DOCUMENT RESUME

ED 034 426 EM 007 592

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TITLE	An Investigation into the Differential Effectiveness for Males and Females, of Three CAI Treatments on Delayed Retention of Mathemtical Concepts.
INSTITUTION	Florida State Univ., Tallahassee. Computer-Assisted Instruction Center.
SPONS AGENCY	Office of Naval Research, Washington, D.C. Personnel and Training Branch.; Office of Naval Research, Washington, D.C. Psychological Sciences Div.
REPORT NO	TM-12
PUB DATE	15 Nov 69
NOTE	49p.
EDRS PRICE	EDRS Price MF-$0.25 HC-$2.50
DESCRIPTORS	*Computer Assisted Instruction, *Elementary School Students, *Grade 8, Individual Differences, Individualized Instruction, Learning Theories, Mathematical Concepts, *Mathematics Instruction, Recall (Psychological), Redundancy, *Retention, Retention Studies, Sex Differences, Teaching Methods

ABSTRACT

A study was developed to evaluate the effectiveness of a preinstruction retention index (designed to maximize recall of mathematical concepts by predicting the idiosyncratic number of examples per mathematical concept required by each student). Subjects, 27 female and 26 male eighth grade students, were administered a retention measure through computer-assisted instruction (CAI) and randomly assigned to one of three treatment groups, each providing similar CAI mathematical concepts and different methods of determining the number of examples per concept provided (variable, choice, or fixed). A two-way analysis of variance, with sex and treatment group as the independent variables, was performed; results showed that females in the "variable" group performed significantly better on retention measures than did females in "choice" or "fixed" groups, and that males in the "choice" group performed better on retention measures than did males in the other two groups. In addition, it was found that the use of the preinstruction index resulted in overall better retention for females but not for males, indicating the possible usefulness of such an index in mathematics instruction and a need for further research into the sex variable in retention. (Author/SP)

ED034426

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TECH MEMO

AN INVESTIGATION INTO THE DIFFERENTIAL EFFECTIVENESS FOR MALES AND FEMALES, OF THREE CAI TREATMENTS ON DELAYED RETENTION OF MATHEMATICAL CONCEPTS

Lorraine R. Gay

Tech Memo No. 12
November 15, 1969

Project NR 154-280
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ABSTRACT

The purpose of this investigation was to evaluate the effectiveness of a pre-instruction retention index. The index was designed to maximize recall of mathematical concepts by predicting the idiosyncratic number of examples per mathematical concept required by each student.

53 high-intelligence eighth grade students (27 females and 26 males) were administered a retention measure via computer-assisted instruction (CAI). Subjects were then randomly assigned to 1 of 3 treatment groups. Although all Ss received the same CAI mathematical concepts, the treatment groups varied in the method of determining the number of examples per concept each student received. The treatments were as follows:

1. Variable example--Ss were presented concepts followed by an idiosyncratic number of examples as determined by each student's score on the pre-instruction retention measure;

2. Choice--Each S was allowed to determine the number of examples received per concept;

3. Fixed--Ss were given three examples per concept.

Since sex was found to be significantly correlated with retention, a series of two-way analyses of variance were computed in which sex and treatment were the independent variables and immediate retention and delayed retention were the dependent variables.

Both analyses revealed a significant sex x treatment interaction. Females in the variable example group performed significantly better on both immediate and delayed retention measures than females in either the choice or fixed group. In contrast, males in the choice group performed better on both retention measures than males in the other 2 experimental conditions.

The use of the pre-instruction retention index resulted in better retention for females but not for males. Thus, it was concluded that use of the retention index for individualization of mathematics instruction will lead to more efficient retention for females.

Traditionally, individualization of instruction has been based primarily on differential mental abilities. Clearly, more research needs to be done in the area of sex x number of examples interactions and their implications for individualization.

INTRODUCTION

Generally speaking, retention and forgetting are two aspects of the same phenomenon; retention refers to preservation of knowledge, forgetting refers to loss of information. It is unfortunately the case that much of what is learned is soon forgotten. One of the major problems of education is, and has been for quite some time, the question of how to maximize the retention of learned material. A major objective of American education is to teach the most information in the least amount of time with maximum retention. The "knowledge explosion" of recent times has made efficient transmittal of pertinent information an even more critical issue. No aspect of instruction is more frustrating, to teachers and students alike, than the extent to which the latter "forget by tomorrow what they learn today" (Mouly, 1968). Layton (1932) found that after a one-year interval only thirty-three and one-third percent of initial algebra material was retained. Pressey et al., (1959) determined that approximately sixty-six percent of the concepts learned in high school and college courses are forgotten within two years. Findings such as these serve to underline the pressing need for investigation into this area of instruction.

Retention has been defined by Pressey et al., (1959) as "the persistence of past learnings as evidenced by the ability to use or recall them in situations similar to those in which the learning originally occurred." The rate and extent of forgetting was first investigated by Ebbinghaus (1913), whose classic forgetting curve depicts the retention of nonsense material learned by memorization. While subsequent research has shown that meaningful material is retained to a greater degree than unmeaningful or nonsense material, all retention curves are very similar, showing the greatest drop immediately after the learning period, followed by gradual losses.

In order to determine ways of improving retention, the factors affecting retention have been arduously determined and analyzed. Of course, amount of retention is dependent on the method used to assess it; a forgetting curve is much steeper for recall than for recognition. However, decline in retention and final level of retention also depend on such factors as meaningfulness of material and inter-relatedness of its components (Dawling, & Braun, 1957; Peterson, Peterson, & Miller, 1961), which in turn are a function of the nature of the material; the intelligence, experience and motivation of the learner; the degree of learning; and the amount of review. Degree of mastery emerges as the crucial factor. Much research indicates that the crucial variables in retention is the degree of original learning (Underwood, 1964).

