many short practices rather than a few long periods.

The timing element can also be viewed from the position of how soon after the original lesson should the review occur. In their review of literature, Peterson et al. (1935) indicated that Thorndike contended that review should occur soon after learning and be relatively long, and future reviews should occur at increasingly longer intervals and require less time. However, Thorndike's conclusions do not take into account the nearness to the final test. Peterson's study showed that the value of any given review session depends upon its nearness to learning and to the time of the test. Students maintain that a review immediately before a test is very beneficial. The basic idea is that review immediately following instruction consolidates and clarifies the material, while delayed review aids in relearning forgotten material (Gay, 1973).

Review questions were found to facilitate the learning and retention of computational skills better than review statements (Lee, 1980). Review questions involve learning strategies for retrieving information and problem-solving processes. By working review

problems, students develop lateral transfer skills and may develop vertical transfer skills more efficiently. The use of testing as an effective method of review was studied by Spitzer (1939) who concluded that tests are learning devices, not just tools for measuring achievement. Tests should be employed more frequently to aid in retention and all tests should be corrected after being graded, with the corrections being made either by the teacher or by the student.

Landauer and Ainslie (1975) also proved tests to be effective review activities in reducing the rate of forgetting of material over a long period of time. In their investigation of the retention of knowledge acquired from advanced technical courses, they determined that an interim test at six months helped students retain information over a period of a year. Gay and Gallagher (1976) compared the effect of tests versus written work on retention by students; students who were required to reach criterion on each of a series of tests scored significantly better in retention of tested concepts and procedures than did students who were required to complete written exercises on the same concepts.

Nungester and Duchastel (1982) recognized the consolidating effect tests can have in helping students remember what was learned. Their data revealed that review is valuable (resulting in a ten per cent

increase in retention over the control group performance), but testing is even more beneficial (resulting in a twenty-five per cent increase in retention over the control group performance).

The study of Halpin and Halpin (1982) clearly showed that the students who took tests achieved more and retained their learning longer than students who did not take tests. Testing causes an improvement of study behaviors which results in higher achievement. Rothkopf and Billington referred to the practice of presenting the students questions similar to those they will receive on a later examination as "priming" (1974, p. 669). The priming question activates topically related domains in memory and therefore makes correct responses to other topically related questions more likely.

McDaris' study (1984) showed that shorter, more frequent tests were preferred over a single, longer test. In his review of research, he mentioned the following studies that supported his findings: Kulik and Kulik in 1979; Dustin in 1971; Keys in 1934; and Turney in 1931. Scanlon (1967) determined that there is a direct relationship between frequency of repetition of a learning activity and the amount of the resultant learning.

Grade Level Differences in Retention

Significant grade level differences were noted by Gagne (1969) in his study of effects of content, isolation and interference on retention. The older students in the study performed better than the younger students. Two possible reasons given by Gagne for the superiority in recall of the older students were greater maturity in intellectual development and better memory strategies.

Gender difference in mathematics-related science performance

In their review of the professional literature concerning factors influencing the entry of females into science oriented careers, Jones and Wheatley (1988) found that mathematics directly influences science course selection and performance. Sells (1978) described the lack of preparation in mathematics as the "critical filter" that denies women entry into science fields.

Research has indicated sex differences in quantitative ability that show up at the time of puberty. Males exhibit better spatial skills and mathematical ability. Ebbeck (1984) has noted that "male-female differences in educational achievement cannot be explained by current understanding of research into basic sex differences in ability." The differences in achievement may be due to a variety of sociological factors that affect the development of

interests and goals of males and females. Some of the environmental influences that have been identified as affecting gender performance in science and mathematics include the presence of the father in the home and birth order (Hoyenga and Hoyenga, 1979), prior experiences in science-oriented activities (Kahle and Lakes, 1983), sex stereotypes that promote or inhibit self-reliance (Barry, Bacon and Child, 1957), and sex bias by teachers (Hodgson, 1979). Stake and Granger (1976) concluded that a same-sex role model is very effective in promoting interest in science. Thus, since there are more male science teachers, male students exhibit a greater interest in science than do female students.

