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ABSTRACT

This study sought to determine a useful frequency for refreshing students' memories of complex procedures that involved a formal computer language. Students were required to execute the Microsoft Disc Operating System (MS-DOS) commands for "copy," "backup," and "restore." A total of 126 college students enrolled in six sections of a computer literacy course were randomly assigned to one of three groups: biweekly reviews, monthly reviews, and no reviews of these commands. A comparison of pretest and posttest scores indicated that the control group (no reviews) retained little of what they had learned, while the biweekly and monthly groups retained much of what they had learned. The monthly groups retained as much as the biweekly group, suggesting that monthly reviews are sufficient to significantly improve the long-term retention of complex procedures. An appendix provides instructions given to students participating in the study. (Contains 27 references.) (MDM)

Running head: REFRESHING MEMORIES FOR PROCEDURES

The Determination of A Useful Frequency for Refreshing Memories for Procedures Among a Collegiate Population

May 27, 1997

by Franco Zambon

Abstract

Educators did not know the frequency at which to refresh their students' memories of complex procedures that involved the translation of statements in English into statements in a formal language. The data comprised post-test scores (on MSDOS) from matched students of computer literacy (Southern liberal arts college) who were randomly assigned to three groups (N=30 per group, mean age 23.5, 83 percent females, 74.4 percent whites). Each group received reviews, but at a different frequency (biweekly, monthly, or never). Afterward, everyone rested for at least 21 days. The researcher accepted the following alternative hypotheses. The biweekly group and the monthly group retained more than the control group (orthogonal test subsequent to ANOVA, $p<.01$). The control group retained little of what they had learned (matched-groups t-test $p<.01$). One null hypothesis was not rejected. The monthly group retained as much as the biweekly group (orthogonal test subsequent to ANOVA, $p>>.05$). One month is a worthwhile period between refreshers.

The Determination of A Useful Frequency for Refreshing Memories for Procedures Among a Collegiate Population

The problem is that educators do not know the frequency at which to refresh their students' memories for complex procedures that involve the translation of statements from English into statements in a formal language.

Formal Language

This study involves procedures to translate problems posed in English into statements in a formal language, such as, mathematics or a programming language.

When trying to solve a mathematical word problem, the student must read English words and translate some of the meaning of the English sentence into a mathematical sentence. The student reads words, recalls the mathematical equivalents, recalls the syntax that mathematics demands, and writes the mathematical sentence. Similarly, when trying to express computer commands, the student reads English words, recalls the programable equivalents in the computer language, recalls the syntax that the computer language demands, and writes the commands in the computer language. The translation from English into a formal language involves a cognitive component as well as both continuous and discrete motor components. Mathematics and programming languages are in such ways similar.

Mathematics and any programing language are specific and restricted languages. In a specific language each word in the vocabulary of the language corresponds to only one meaning. In a restricted language the language describes only certain facts and no others. A specific and restricted language that contains rules by which the vocabulary may be arranged or rearranged is called a formal language. The formal language usually consists of a set of symbols subject to permutation and rearrangements as the rules allow. The set of these rules is called the syntax of the formal language. The manipulation of these symbols according to the rules produces a correct result. The purpose of a formal language is to avoid the ambiguities and contradictions of natural languages, such as English. Mathematics and any programing language are examples of formal languages.

For a formal language, this study uses the Microsoft Disk Operating System (MSDOS version 4.01). It is a specific and restricted language. Furthermore, the conclusions derived from this formal language can be tested on machines. The student's approach to the translation of English commands into MSDOS commands is similar to the student's approach to the translation of English sentences into Mathematical sentences. Moreover, the student's answers can be assessed by machine, in doubtful instances.

Many college students attempt to learn and retain procedures in the following way. They attend their classes, listen to their instructors, take notes, complete their exercises, review their work for teacher-made or standardized tests, and complete tests. They later repeat the cycle with

new topics. Before their final exams they review the topics. Eventually they complete tests of retention on all of the topics. The tests essentially measure the students' commitment of learned procedures to their long-term memories. Unfortunately, the scores on these tests of their long-term learning often disappoint students, as well as instructors. What would facilitate the long-term retention of memories for complex procedures?