Individual student abilities result in sizeable differences in the amount of material retained. As the literature indicates, these differences are not apparent when equivalent levels of learning are involved. If students, regardless of their learning rate, achieve the same degree of learning before the retention level is introduced, there is no evidence that their forgetting rates will differ beyond a negligible degree; what determines the rate and level of forgetting is mainly the degree of learning, regardless of the time and effort required to get the material up to a given level of acquisition (Mouly, 1968). The problem is that excessive overlearning tends to be uneconomical. Beyond a certain point further training efforts result in relatively small retention gains, especially in the case of bright students (Shay, 1961). Some researchers have expressed the opinion that if one of the goals of instruction is maximization of retention of learned information, the additional time and effort required to bring all students to a desired level may well be worth it (Dick, 1963).

The question of individual differences in retention is a significant one. The real question concerns the relative weights of such variables as intelligence and subject aptitude in contributing to variation between individuals (Gilliand, 1948). It has long been debated whether memory is a separate factor or whether it is related to the above-mentioned variables.

Traditionally, individual differences have been ignored. The possibility that different students may require different numbers of examples in order to retain a given concept has not been effectively investigated, i.e., research results have not been utilized in individualizing instruction in this respect. The number of examples received by students has typically been uniform for all and determined by the teacher or textbook.

The growth and development of computer-assisted instruction (CAI) has made individualization of instruction a reality rather than mere possibility. Using CAI, student data can be collected, stored and analyzed and instructional materials adjusted to individual differences.

Research has found a strong indication of relationship between amount of repetition and learning. The majority of reported studies are concerned with non-meaningful material and short-term or immediate retention. Such studies typically report frequency of repetition to be directly related to amount of recall and, to a lesser degree, recognition (Pratt, 1936; Murphy, 1953; Peterson, 1956, Korn, & Lindley, 1963; Boschke, & Lim, 1967). Similarly, studies investigating non-meaningful material and both short-term and long-term retention have found amount of forgetting to be a function of repetition (Kintsch, 1965; Kintz, 1965). In a study on meaningful material and delayed retention (Ausubel, & Youssef, 1965) it was found that spaced repetition significantly enhances the substantive delayed retention scores of an experimental group of undergraduates in comparison with the retention scores of a control group that does not have the benefit of repetition. Ausubel attributes the effect of repetition to the opportunity provided by another trial (a) to acquire new meanings and consolidate established meanings and (b) to test remembered knowledge against the rest. These studies suggest a linear relationship between repetition and retention. Also, the above studies use "repetition" in the definitional sense rather than in a conceptual sense.

The problem is how to determine the number of examples needed by each student. It seems reasonable to posit a relationship between intelligence and number of examples required; we would expect highly intelligent students to require less repetition than slower students. The literature, however, presents conflicting evidence on the relationship between intelligence and memory.

With one exception (Noble, 1940), studies investigating the relationship between intelligence and short-term retention of non-meaningful material have found high correlations between intelligence and retention (Maiti, 1931; Eysenck, & Halstead, 1945; Schoer, 1962; Jensen, 1965; Madsen, 1966). This is probably attributable to the fact that most in[illegible]gence tests include a subtest on immediate recall of non-meaningful material, e.g., digit span. Basu (1964) found that delayed retention of non-meaningful material was not appreciably correlated with mental ability. Studies investigating delayed retention of meaningful material have generally found no relationship between intelligence and retention. A study by Klausmeier and Feldhausen (1959) concerned with elementary arithmetic learning as usually defined in school situations reported no significnat differences among the means of three IQ groups ($p < .05$). The authors concluded that retention is the same for all levels of intelligence. In a similar study, Klausmeier and Check (1962) investigated retention and transfer of arithmetic learning for three levels of intelligence. In both relearning and transfer and at time intervals of five minutes and seven weeks, no significant differences among the three IQ groups were found ($p < .05$).

Thalberg (1967) found that immediate retention differences between students of different reading rates disappeared under delayed retention conditions. An explainable exception to the above findings are the findings of Alter (1963) who reported that intelligence bore a significant, positive, though small relation to retention of mathematics material at the junior and senior high school level. It appears that, in general, intelligence is not related to retention. For more difficult tasks intelligence may be slightly related to retention but it is impossible to draw this conclusion based on one study.

Studies on individual differences in retention have only been initiated within the past fifteen years. The results of analyses by Stroud and Schoer (1959) suggested no more than a slight relationship between rate of learning and recall. In another aspect of their study, the authors found that significant differences in retention do exist among subjects who have achieved a common trials-to-learn criterion. The relationship between sex and retention has not been adequately investigated. Dietze (1932) found that in general boys were better on factual memory though not markedly so. In contrast, Layton (1932) found that girls were slightly superior to boys on measures of delayed retention on algebra. Revay (1938) also found that girls were rated higher in memory.

It is apparent that no generalization can be formed regarding the superiority of either sex in relation to retention. Previous research results do suggest, however, that delayed retention of meaningful material is directly related to the repetition involved in the original learning, that intelligence has been shown to be related to retention only in the case of short-term retention of non-meaningful materials.

The present study was conducted to compare three methods of presenting a unit of mathematics in order to determine which method resulted in the most efficient retention of material as measured by a delayed criterion measure. The three methods under study were: (1) Variable example method (VE)--determining the idiosyncratic number of examples needed by a student per mathematical concept (taught via algorithms) as determined by a pre-instruction retention index (the GRI--Gay Retention Index); (2) Choice method--allowing students complete choice during the instructional period of the number of examples to be received per mathematical concept; and (3) Fixed method--presenting each student with a constant number of examples [3] per mathematical concept.