Minority student versus Nonminority Student Performances in Mathematics and Science Skills

Minority students are underrepresented in the sciences, mathematics and engineering fields (Doigan, 1982). The high school preparation of minority students is often inadequate for college science programs, and mathematics, not science, is the primary obstacle (Sells, 1978). When minority students do not take advanced coursework in mathematics, poor achievement on standardized tests will result (Atwater, 1986). The average national scores on the ACT Natural Science subtest for 1984 showed nonminority students scoring 22.4 (out of 36 possible) while Blacks scored only 15.3, Mexicans scored 17.1, and Indians scored

18.3. Some of the factors that Atwater (1986) stated as affecting the minority student's interest and achievement in science are career counseling, teachers' expectations, student persistence, role models, and early exposure to science.

The goal of this literature search was to examine the value of review through short, frequent tests as a method of increasing the amount of material retained. Research showed strong support of review as a facilitator of retention. It was also shown that spaced frequent reviews may be of more benefit than massed review. The temporal position of singular reviews was found to be insignificant. Also noted was the benefit of early review as a consolidator of material and the benefit of delayed review as a time to relearn material. Tests were shown to be effective as a method of review. The achievement of males in the mathematics and science fields was shown to be superior to females. Minority students are underrepresented in science careers, and achievement in mathematics is a contributing factor.

CHAPTER 3

Methods

Purpose

The phrase "time-on-task" has become popular recently in light of the increasing scrutiny of schools by the American public. There is a need for utilization of every minute in the classroom. One technique suggested by some educators to effectively use the first few minutes of class is the use of sponge activities (Hunter, 1987). The researcher has also noted the students' need for review of previously presented materials, especially in mathematical calculations in chemistry. The joining of these two activities, sponge and review, may prove very beneficial. This research was designed to determine if this technique actually does improve the retention of previously learned mathematical skills by Chemistry I students at Harrison High School in Colorado Springs, Colorado.

Description of Setting

The setting of this study was Harrison High School, District Two. Harrison High School is located near the southeastern boundary of Colorado Springs, Colorado. Colorado Springs is a large city with over a third of a million people. It is widely known for the large number of electronics industries and military installations located in and around the city.

Until recently District Two was comprised mainly of residential areas. Growth has led to an influx of industry and commercial buildings as well as more residences. The communities within the school district are diverse, ranging from lower middle class to upper middle class. The district serves over 8000 students in ten elementary schools, three middle schools, and two high schools.

Harrison High School has a staff of 105, including administrators (4), teachers and classified staff (72), and support personnel (29). Student population is approximately 1150. There is about a thirty-three percent turnover rate, primarily due to the military influence. The drop-out rate is currently about five percent. There is a large population of minorities living in the school district, and that is reflected in a student body which is approximately eighteen percent Hispanic, seventeen percent Black, and six percent Asian. Less that one third of the students who

graduate from Harrison High School obtain any form of additional education beyond the high school level. This includes not only four year colleges, but also community colleges, junior colleges, technical trades schools and business colleges.

Procedures

Identification of Subjects

The subjects of this research study were students enrolled in Chemistry I at Harrison High School. There were 101 students included in the experiment. The majority of the students (64.4 %) were in the eleventh grade, 15.8 % were in the tenth grade, and 19.8 % were in the twelfth grade. Two years of science are required for graduation from Harrison High School, one year of physical science and one year of life science. Most students take Earth Science in the ninth grade and Biology in the tenth grade, thus completing their graduation requirements. Therefore, Chemistry I is usually taken as an elective by students who are fulfilling college admission requirements.

The ethnic composition of the Chemistry I classes studied was 0.99 % American Indian, 16.8 % Asian, 11.9 % Black, 16.8 % Hispanic, and 53.5 % Caucasian. Females comprised 45.5 % of the group; 54.5 % were males.

Group Design

This project was designed to measure the effect of the use of frequent review quizzes on the retention of mathematical skills for chemistry calculations. Five Chemistry I sections were used in the experiment. The students were scheduled into the sections by the district computer; therefore, the composition and size of the classes was approximately equal with the exception of period two. The first experimental group, periods three and five, consisted of 41 students. The second experimental group, periods one and four, contained 46 students. Period two was smallest in number (14 students) and was a constituent of the control group for both quarters of the study. The numbers of students in these groups does not actually represent the sizes of the five classes because students who moved into or out of Chemistry I during the two quarters of the study were eliminated from the data collected.