Spaced Practice and Complex Procedures

> The National Research Council (1991: 30) concluded the following about spaced practice. . . . . Given the benefits of spaced practice and the fact that those benefits have been known to researchers since the beginning of controlled research on human memory. . . . one would expect that spaced repetition would be a major component of modern programs of training and instruction.

Nevertheless, primary sources of studies about the long term retention of memories for procedures failed to provide some approximate frequency for the refreshment of memories.

In their review of what is remembered from knowledge taught in college, Semb and Ellis (1994) noted the sparsity of research on the long-term retention of learning. Additionally, they expressly omitted the long-term retention of procedures from their library research. The literature contains little on the retention of complex procedures — procedures that place demands on the individual's information processing or memory and that comprise a cognitive component as well as both continuous and discrete motor components. Wofle (1983, 1987) provided some of the scant evidence about the benefits of spaced practice of mathematics as it occurred outside the laboratory. (Mathematics requires the use of complex procedures.) He conducted a longitudinal study of subjects from their high school graduations to seven years later.

> . . . from 1972 to 1979, overall mathematics scores tended to decline . . . . The statistically significant net difference found between those individuals who completed a B.A. degree and those whose formal education ended with secondary schools was largely a function of the college degree recipients maintaining 1972 levels, while the high school graduates retrogressed.

The repetition provided by college courses had enhanced the retention of some students' mathematical procedures.

Each of the few reports that did deal with the retention of memories for complex procedures had distinguishing limitations, assumption, or definitions. Still, the literature might be interpretable. The learning and the retention of procedures requires the learner's completion of Piaget's preoperational, developmental stage. The preoperational stage ends at approximately 7 years of age. Geary (1994) and Lapointe et al. (1992) advise the teaching of procedures to remedy the deficiencies of American children who will complete assessments when the children reach 13 years of age. So, College students, certainly have an appropriate level of cognitive development for the learning and retention of complex cognitive memories.

The International Assessment of Educational Progress offered an impression of the importance of procedures in mathematics for 13 year olds. When writing about mathematically disabled students, Lapointe, et al. (1992) wrote the following.

> In looking for ways to improve students' mathematics performance, more and more educators are focusing as much on mathematical processes that the students must use as on the content of the specific topics. Mathematics specialists in many countries are now recommending that teachers increasingly focus on process skills through problem-solving, communication, and reasoning tasks.

On the same topic, Geary (1994) recommend as follows.

> Because there does not appear to be a long-term cognitive or neuropsychological deficit underlying these delays in procedural use, no special remediation techniques are likely to be needed for most of the children.
>
> Rather, any remediation attempts should be directed toward facilitating the development of the child's procedural skills. . . .

Recommendations to teach students procedures might be important for pre and post-baccalaureate individuals, as well as, for grammar school students. Repeating studies in mathematics did seem to help college students retain high school procedures. Unfortunately, the review of the literature failed to provide the frequency at which to refresh the memories for procedures, of any students.

Importance

The International Assessment of Educational Progress revealed that the 13 year olds of the United States ranked fourteenth in mathematics, among fifteen nations (Lapointe, et al., 1992). The National Educational Goals Panel (1994-1995:37) reported that only 16 percent of 12th graders met the standards set for their grade and that the increase from the previous year was not significant. The national mean scores — even for college graduates — on many standardized achievement tests have disappointed educators, businessmen, and legislators (Bryant, 1994-95). This has led to potentially powerful lobbies or special interest groups to push educators to produce students who retain more learning than the students currently retain.