It was hypothesized that due to the individualizing of the instruction the VE group would perform better on both immediate retention (IR) and delayed retention (DR) than Ss in either of the other experimental groups. It was also hypothesized that the variable example group would make fewer errors on response frames as a result of the belief that (1) the choice group would tend to underestimate the number of examples needed for concept mastery, and (2) three examples would not be enough for the majority of Ss in the fixed group. The rejection level for the above hypotheses was set at = .05.

METHOD

Subjects

This study was conducted at the CAI Center at the Florida State University. Fifty-three eighth grade students currently enrolled at the University School were the Ss for this study. All but one of the Ss had a measured intelligence rated as average or above. The range of Beta IQs (conversions of the OTIS raw scores) was from 91 to 129 with a mean of 115. While subject selection was not random, assignment to treatment group was random, and, although the Ss are in some sense a population unto themselves, it is the author's belief that they are representative of above-average eighth graders. Furthermore, the homogeneity of the Ss with respect to intelligence was desirable in light of the fact that intelligence was not included as a factor in this study.

Procedure

The retention index (GRI) was developed in the following manner. Approximately thirty high school mathematics texts (elementary and advanced) were secured. From these sources forty concepts were selected, these forty being a representative sample of all areas covered in the texts. Concepts were selected on the basis of two criteria:

1. Non-familiarity--care was taken to select concepts for which most eighth grade Ss would have no previous knowledge.

2. Serviceability--serviceability is used in the sense that the concepts, while coming from an area unknown to the Ss, could be learned independently of any entry skill, i.e., the concept selected were non-hierarchical in the sense that they could be learned in and of themselves.

The concepts selected were randomly ordered and a criterion test was developed. The test consisted of one item per concept; items were of the recall-type requiring the filling in of the appropriate term or a computation using the appropriate formula. The criterion test was administered to a high ability (as defined by the school) group of eighth graders at Augusta Raa Junior High School. Since the entire population of eighth graders at the University School was required for the actual study, it was felt that a high ability group of eighth graders from another junior high school would make a reasonable validation group for the GRI. Any test item, to which more than five percent of the students responded correctly, was eliminated from the criterion measure. The result was a thirty-item criterion measure.

Following the validation procedure, the GRI was developed, coded and entered on the 1500 system at the CAI Center. The GRI was developed by randomly dividing the thirty concepts into five groups. For each concept in the first group, three frames were written:

1. A frame presenting the concept,
2. A frame showing an example, and,
3. A frame requiring the Ss to demonstrate recall of the concept. The concepts in each of the other four groups had the same general format, i.e., presentation of concept, example, response frame. However, each concept in the second group was presented with two examples, each concept in the third group was presented with five examples, the fourth group with ten examples, and the fifth group with fifteen examples. The specific numbers of examples selected (i.e., 1, 2, 5, 10, 15) were chosen in order to provide finer discrimination for smaller numbers of examples. It was felt that including fifteen examples would eliminate the possibility of a ceiling effect. The program was presented with the concepts in a random order. The maximum time required to take the program was found to be one hour. The instructional unit was then developed and entered on the 1500 system. The instructional unit selected for presentation was polynomials.

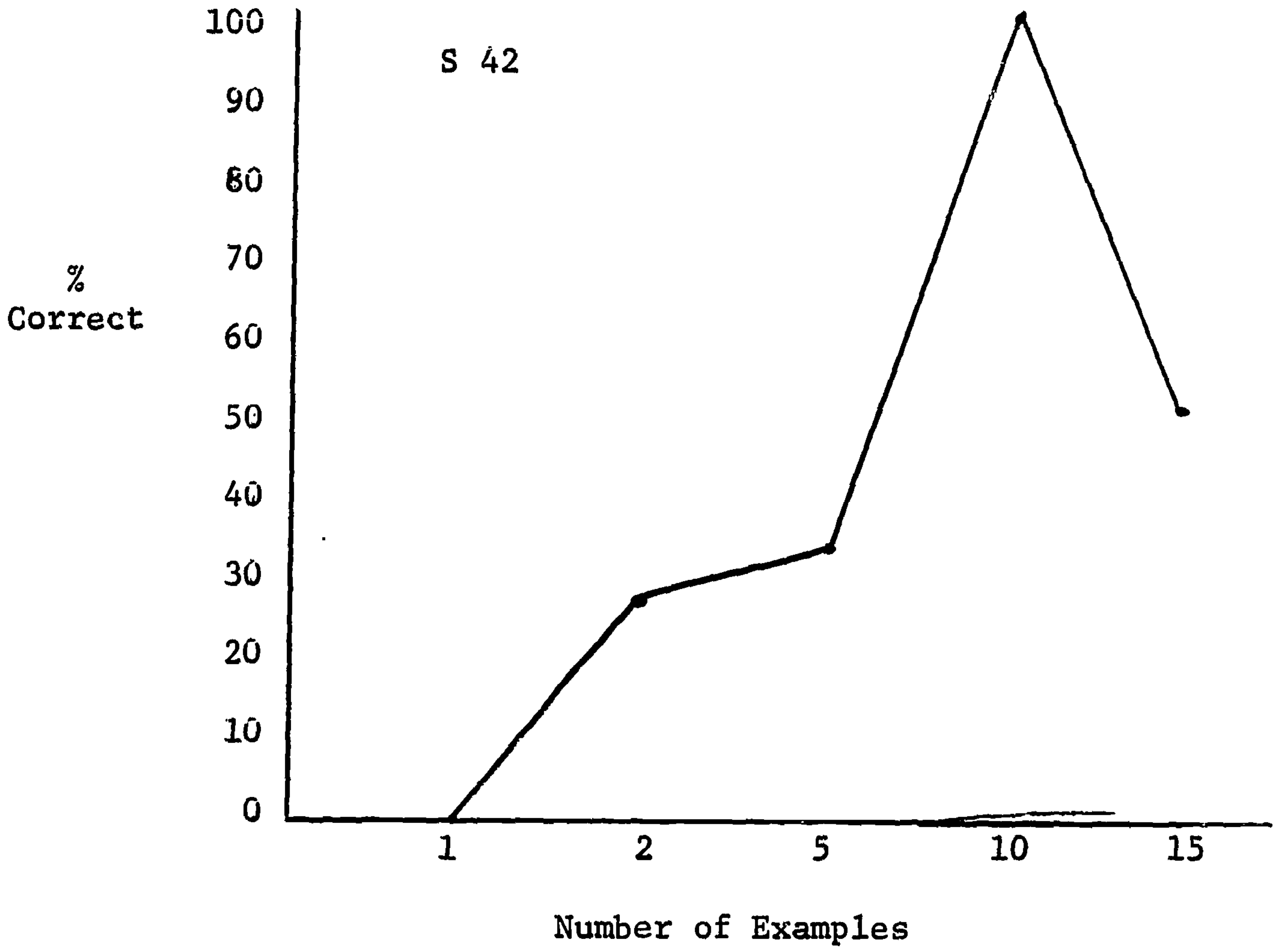
The main reason for this choice was the fact the author had previously written a programmed text on polynomials which had been judged successful by a ninth grade teacher at Augusta Raa Junior High School who had used it in one of her classes. Secondly, it was determined that polynomials was an area not yet covered by the University School Ss but was an area for which they possessed the necessary entry skills. The program consisted of a total of twenty concepts on polynomials. These concepts were presented in the format described for the GRI, i.e., presentation of concepts, examples, and response frame. Fifteen examples were written for each concept; the logic of the program, however, allowed for each student to have a different number of examples as determined by the treatment to which he was assigned. Immediate and delayed criterion measures were developed for the program using items comparable to response frames in the instructional program. The immediate and delayed criterion measures were identical except for the actual numbers used.