Experimental Design

The researcher used the nonequivalent pretest-posttest control group design. This is a quasi-experimental design, due to the inability of the researcher to randomize the subjects. The design is represented on the next page with Group A - class periods three and five - being the first experimental group , and Group B - class periods one, two and four -

being the control group. During the second quarter of the study Group A (experimental) consisted of periods one and four, and Group B (control) was periods two, three and five. The pretest (diagnostic test) represented by O1 was administered to all five sections on the same day. A copy of the diagnostic or pretest is included in Appendix A.

Nonequivalent Pretest-Posttest

Control Group Design

group	pretest	treatment	posttest
A	O1	X	O2
B	O1		O2

(McMillan And Schumacher, 1984)

X represents the treatment. During the first quarter of the study, the experimental group (periods three and five) received short review quizzes during the first five minutes of class time a minimum of twice a week. The final examination (the posttest, represented by O2) for the quarter was administered to all five sections. The experiment was repeated during the following quarter, but the experimental group was changed to periods one and four. Period two students did not receive the review quizzes either quarter. Once again all five sections of students received the same quarter final examination.

All five sections of Chemistry I received the same instruction, assignments, laboratory work, major reviews, and tests during the two quarters of the study. The only variable was the review quizzes.

Experimental Treatment

The review quizzes were administered to students in the experimental group during the first five minutes of the class period. While the researcher was involved in checking attendance and other classroom management chores, the students were given a chemistry problem to solve. The review quizzes consisted of chemistry calculations requiring mathematical skills that were presented in previous lessons. A copy of the review quiz questions is included in Appendix A.

The students had five minutes to complete the review quiz. As soon as the quiz papers were collected, the correct solution to the problem was discussed. The corrected papers were returned the following day. Many students saved these papers and used them for review before major tests.

The review quizzes were administered a minimum of twice a week during the quarter. The entire experimental treatment covered nine weeks for each of the two experimental groups. The control group did not receive the review quizzes. Any review that they received in class was the same as the traditional review given in the experimental group. The

independent variable then was not review in general, but specifically the short frequent review quizzes.

Evaluation

The effect of short frequent review quizzes on the retention of previously presented chemistry problem-solving mathematic skills was evaluated with a teacher-constructed test. The test was a final examination for the quarter and consisted of questions covering material presented during the quarter. A copy of the quarter examinations is included in Appendix A.

CHAPTER 4

Analysis of the Data

The objective of this study was to determine if short frequent review quizzes improved the retention of previously learned mathematical skills in chemistry calculations among Chemistry I students at Harrison High School and to further determine if student performance on a comprehensive exam would differ by gender, grade level, or minority status.

The raw pretest and posttest scores for each student by period are reported in Tables 8, 9, and 10 in Appendix B. Upon completion of the collection and organization of the data, the pretest and posttest results were compared for each of the three groups of students: Experimental Group I (periods three and five which had the review quizzes the first quarter); Experimental Group II (periods one and four which had the review quizzes the second quarter); and Control Group (period two, which did not receive any review quizzes). The means and standard deviations of these group scores are reported in Table 1 on the next page. The pretest and posttest scores for each student by

gender, ethnicity, and grade level are reported in Tables 11, 12, 13, and 14 in Appendix B.

Table 1

Student Performance Scores for Pretest, First Quarter and Second Quarter Exams

	n (count)	Mean (% Scores)	Standard Deviation	Standard Error of the Mean
Pretest				
Periods 1 & 4	46	41.0	18.47	2.72
Period 3 & 5	41	47.3	17.88	2.79
Period 2	14	34.3	11.49	3.07
Quarter Exam I				
Periods 1 & 4	46	58.2	17.17	2.53
*Periods 3 & 5	41	69.1	20.05	3.13
Period 2	14	49.1	15.52	4.15
Quarter Exam II				
*Periods 1 & 4	46	65.4	17.05	2.51
Periods 3 & 5	41	72.8	19.90	3.11
Period 2	14	55.9	21.83	5.84

* review quizzes

Visual comparison shows a difference in the mean scores of the three groups on the pretest. The students in periods three and five had a better foundation in mathematics and chemistry problem-solving at the beginning of the study. The students in period two had the lowest mean scores on the pretest. This pattern continued throughout the study. Although the scores on the first and second quarter examinations were better

than the pretest scores for all groups, the students in periods three and five had consistently higher test scores than periods one and four, and period two had the lowest scores on both examinations.

A Pearson product-moment correlation (r) was computed to determine the relationship of the tests to each other. High positive values of r were determined for all combinations, indicating that there was a strong correlation between the tests.