Long-Term Interval

The length of the intervals between the sessions of practice seems to be somewhere between ten and 31 days. In a study of offshore oil field workers using quarterly reviews, Zambon (1988) found that those individuals maintained their factual knowledge above their pre-test scores but below their post-test scores. They eliminated 92% of their mistakes. They were assessed after a resting period of three months. On the other hand, Zambon (1992) found that a sample of 230 sophomore and junior college-preparatory students missed 56% of an achievement test composed of fifth grade level mathematics questions, questions the answering

of which required the student's recall of procedures. The initial use of a computer assisted instructional (CAI) package followed by a summertime, monthly refreshers were found to reduce these students' errors by 30%, overall. They were assessed after a resting period of 30 days. Such a difference in the amount of long-term retention of facts and the long-term retention of complex procedures might be explained by the results of Driskell, Willis, and Copper (1992). They reported a reduced retention of the cognitive components of a task over the physical components of a task. Further, Mengelkoch, Adams and Gainer (1971) added that discrete responses are less durable than continuous responses.

The literature offered little information about the rate of an individual's deterioration of long-term memory for procedures. A graph of an individual's retention of knowledge over time displays a negative acceleration (Hagman & Rose, 1983). Semb, Ellis, and Aranjo (1993: 309) concluded the following about the shape of the curve of retention from their data: "The shape of the curve is consistent with the negatively accelerated shape of retention curves found in laboratory studies dating back to Ebbinghaus . . . ." Of the kinds of measures of long term-memory, the measure that deteriorates least has been the individual's savings. Historically, the typical curve of the plot of savings versus time has been found to be essentially parallel to the abscissa at approximately ten days — and flatter still at twenty one days (Ebbinghaus, 1913; Morgan & King, 1971).

Experimental Design

Usually, studies of retention (the change of performance due to the passage of time) purposely raised the initial performance of their groups. The groups were assessed after a resting period. As for the design of the experiments, Wildt and Ahtola (1978: 15) noted the following.

> In general, direct experimental control is considered preferable to analysis of covariance if an experimenter's principal interest is in reducing the experimental error. . . . Randomized block analysis of variance requires less restrictive assumptions than does covariance analysis. . . . The randomized block design is essentially a function-free regression that is appropriate even though the relationship between the dependent variable and the extraneous variable is non linear.

Fitz-Gibbon and Morris (1987: 73, 94, 150) asserted that analysis of covariance not only must meet "rigorous assumptions," but also, is of "controversial value." They further stated that blocked randomization is the best method to use when the number of participants is small. So, a randomized complete block analysis of variance offered the safest and most sensitive way to compare the values of the dependent variable.

In summary, the information from the literature is only suggestive. The literature suggests that almost all forgetting occurs well before the first 21 days after learning. It suggests that spaced practice improves the retention of long-term learning. Information about retained memory for complex procedural tasks is almost non existent. To complicate the issue,

researchers in the field of instruction have discerned that some procedures that hinder an individual's initial acquisition of learning might improve the individual's long-term retention of learning (National Research Council, 1991:49; Schneider, Healy, Ericsson, & Bourne, 1995). Indeed, the literature can only induce heavily qualified speculations because researchers often adapted quasi-experimental designs to their situations. Consequently, an experiment to examine the effects of several frequencies of spaced practice seems needed. What is an efficient frequency at which to review the students' previous learning in order to improve their long-term retention of the learning?

Purpose

The purpose of this research was to contribute to educational knowledge about an efficient spacing of refresher programs. The following comprises the research hypotheses. The second and third hypotheses constitute the core of the research.

1. Refreshers help students to retain their memories for procedures.

2. A rate of refreshment of once per two weeks corresponds to a higher percent of recall than does a rate of refreshment of once per four weeks.

3. The post-test mean of each group but the control group surpasses its group's pre-test mean.

Variables

For this experiment the independent variable is the frequency of the practice. The dependent variable is the score on the last test on a particular set of MSDOS commands. In writing about what is retained long-term in classrooms, Semb and Ellis (1992) propose other variables that might affect the long-term retention of learning: degree of original learning, the tasks to be learned, the characteristics of the retention interval, the method of instruction, the manner of testing, and individual differences.