The fifty-three Ss went through the GRI at the CAI Center in groups of twelve and thirteen. One week later the Ss were administered the GRI criterion test. Twenty-one of the Ss were randomly selected to be in the variable group. For these selected Ss, retention curves were plotted from the GRI criterion test scores. Figure I demonstrates four typical curves. The vertical axis is the percent correct on the GRI criterion test and the horizontal axis shows for which number of examples this percent was achieved. For example, S 51 correctly recalled: None of the concepts which were presented with one example, twenty-five percent of the concepts which were presented with two examples, sixty-six percent of the concepts with five examples, seventy-five percent of the concepts with ten examples and fifty percent of the concepts with fifteen examples. The pattern shown by the Ss in Figure I held for all the data graphed. A retention peak was reached at five or ten examples followed by a decline. This held true regardless of the maximum percent of retention (which ranged from thirty-three to one hundred percent). On the basis of the curves the optimal number of examples for each S in the variable example group was determined. For example, it was determined that S 51 required ten examples. The remaining thirty-two Ss were randomly assigned to one of two groups, the choice group and the fixed group.

Two weeks later the Ss were administered the polynomial program. Ss in the variable example group were presented each concept followed by the idiosyncratic number of examples which had been determined by the GRI, followed by a response frame. Students in the choice group were presented with a concept and an example and were then presented with an option to see another example. They had latitude to choose to see a maximum of fifteen examples. At the point at which an S chose not to see another example he was branched immediately to the response frame. Ss in the fixed program were presented a concept, three examples and were then branched to the response frame. This group was instructed in the manner typically adopted by traditional instruction, with every S receiving the same number of examples. All fifty-three Ss received exactly the same instructional material, differing only in number of examples received.