Table 2

Pearson Product-moment Correlation Coefficients Between the Pretest and Quarter Exams

Pretest with Quarter Exam I	r = 0.7655
Pretest with Quarter Exam II	r = 0.6703
Quarter Exam I with Quarter Exam II	r = 0.8234

An analysis of variance was performed to determine the significance of differences on the first and second quarter examination raw scores due to the use of the review quizzes. No significant difference was found for second quarter final examination scores due to review quizzes ($F(1,99) = .633$, $p > .05$). However, there was a significant difference for the effect of review quizzes for first quarter ($F(1,99) = 10.528$, $p < .002$). The results of the ANOVA are shown in Table 3.

Table 3

Analysis of Variance of Quarter Exam I Scores for Review-quizzed Students versus Non-reviewed Students

Source	SS	df	ms	F	p
Total	9019.0	100	90.19	-----	-----
Between groups	866.9	1	866.9	10.53	<.002
Within groups	8152.1	99	82.3	-----	-----

To investigate the effect of the review quizzes and gender on first quarter final examination scores a 2 X 2 factorial analysis of variance was performed. While gender had no significant effect on performance ($F(1,97) = 3.08$, $p > .05$), and the interaction of gender and review quizzes was also not significant ($F(1,97) = .246$, $p > .05$), the positive effect of the review quizzes on the first quarter final test scores was significant ($F(1,97) = 9.765$, $p < .01$).

Table 4

Analysis of Variance of Quarter Exam I Scores for Review-quizzed versus Non-reviewed Students by Gender

Source	SS	df	ms	F	p
Total	9019.01	100	90.19	-----	-----
Review Quiz	793.83	1	793.83	9.765	<.002
Gender	246.29	1	246.29	3.030	.085
Review X Gender	19.9	1	19.99	.246	.621
Error	7885.80	97	81.29	-----	-----

When this same method of analysis of variance was performed on second quarter final scores, the review quizzes did not significantly affect examination

scores ($F(1,97) = 1.015$, $p > .01$), but gender did have a significant effect ($F(1,97) = 5.602$, $p < .05$). Females scored better than males in both the experimental group (female $\bar{x} = 26.91$, male $\bar{x} = 25.39$) and the control group without review quizzes (female $\bar{x} = 30.57$, male $\bar{x} = 25.13$). The results of the ANOVA are shown in Table 5 below.

Table 5

Analysis of Variance of Quarter Exam II Scores for Review-quizzed versus Non-reviewed Students by Gender

Source	SS	df	ms	F	p
Total	6136.14	100	61.36	-----	-----
Review quiz	59.38	1	59.38	1.015	.316
Gender	327.71	1	327.71	5.602	<.020
Rev X Gend	94.96	1	94.96	1.623	.206
Error	5674.46	97	58.50	-----	-----

A 2 X 3 factorial analysis was performed to test the effects of the review quizzes and grade levels of the students (10, 11, 12) on the final exam scores. Once again in the analysis of data from first quarter, review quizzes were significantly beneficial ($F(1,95) = 11.764$, $p < .001$). Grade level and the interaction of review quizzes with grade level were not significant. The results of the ANOVA are given in Table 6.

Table 6

Analysis of Variance of Quarter Exam I Scores for Review-quizzed versus Non-reviewed Students by Grade Level

Source	SS	df	ms	F	p
Total	9019.01	100	90.19	-----	-----
Review quiz	953.04	1	953.04	11.764	<.001
Grade level	355.13	2	177.56	2.192	.117
Rev X grade	101.00	2	50.50	.623	.538
Error	7695.95	95	81.01	-----	-----

Results of the 2 X 3 factorial analysis of second quarter data indicated that neither grade level ($F(2,95) = 2.83$, $p > .05$) or review quizzes ($F(1,95) = .625$, $p > .05$) were significant.

Nearly half (46.5 %) of the students in this experiment were minorities (Asian = 16.8 %, Black = 11.8 %, Hispanic = 16.8 %, and American Indian = 1 %). A 2 X 2 (nonminority versus minority) factorial analysis of variance was performed for final test scores both quarters. Significance was determined for both review quizzes ($F(1,97) = 7.559$, $p < .01$) and minority ($F(1,97) = 3.993$, $p < .05$) for first quarter test scores. Nonminority students scored higher than minority students both with review quizzes ($\bar{x}$ nonminority = 35, $\bar{x}$ minority = 30.7) and without review quizzes ($\bar{x}$ nonminority = 29.5, $\bar{x}$ minority = 26.1). The results of the ANOVA are given in Table 7.