Accordingly, the current experiment should provide each student with a high degree of original learning within a generous conditioning period. Each student should attempt to learn the same procedures. Computer assisted instruction provided the same initial instruction to every participant. These tasks should require the student to process information, to recall facts, and to make decisions. Some tasks should require few decisions, and the motor components required by these tasks should be continuous. Some tasks should require many decisions, and the motor components required by these tasks should be discrete. When students receive problems for practice, each student should receive the same questions as any other student. Every student should receive no formal practice during the retention interval. Through random

assignment, each group in the experiment should experience as many spontaneous reviews as any other group. The formal methods of instruction for each group should be the same. The methods of instruction should be the same for all the participants. Random assignment should produce equivalent groups, in terms of the methods of instruction that the groups received. The conditions of the testing for learning after instruction should be the same as the conditions of the testing for long-term retention. By matching, individual differences should not have affected the results of the experiment.

Orientation

The setting for the experiment was a computer classroom. So, the experiment is naturalistic, and it corresponds to Neisser's (1978,1988) ecological approach to research. Although not concerned with the subject's consciousness, the research has a functionalist's orientation. The experiment is concerned with only dependency relationships between antecedents and consequents. The study is in accord with Summers, Peters, and Armstrong (1977: 483) that, "By way of contrast with classical laboratory experiments, natural experiments are conduced in the environment that the findings will carry over when applied to actual operations."

Null Hypotheses

The first research hypothesis implies two null hypotheses.

1a. The means of the posttests for the three conditions of memory refreshment are the same.

1b. The mean of the posttests for the groups having practiced equals the mean for the group having not practiced.

The second research question implies the following hypothesis.

2. The mean of the posttests for the group that practiced every two weeks equals the mean for the group that practiced every four weeks.

The third research question implies the following hypotheses.

3a. The pretest mean of the biweekly refreshed group equals its post-test mean.

3b. The pretest mean of the monthly refreshed group equals its post-test mean.

3c. The pretest mean of the control group equals its post-test mean.

The procedure for this experiment added reviews to two treatment groups, but at different frequencies -- once a fortnight and once a month. The procedure added no pertinent reviews to the third (control) group. After the last review, the control group reviewed other material instead. Each group rested for a period of at least 21 days. The researcher compared the means of the three groups using two-way analysis of variance without replication and orthogonal tests

subsequent to the analysis of variance. The researcher also compared the pre-test mean of each group with the same group's mean by way of correlated t-tests. These comparisons were intended to reveal whether this intervention improved some students' long-term retention of complex procedures.

Method

Apparatus

The researcher provided his students a computer assisted instructional program that taught students how to use the commands, "copy, backup," and, "restore." This program ran on IBM 386 compatible computers with color monitors and printers. The program printed the student's results on the screen after the student had completed the program. The students used the textbook, by Shelly, Cashman, and Wagoner (1992).

The researcher produced an achievement test, pretest, and posttest. The achievement test, pretest, and posttest contained questions that required the student to translate a command given in English into a command to be written in MSDOS 4.01. Each test had exactly the same questions about the above commands, although the achievement test had additional kinds of questions. The posttest was embedded in the regular not-for-credit test that the institution required at the end of the course.

The researcher then produced review sheets that had similar, but not exactly the same, questions as the pretest had. Afterward, the researcher composed additional review sheets of questions that had nothing to do with the kind of questions that were on the pre and posttests. For only the review sheets, the researcher prepared sheets with the answers printed on them. Each review sheet and each answered sheet had a distinct student's name printed on it.

Participants

This study included all of the students who were regularly (not late) enrolled students who attend computer literacy classes during weekdays during regular working hours (9 am to 6 PM) at the researcher's institution. The institution was a small, Catholic, commuter college in a Southern city. The mean score on the ACT for its traditional students was 19 as compared to a mean score of 20.6 nationally. Thirty five percent of the student body consisted of traditional students. The mean age of the individuals was 23.5 years. The racial composition of the student body consisted of the following: not indicated 4.4 percent, white 74.4 percent, Hispanic 5.6 percent, black 11.1 percent, American Indian 1.1 percent, and Asian or Pacific Islander 3.3 percent. Seventeen percent of its student body was male. The college offered undergraduate degrees in nursing, business administration, education, and biology. It offered masters degrees in education.