Figure I

Delayed Retention Curves for Four Ss



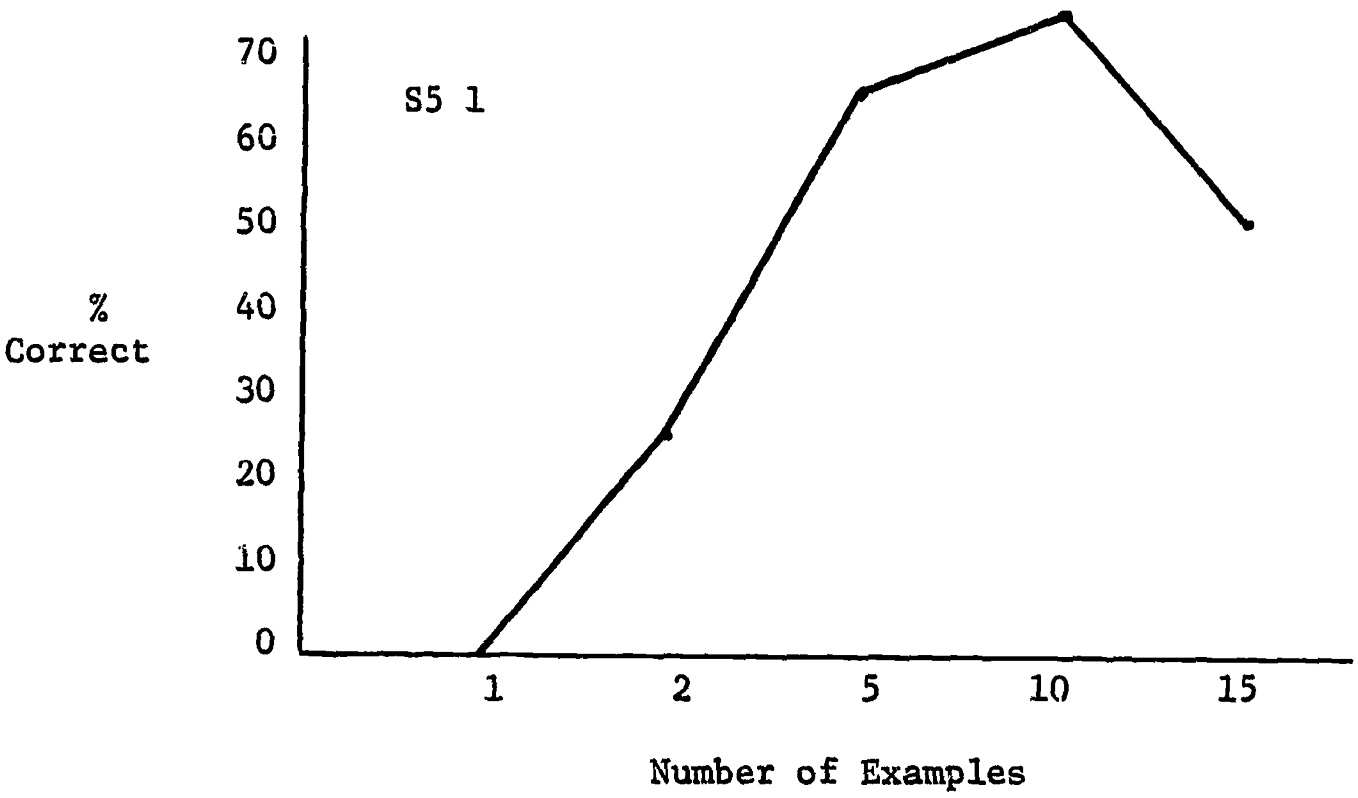
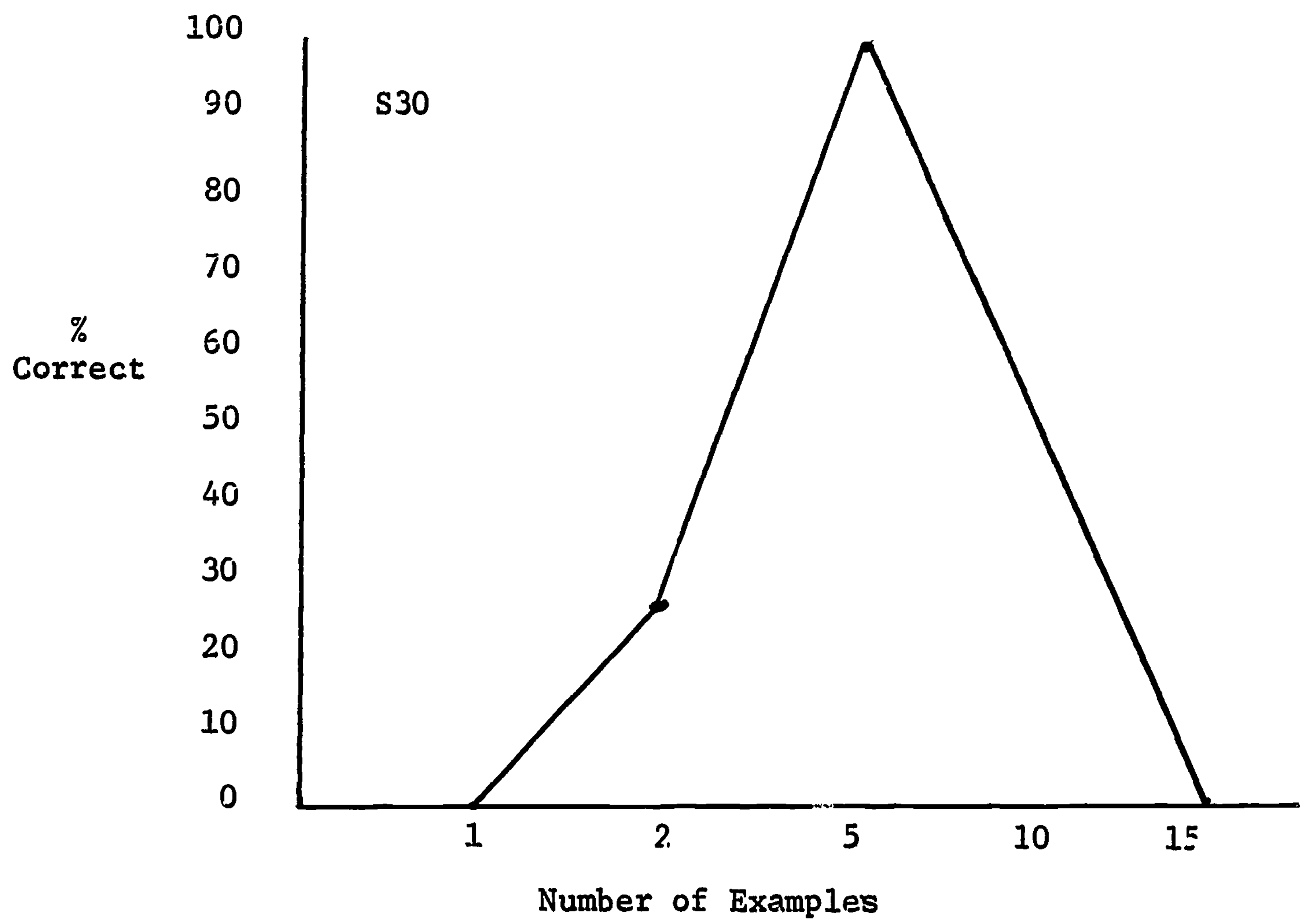
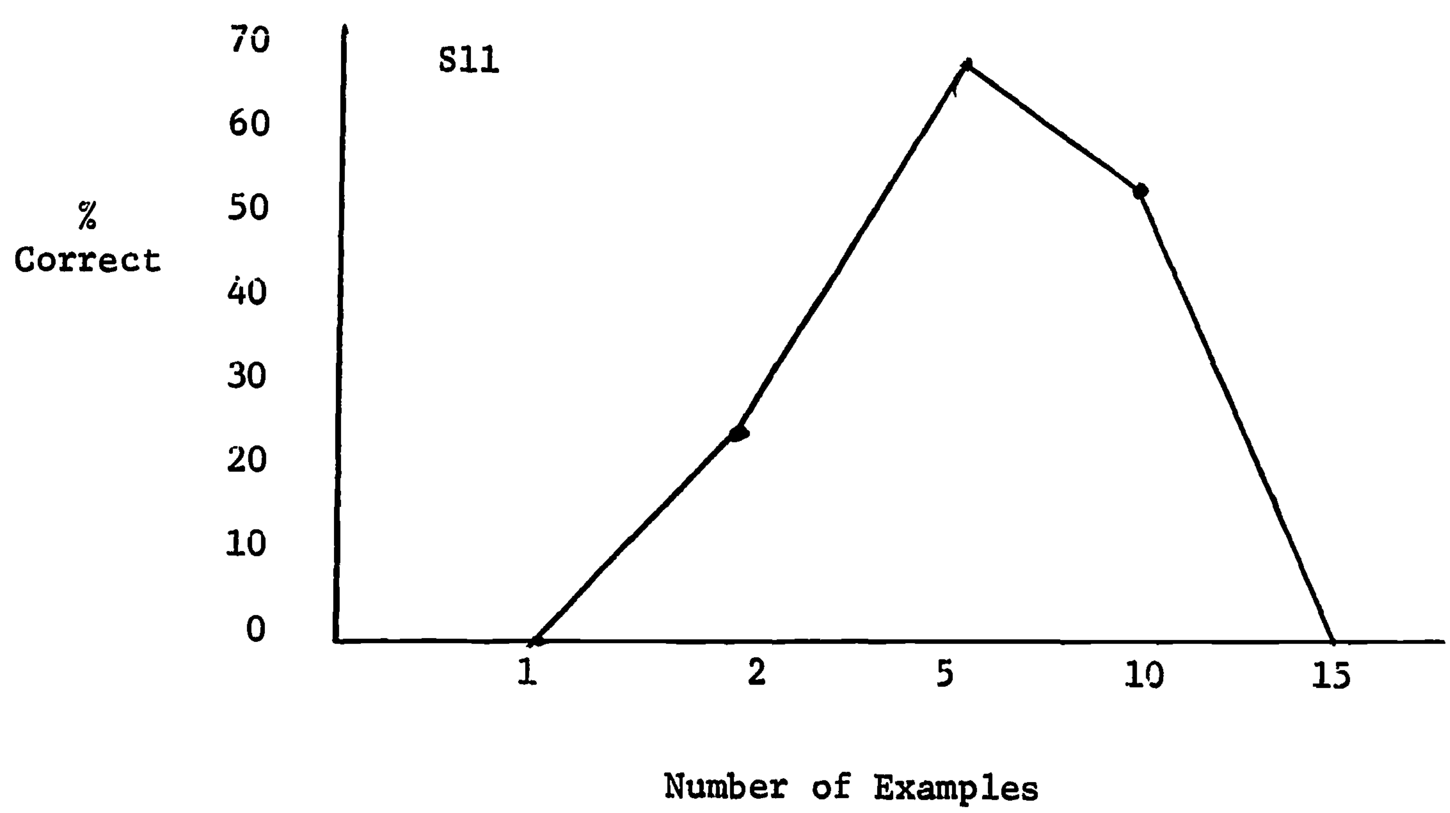