Table 7

Analysis of Variance of Quarter Exam I Scores for Review-quizzed versus Non-reviewed Students by Ethnic Minority Background

Source	SS	df	ms	F	p
Total	9019.0	100	90.19	-----	-----
Review quiz	609.7	1	609.7	7.559	< .007
Minority	322.1	1	322.1	3.993	< .048
Rev X Min	5.7	1	5.7	.071	.790
Error	7824.2	97	80.6	-----	-----

No significant differences were found for review quizzes ($F(1,97) = .322$, $p > .05$), minority groups ($F(1,97) = 1.37$, $p > .05$), and for the interaction of review and minority ($F(1,97) = .59$, $p > .05$) for second quarter final examination scores.

CHAPTER 5

Discussion

The design of this study was a nonequivalent pretest-posttest control group. The experiment was repeated twice. During the first quarter of the study the first experimental group (periods three and five) received the review quizzes and the control group consisted of periods one, four, and two. During the second quarter of the study the second experimental group to receive the review quizzes was composed of students in periods one and four, and students in periods two, three and five made up the control group. The control group did not receive the review quizzes. All of the students took the same pretests and the same quarter final examinations (the posttests).

The data from the study was collected and organized. It appears in table form in Appendix B. The data was analysed using a variety of statistical tests.

The Pearson product-moment correlation coefficient indicated a high correlation between the pretest and quarter exam I, between the pretest and quarter exam II, and between the two quarter exams. An analysis of

variance determined a significant difference on first quarter exam scores after the review quizzes. There was no significance in the final test scores after review quizzes second quarter.

There were unavoidable differences among the classes that might have affected the results. For example, during the first quarter of the study the classes were on fifty-five minute class periods. The length of the class periods was shortened to forty-seven minutes for the second quarter of the study. The loss of eight minutes per day for the students in the experimental group during the second quarter must certainly have affected their performance and contributed to the nonsignificance of the review quizzes. It was much more difficult to take the time to discuss the correct solutions for the review quizzes. Also, time that was used on the quizzes was taken away from other classwork, such as guided practice, that might have benefited the students more. This data seems to contradict the findings of Nungester and Duchastel (1982) who studied a practical issue concerning the testing effect: Is learning time better spent on testing or on review and study? Their data revealed that testing is a profitable use of class time even when it replaces study time.

The problem was certainly not one of maximizing "time-on-task", but was rather having enough time to

complete all the tasks that were required. Therefore, although the null hypothesis is accepted according to the results from second quarter, extenuating circumstances and lack of sufficient time could have affected the data.

There was a statistically significant difference in the first quarter examination scores between students who took the review quizzes and those who did not. The ANOVA indicated that the review quizzes had a positive effect on the retention of mathematic skills in problem-solving for chemistry. The null hypothesis is rejected according to first quarter results. This data supports previous research that indicated that testing is a superior way to enhance retention. Formal written testing does promote greater student retention of learned concepts (Gay and Gallagher, 1976). Tests are practically effective although they are often distasteful to students and educators alike.

Halpin and Halpin (1982) determined that when students expect a test they will put forth their best effort. Testing elicits and sustains study behaviors that result in higher achievement. Students "work harder, learn more, and remember longer what was learned" (p. 37). Testing facilitates what Rothkopf (1974) called mathemagenic behavior - attending behaviors that give birth to learning.

This study also supports the previous study by Peterson et al. (1935) which showed that repeated reviews are more effective than single reviews. Additionally, the present study indicates that the review quiz can be valuable to the teacher because it provides systematic feedback of what topics need further development, as previously determined by Godfrey (1979). The review quizzes were very useful to the researcher by identifying the mathematic concepts that were causing the most problems to the students.

A 2 X 2 factorial analysis indicated no statistically significant effect on performance by gender first quarter, but gender did produce a significant difference on test scores during second quarter. Females scored better than males in both the experimental (with review quizzes) and control (no quizzes) groups. Second quarter, females with the review quizzes did not score as high as females in the control group. Males with and without review quizzes had approximately the same average scores.

The significance of sex differences on test scores was surprising. The results of this study indicate that girls are succeeding in achieving equal or better test scores requiring mathematical skills.