These participants constituted a sample of the population that consisted of regularly enrolled, daytime, weekday students of computer literacy at the researcher's institution. Some of the individuals elected a section extending from twelve o'clock noon to one fifteen on Mondays and Wednesdays. Some of the individuals elected a section extending from twelve o'clock noon to one fifteen on Tuesdays and Thursdays. Some of the individuals elected a section that extended from twelve o'clock noon till two thirty on Fridays. The course was offered in the Fall

of 1994 and the Spring of 1995. Knowledge about the kind of students who participated is knowledge about a large subset of the students of the college.

Some kinds of students were excluded from the experiment, though. Ideally, this study should have included individuals who added the course after the first day of class. Nevertheless, such individuals were excluded due to the constraints of the length of the semester and the time required for the treatments. Furthermore, only daytime students were available. Males constituted only seventeen percent of the population of the college. Knowledge about the kinds of students who participated, nevertheless, is knowledge about an important population.

The research embraced those regularly enrolled, week-day, daytime, students who could reliably complete assignments of computer literacy. This group was representative of the population under study, even though it was not randomly selected; this group contained all of the students who fit the description of members of the population.

Procedure

Learning the minimum amount of time that a typical class needed to complete the computer assisted instruction was an important preliminary step to the experiment. During the Summer term before the experiment started, the researcher confirmed that students of computer literacy could complete the initial training on the pertinent procedures well within the period allotted by the experiment.

The researcher matched students on their pretests and then randomly assigned the students of computer literacy to one of three groups (a randomized complete block design). The researcher randomly named one of the groups, the biweekly group, one of the remaining groups, the monthly group, and the remaining group, the control group. The description of the actual gathering of data for the experiment follows.

The experiment used the data that were collected over a period of two semesters, the Fall of 1994 and the Spring of 1995. On the first day of class each student completed an achievement test part of which asked the student to translate each of five English commands into a command written in the language of the Microsoft Operating System (MSDOS). These five questions were included on the paper and pencil test that the college requires as part of its evaluation of the course. Each of the five commands used: "xcopy", "backup", or "restore," and the composition of complete pathnames and the use of switches.

After the achievement test, the instructor lectured the students about MSDOS. The researcher assigned computer assisted instruction (CAI) on the topics of "xcopy", "backup", and "restore" to the students. (The printout of the last screen of the computer assisted tutorial contained the student's percent of correct answers and the student's name.) The instructor also told the students that, after fourteen days, the students would enter the classroom and complete the same CAI on MSDOS, for a test grade. The instructor assigned readings on MSDOS from Shelly, Cashman, and Wagoner (1992). Each student's syllabus restated the instructor's assignments. (The experiment accorded with the usual classroom procedures.) He directed the

students to practice the above commands on their computers. At the end of fourteen days the instructor stopped these activities.

On the fourteenth day, each student completed the CAI for a test grade, during class-time. If the student had the time, the student could repeat the CAI in order to try for a high score. Each student handed the instructor the student's last printout. The printout of the last screen of the computer assisted tutorial contained the percent of the correct answers and the student's name.

Immediately after handing the instructor the printout, the student completed a paper-and-pencil test consisting of the five items found on the achievement test and among questions in the CAI. The student could use only his recall for this paper-and-pencil test. This paper-and-pencil test was called the pretest. Upon completing the pretest, the student could leave the classroom.

After the students' completion of the pretest, the instructor advised the students intermittently to review the CAI, their notes, and the section of their books on MSDOS, for the exam. (Every previous semester, the instructor had advised his students to review MSDOS, after the CAI.) The instructor intended not to review the topics covered by the CAI in any other manner.