Figure I (Continued)

Delayed Retention Curves for Four Ss





It took each S three days to complete the program. The program was divided into three parts so that Ss could take the program during their regularly scheduled mathematics period. Due to the nature of the treatment groups some Ss finished each session sooner than others; there was a maximum of one hour per session. At the conclusion of each session the Ss were administered an immediate criterion measure on the material covered during that session. The scores on all three IR measures were combined to give an IR total. One week following the last session the Ss were administered the DR criterion measure.

The results were analyzed using the BMDO5V General Linear Hypothesis Program at the Florida State University Computing Center.

RESULTS

A correlation of .35 ($p < .01$) between sex and DR indicated that the treatments were differentially effective for males and females. Consequently all analyses included sex as a factor. It must be recognized from the onset that males and females were not randomly assigned to treatments; this fact must be kept in mind when interpreting results and appropriate caution exercised.

The results of 3x2 (treatment by sex) factorial analysis on IR revealed a strong interaction between treatment and sex ($p < .01$). Application of the Neuman-Keuls Procedure to the six cell means revealed that for females the VE group performed significantly better than both the choice group and the fixed group ($p < .05$). Also, males in the choice group performed significantly better than females in the choice group. The means (see Appendix A) show that males in the choice group tended to perform better than males in both the VE group and the fixed group.

TABLE 1.--Analysis of Variance on IR -- Treatments by Sex

SOURCE	df	MS	F
Treatments (A)	2	44.46	
Sex (B)	1	22.12	
A x B	2	91.66	7.44**
Error	47	12.32	

**$p < .01$
N = 53

TABLE 2.--Summary of the Neuman-Keuls Procedure for IR Data

TREATMENT x SEX COMBINATIONS[1]		FV	MC	MF	MV	FF	FC
Ordered Means		12.56	10.83	9.13	9.00	7.11	5.33
		FV	MC	MF	MV	FF	FC
	FV		1.73	3.43	3.56	5.45	7.33
	MC			1.70	1.83	3.72	5.50
Difference between pairs	MF				.13	2.02	3.80
	MV					1.89	3.67
	FF						1.78
$s\bar{y} = 1.20$	r =		2	3	4	5	6
(r, 47).95			2.92	3.53	3.90	4.17	4.37
$s\bar{y}$ (r, 47)			3.50	4.24	4.68	5.00	5.24
		FV	MC	MF	MV	FF	FC
	FV					*	*
	MC						*
	MF						
	MV						
	FF						

* $p < .05$

1
FV = Females - VE group
MC = Males - Choice group
MF = Males - Fixed group
MV = Males - VE group
FF = Females - Fixed group
FC = Females - Choice group

The results of a 3x2 (treatment by sex) factorial analysis on DR also revealed a strong interaction between treatment and sex ($p < .01$), as well as a significant sex effect ($p < .05$). Application of the Neuman-Keuls Procedure to the six cell means revealed that females in the VE group performed significantly better than females in both the choice group and the fixed group; they also performed better than males in both the VE group and the fixed group ($p < .05$). Again, the means, (see Appendix B), show that, to an even greater degree than for IR, males in the choice group tended to perform better than males in both the VE group and the fixed group.