In Lynn Fox's report to the Ford Foundation The Problem of Women and Mathematics (1981) she cited research indicating that boys have frequently performed

better than girls in mathematics. However, she did suggest that girls could be encouraged to develop their mathematic potential through early support at home and reinforcement from educators and society at large. The results of this study contradict previous research studies on sex differences and science achievement which indicate that males perform better than females in science examinations requiring mathematical skills (Ebbeck, 1984, and Jones and Wheatley, 1988). It appears that females may be receiving the encouragement to succeed in science fields.

Nonminority students were found to score significantly higher than minority students first quarter in a 2 X 2 factorial analysis. The same analysis of variance second quarter did not indicate a significant difference for nonminority students. Achievement of minority students is a concern of all educators, and it is a major concern of educators in districts with a high percentage of minorities. High schools are not adequately preparing minority students for college science curricula (Sells, 1978). This study supports previous research that indicated that minority students score lower on important tests than do nonminority students (Atwater, 1986).

Harrison High School is attempting to prepare more minority students for careers in science and mathematic related fields through a program called MESA

(Mathematics, Engineering, Science Achievement). MESA identifies high potential minority students who are interested in mathematics and science. These students are then given the opportunity to learn more about career opportunities through field trips, guest speakers and summer programs. MESA students are also provided counseling and instruction in college applications and admission requirements, interview skills, and financial aid. Hopefully, programs such as MESA will result in the improvement of test scores of the minority students.

A 2 X 3 factorial analysis for the effect of grade level on test scores determined that grade level did not affect the test scores either first quarter or second quarter. The nonsignificance of grade level on performance in chemistry calculations is an important factor to consider. Students traditionally take Chemistry I in the eleventh grade; the high number of eleventh grade students in this experiment supported this. However, tenth grade students who are highly motivated and have an adequate background in science and in algebra are permitted to enroll in Chemistry I at Harrison High School. Some chemistry teachers do not support the policy of allowing tenth grade students to take chemistry, but this study indicates that tenth graders can perform as well as older students, at least in the comprehension of mathematic applications. This

study contradicts the data of Gagne (1969) which indicated that older students have superiority in recall abilities.

There were a number of factors that may have influenced the results of this study. These included: 1) the inability of the researcher to randomize the subjects, 2) differences in length of class periods between the two quarters of the study due to unexpected changes in scheduling, 3) inevitable variations among the classes such as class size, time of day, or composition by gender or minority groups, 4) differences in motivation of the students in the classes, or 5) a possible inaccurate assumption that the students had actually learned the previously presented chemistry calculations.

The inability to randomize the subjects was noted before the experiment began. Because this is a threat to internal validity, the researcher attempted to minimize this effect by performing the experiment twice and collecting data from two experimental groups that also alternated as control groups.

Recommendations

Retention is a vital part of a student's success in all areas of education. Additional research should be conducted to clarify the effectiveness of the various methods of improving retention. Although the null hypothesis is rejected from the results of the

experiment performed during first quarter, it is rejected due to the data from the repeat of the experiment second quarter. This indicates that the experiment should be performed again. Should further studies be conducted, it is recommended that:

1. The researcher should randomize subject selection.

2. Any gross differences between the experimental and the control groups should be minimized or eliminated. This would include such considerations as length of class periods, grade levels of students, racial mix, and gender.

3. Increase the sample size for both the experimental and control groups. At the same time, be certain the groups are equivalent in size. Not only does this improve the validity of the study, but it also strengthens the statistical analysis.

4. Select a setting for the study that would minimize attrition and student absenteeism.

5. Use a standardized test for the pretest and posttest if one is available.

6. Explore the variations possible in the parameters such as the frequency of the review quizzes, the format of the quizzes, or the use of the mastery concept, where students would be required to solve the problem correctly before progressing to the next level of competency.

7. Develop some type of motivation or rewards for students to ensure that they are giving maximum effort to the review process. Alesandrini and Rigney (1981) employed an interestinng, but impractical, motivational technique. As an incentive for college students to do their best on a posttest, the students were promised they would be paid $3.00 if they scored 70 per cent or better. The researcher has used stickers, food, and special privileges as rewards for good performance.

8. Enlist the cooperation of several teachers in different schools in the same school district to perform the study. The results would indicate if a revision was needed in the curriculum to allow more class time for review and testing.

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