The researcher matched his students on their pretests and then randomly assigned each of them to one of three groups. The researcher named one of the groups the biweekly group, one of the remaining groups the monthly group, and the remaining group the control group.

The instructor apprised his students that after two weeks the instructor would, from time to time, sample the usefulness of their notes. To save time, they were told, the instructor would give different questions to each group. Thereby, each group would receive only a few questions to answer. The concomitant purpose of the problems, the experiment, was not revealed to them.

Each set of problems corresponded to the requirements of the student's group. After intervals of 13 days, during class time, each student received a set of problems with the student's name already printed on the student's paper. The individuals received five sets of problems over a period of 56 days.

The students in the biweekly group received a set of five problems of the kinds found in the achievement test. The order in which these kinds of problems were listed on the paper was changed from session to session. The number of subdirectories stated in the problems was sometimes changed as was the requirement to include subdirectories as well as files. The name of the student was printed on the student's paper.

After intervals of 13 days, during class time, each student in the control group received a set of five problems taken from the topics that their latest test covered. The name of the student was printed on the student's paper.

Each student in the monthly group received problems after intervals of 13 days, during class time. On the first and thereafter every other occasion the student received the same problems as the biweekly group received. On the second and thereafter every other occasion, the monthly group received the same problems as the control group received. The name of the

student was printed on the student's paper. See Appendix A for the oral directions for the treatments.

To solve these problems, the students could use only their notes. They were directed to work silently. As each student finished, the instructor collected the attempted problems. Upon collecting each paper, the instructor handed the student an appropriate sheet of correctly answered problems. Upon receiving the answers the student was directed to correct his or her notes and to work on the current topic of the syllabus. No oral discussion of the problems followed. Instead, instruction on the then current topic followed quickly as possible. The instructor telephoned absentees in order to treat them on the very next day. Absentees who could not receive treatment on the very next day were removed from the experiment, although they continued to complete their sets of problems. Students who had been matched with the dropped participants were also dropped.

Throughout the course, the instructor orally answered any question that any student presented him, but he did not plan to review the topics covered on the achievement test.

After the last treatments, each group received no further formal instruction on the three MSDOS commands. To test their long-term retention, the individuals received the same five problems from their achievement tests, at the end of the semester. The periods from the last treatments to the tests of long-term retention were foreseen to vary from 21 to 28 days. These last tests were called the posttests.

Any student who enrolled in one of the experimenter's classes after the first day of class was removed from the collection of prospective individuals. The remaining students were ordered by their pretest scores and secondarily by their scores from the computer assisted instruction. If the number of students could not be evenly divided by three, enough students were randomly discarded to reach a number that is divisible by three. While going down the list in order, sets of three consecutive students were formed. The students in each set were randomly assigned to a distinct group.

The various posttests were sorted according to the groups of participants. Two-way analysis of variance tested the hypothesis 1a (α=.05). Orthogonal tests subsequent to the analysis of variance tested hypotheses 1b, and 2 (α=.05). The matched groups t-test of the difference between means was used to test each of the hypotheses: 3a, 3b, and 3c (α=.05).

Contamination

Contamination occurs in every course. Some students discuss and share whatever the instructor presents to them, as they should do. Most would review their work at the end of the semester. This experiment examined whether or not the imposition of extra, spaced reviews among some individuals improves their long-term retention under usual conditions. No discussion occurred among the individuals while they completed their worksheets nor while they subsequently corrected their notes. The experiment did not concern itself with the actions of the students outside of the treatments. The experiment concerned itself with the spaced reviews

imposed on the usual actions of the class. A significant difference between the treatment and control groups should reveal the negligibility of the contamination outside of the treatments.
Schedules

Results

Over two semesters, 162 individuals were registered for six sections of computer literacy. Of the total, 30 individuals failed to undergo the scheduled treatments on time. Two individuals were dropped because they completed the wrong version of the CAI. Four individuals were dropped because they lacked a match. One hundred twenty six individuals were randomly assigned among three groups.