TABLE 3.--Analysis of Variance on DR -- Treatments By Sex

SOURCE	df	MS	F
Treatments (A)	2	13.25	
Sex (B)	1	36.28	5.15*
A x B	2	43.38	6.15**
Error	47	7.05	

* $p < .05$
** $p < .01$
N = 53

Figure II

Sex by Treatment Interaction on DR Data--N = 53

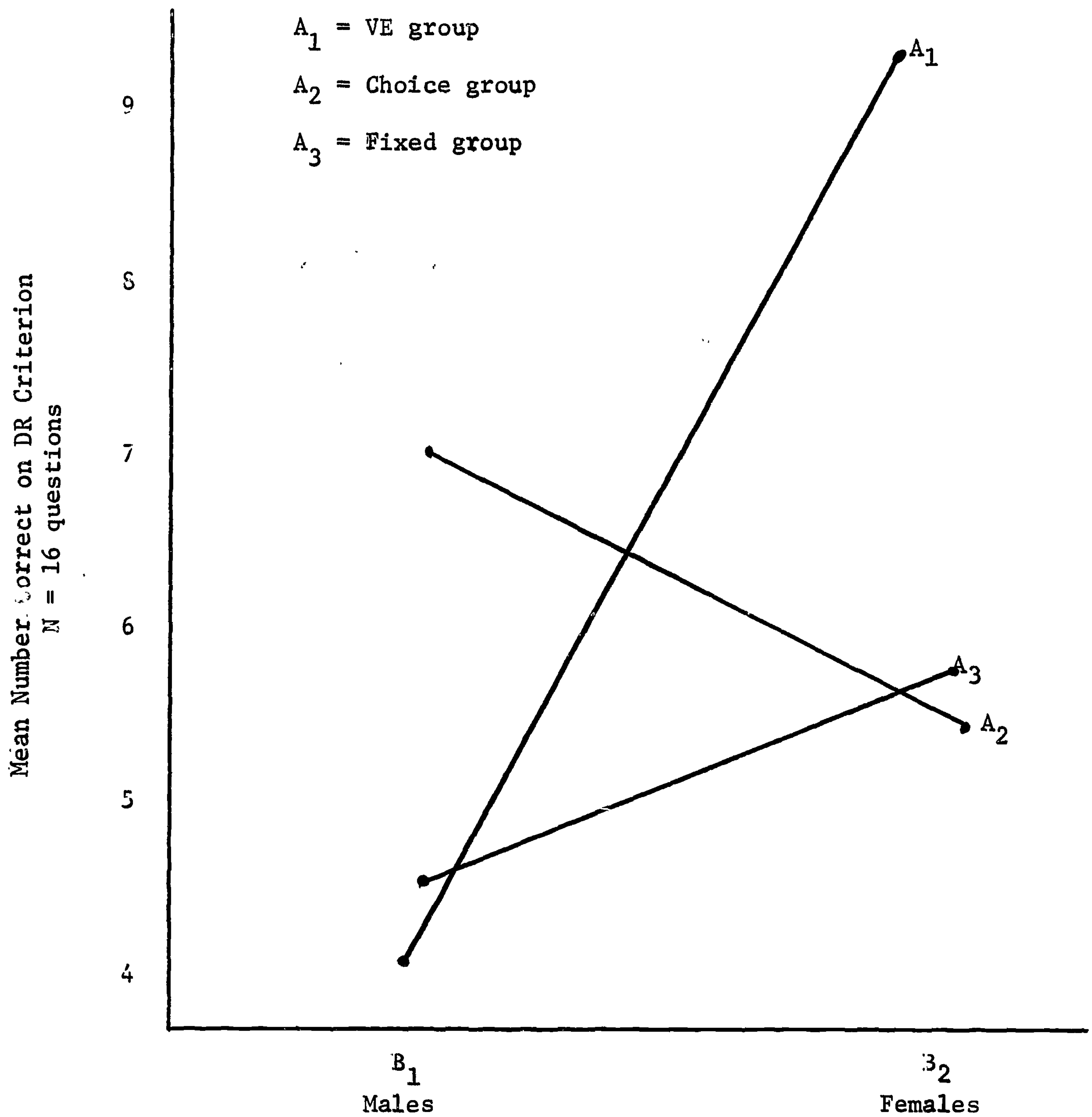


TABLE 4.--Summary of the Neuman-Keuls Procedure for DR Data

TREATMENT x SEX COMBINATIONS		FV	MC	FF	MV	MF	MV [2]
Ordered Means		9.44	7.00	5.89	5.77	4.62	4.42
		FV	MC	FF	MV	MF	MV
	FV		2.44	3.55	3.67	4.82	5.02
	MC			1.11	1.23	2.38	2.58
Difference between pairs	FF				.12	1.27	1.47
	FC					1.15	1.35
	MF						.20
$s_{\bar{y}} = .91$		r =	2	3	4	5	6
(r, 47).95			2.92	3.58	3.90	4.17	4.37
$s_{\bar{y}}$ (r, 47)			2.66	3.21	3.55	3.79	3.98
		FV	MC	FF	MV	MF	MV
	FV			*	*	*	*
	MC						
	FF						
	FC						
	MF						

* $p < .05$

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[2]
FV = Females - VE group
MC = Males - Choice group
FF = Females - Fixed group
FC = Females - Choice group
MF = Males - Fixed group
MV = Males - VE group

The results of a 3x2 (treatment by sex) factorial analysis on acquisition errors revealed a highly significant treatment effect ($p < .01$) as well as a significant treatment by sex interaction ($p < .05$). Application of the Neuman-Keuls Procedure to the six cell means revealed that females in the fixed group made significantly more errors than females in the VE group. The means (see Appendix C) show that the males and females in the VE group made fewer errors than Ss in any other treatment by sex combination.