The 42 individuals initially assigned to the biweekly group earned a mean of 3.59 and a standard deviation of 1.76 on their pretest scores. The 42 individuals initially assigned to the monthly group earned a mean of 3.66 and a standard deviation of 1.71 on their pretest scores. The 42 individuals initially assigned to the control group earned a mean of 3.57 and a standard deviation of 1.68 on their pretest scores. Through the attrition of some of these individuals, their matches were also removed from the experiment. Thirty individuals (30) survived in each group.

After attrition, the biweekly group earned a pre-test mean of 3.7 with a standard deviation of 1.62. After attrition, the monthly group earned a mean of 3.6 with a standard deviation of 1.68. After attrition, the control group earned a mean of 3.63 with a standard deviation of 1.68. The assertion that the pre-test means were equal was not rejected, at the five percent level of significance. Two-way analysis of variance produced an F-ratio of .02.

The number of days between the last treatment and the posttest for each group follow: for Fall 1994; the Monday-Wednesday section, 28 days; the Tuesday-Thursday section, 28 days; the Friday section, 28 days; for Spring 1995; the Monday-Wednesday section, 23 days; the Tuesday-Thursday section, 26 days; the Friday section, 21 days.

Tests of Hypotheses

The first research hypothesis was structured to query whether the means of the posttests for the three conditions of memory refreshment were equal. For the treatments, two-way analysis of variance provided an $F(2, 58)$ of 14.0, which was significant at the one percent level ($p<.01$). (See Table 1.)

The mean of the posttests for the groups having practiced equals the mean for the group having not practiced. An orthogonal test subsequent to analysis of variance provided an $F(1,58)$ of 27.79, significant at the one percent level ($p<.01$).

The mean of the posttests for the group that practiced every two weeks equals the mean for the group that practiced every four weeks. An orthogonal test subsequent to the analysis of variance provided an $F(1, 58)$ of .204, which was not significant at the five percent level ($p>.05$). The proportion of the variance accounted for by the between groups effects was .224.

Table 1

Comparison of Means from the Biweekly, Monthly, and Control Groups by Analysis of Variance

Source	df	F
Treatment	2	14.0*
Block	29	
Residual	58	(2.03)
Contrasts		
Treatments vs control	1	27.79*
Biweekly vs Monthly	1	.204

Note. Values enclosed in parentheses represent mean square errors.
*p<.01.

So far the statistical tests revealed the following. The means of the biweekly, the monthly, and the control groups were not the same. The mean of the control group was different from the means of the treated groups. The mean of the biweekly treated group was not different from the mean of the monthly treated group. This last finding was unexpected. (The strictly arithmetic average for the monthly group was greater than the average for the biweekly group!)

The pretest mean of the biweekly refreshed group should equal its postest mean. The correlated t-test detected no significant difference between the means, at the five percent level. For the pretest, N=30, mean = 3.7, standard deviation = 1.62 and for the postest group, N=30, the mean = 3.3, the standard deviation = 1.57. The resulting t(29)=.98 is not significant at the .05 level. According to Lipsey's (1990) charts for determining statistical power, the probability of detecting a significant difference between these sample means is .93.

The pretest mean of the monthly refreshed group is equal to its post-test mean. The correlated t-test detected no significant difference between the means at the five percent level.

For the pretest, N=30, mean = 3.6, standard deviation = 1.68 and for the post-test group, N=30, the mean = 3.47, the standard deviation = 1.62. The resulting t(29)=.31 is not significant at the .05 level. According to Lipsey's (1990) charts for determining statistical power, the probability of detecting a significant difference between these sample means is greater than .95.

The pretest mean of the control group should equal its post-test mean. The correlated t-test led to the rejection of the null hypothesis at the five percent level of significance. ($p<.01$). For the pretest, N=30, mean = 3.63, standard deviation = 1.68 and for the post-test group, N = 30, the mean = 1.7, the standard deviation = 1.73. The resulting t(29) is significant at below the .01 level. According to Lipsey's (1990) charts for determining statistical power, the probability of detecting a significant difference between these sample means is greater than .95.

Conclusions

This experiment bracketed the spacing for refreshing memories for some procedures taught in the junior divisions of colleges. The recalled procedures involve the student's translations of English statements into a formal language. The test of the students' retention involved the students' transfer of learning to tasks similar to those presented in the pretests.

The means for the three conditions of refreshing the students' memories for procedures were not the same. The means of the refreshed groups significantly differed from the mean of the control group. (So, contamination did not overpower the influence of the reviews.) The control group retained less than the refreshed groups. The mean of the biweekly refreshed group was not significantly different from the mean of the monthly group. Unexpectedly, the monthly refreshed group retained as much as the biweekly refreshed group retained.

Both the biweekly refreshed group and the monthly refreshed group retained much of what they had learned. The post-test mean of the biweekly group did not significantly differ from its pretest mean. The post-test mean of the monthly group did not significantly differ from its pre-test mean.

The control group retained significantly less than it had originally learned. Lastly, the results indicate that monthly reviews nearly double the long-term retention of certain procedures that an educator may otherwise expect. One month serves as a worthwhile period between refreshers. Knowing the proper spacing of practice sessions allows instructors to guide their students to improve their retention of the student's memory for procedures.

Applying different frequencies to each group meant that each group experienced a different number of questions during the refreshers. The definition of frequency prevented the application of the same number of questions to all groups. Since the biweekly group received more questions than the monthly group, but the biweekly group fared no better than the monthly group, then a the final score of a group does not increase with an increase in the number of completed questions.

Monthly practice aids for the students improve the students' long-term retention of complex procedures. Such practice would help the students keep selected memories for procedures involving translations.

Recommendations

Instructors should advise their students to review fundamental procedures -- involving translation from English into a formal language -- every month. Instructors should provide monthly practice on such procedures for their students. Specifically, each review should include varied problems that require the student to make decisions based on the rules that the student had learned. The student should be able to use his notes (but not his textbook) while attempting the problems. Afterward, the student should receive corrected answers to for the problems.

Finally, the student should correct the notes that led the student to incorrect answers.

Administrators should direct instructors to identify which objectives require the students' monthly practice. During each course, administrators should require monthly practice corresponding to selected objectives -- those that instruments of assessing achievement measure. Such instruments might include the Graduate Record Examination, the National Teachers Examination, the Graduate Management Achievement Test, or the like.

The experiment measured the results of the treatment on a group that was below the national norm on the ACT, and the group contained mostly females, whites, and non traditional students. Research involving students who are mostly men, or who have above average ACT composite scores, or who are mostly non-white should occur.

Implementation

Many administrators already receive reports on pre-test versus post-test differences from their sections. They should direct their instructors to identify one or two questions that correspond to objectives the attainment of which requires subsequent, monthly practice. The instructors should list these objectives and report the pre-test versus post-test differences for the corresponding questions. These objectives should correspond to fundamental objectives of the college. The administration should cause the preparation of aids and schedules for the monthly refreshment of their students' memories for procedures that involve translation. The administrators should provide feedback to the faculty on the success or failure of the faculty's attempt to improve the long-term retention of their students.

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Appendix A

INSTRUCTIONS TO THE STUDENTS BEFORE THE TREATMENTS

I have some papers that I want you to complete if you can.

Every so often, I'll want to know how you are taking notes and studying them, but I don not want you to waste a lot of classtime. So, some of you will answer questions about one topic, and other of you will answer questions about another topic. You may use your notes but nothing else to answer these questions. If you can not answer some of these questions, then you are taking notes and studying incorrectly. Missing a question should lead you to change the way your take notes and study.

You can not loose points on these papers. You can only gain two points for doing your best on these assignments. Answer what you can, but don't waste time if you don't know an answer. Work by yourself.

Hand me your paper when you're through. I'll give you an answer sheet when you're finished. Please stay quiet while people are working. Continue working along with your book when you're finished.

(Hand out the papers.)

Start now.

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