TABLE 5.--Analysis of Variance on Acquisition Errors -- Treatments By Sex

SOURCE	df	MS	F
Treatments (A)	2	38.75	5.78**
Sex (B)	1	.03	
A x B	2	22.34	3.33*
Error	47	6.70	

*p < .05
**p < .01
N = 53

TABLE 6.--Summary of the Neuman-Keuls Procedure for Acquisition Error Data

TREATMENTS x SEX COMBINATIONS		FF	MC	FC	MF	MV	FV [3]
Ordered Means		6.33	6.00	3.89	3.75	2.67	2.33
		FF	MC	FC	MF	MV	FV
	FF		.33	2.44	2.58	3.66	4.00
	MC			2.11	2.25	3.33	3.67
Difference between pairs	FC				.14	1.22	1.56
	MF					1.08	1.42
	MV						.34
$s\bar{y}$ = .89	r =		2	3	4	5	6
(r, 47).95			2.92	3.53	3.90	4.17	4.37
$s\bar{y}$ (r, 47)			2.60	3.14	3.47	3.71	3.89
		FF	MC	FC	MF	MV	FV
	FF						*
	MC						
	FC						
	MF						
	MV						

* $p < .05$

3

FF = Females - Fixed group
MC = Males - Choice group
FC = Females - Choice group
MF = Males - Fixed group
MV = Males - VE group
FV = Females - VE group

It could be argued that perhaps DR performance was simply linearly related to number of examples rather than to treatment; however, a correlation of .18 did not support this hypothesis. Furthermore, a 2x2 (number of examples--5 or 10--by sex) factorial analysis on DR did not show a significant effect for number of examples. As would be expected, the main effect for sex was highly significant ($p < .01$). Application of the Neuman-Keuls Procedure to the four cell means revealed that females with ten examples performed significantly better than males with both five and ten examples, but not significantly better than females with five examples (see Appendix D).

TABLE 7.--Analysis of Variance on DR -- Ss with 5 or 10 Examples By Sex

SOURCE	df	MS	F
Examples (A)	1	3.56	
Sex (B)	1	88.97	14.08*
A x B	1	6.62	
Error	17	6.32	

* $p < .01$
N = 21

TABLE 8.--Summary of the Neuman-Keuls Procedure for DR of the VE Group

EXAMPLES x SEX COMBINATIONS [4]		F 10	F 5	M 5	M 10
Ordered Means		10.17	8.00	4.67	4.33
		F 10	F 5	M 5	M 10
Difference between pairs	F 10		2.17	5.50	5.84
	F 5			3.33	3.67
	M 5				.34
$s_{\bar{y}} = 1.23$		r =	2	3	4
(r, 17).95			3.00	3.65	4.05
$s_{\bar{y}}$ (r, 17)			3.69	4.49	4.98
		F 10	F 5	M 5	M 10
	F 10			*	*
	F 5				
	M 5				

* $p < .05$

4
F 10 = Females with 10 examples
F 5 = Females with 5 examples
M 5 = Males with 5 examples
M 10 = Males with 10 examples

DISCUSSION

The results strongly suggest a sex difference for retention; the VE method was significantly better for females, while the choice method was better for males (for both IR and DR). It is interesting to note that the average number of examples per item chosen by the choice group was three; males in the choice group and the fixed group received the same average number of examples and yet males in the choice group performed better than males in the fixed group.

It is possible that, while the average number of examples chosen was three, more were chosen for more difficult items and fewer were chosen for easier items; analogously, for the fixed group, three examples might have been too few for some questions and too many for others. The previously noted fact that the retention curves exhibited sharp drops after a number of examples suggests that too many examples may interfere with retention. It would be interesting in future research in this area to assess the difficulty level of the items and to then compare performance between the choice and fixed groups.

The GRI would appear to be a reasonable effective instrument for determining the number of examples needed by females. The fact that there was no difference in DR performance between Ss who had five examples and Ss who had ten examples, leads one to the conclusion that the GRI measured some variable heretofore unassessed. One main drawback of the GRI was its lack of discrimination between five and ten examples. It was originally believed that the index should be designed to allow for finer distinction at the lower end of the index. It is now suggested that future research use a revision of the GRI wherein the concepts are presented with 4, 6, 8, 10, or 12 examples rather than the original 1, 2, 5, 10, and 15. The GRI should further be revised to take into account item difficulty; this would result in a student receiving a certain number of examples for simpler items and more examples for more difficult items. Reasonably, this would not increase the time required but would increase DR. Finally, both the GRI and the instructional program should be revised so that students are required to respond after each example; this would reasonable increase delayed retention across groups. It is a value judgment as to whether the increased DR is worth the additional time required to obtain it. The author believes that the additional time in many cases _is_ worth it, especially if the material to be learned involves basic concepts believed to be necessary basic knowledge for all students.

The pattern of results for acquisition errors was similar to that for the retention data. The existence of the treatment by sex interaction leads further credence to the belief that there are sex differences in retention styles. The significant treatment effect in favor of the VE group indicates that retention is a different process from acquisition. The implications for education, if the effect could be replicated under other conditions, are promising. Up to this time few attempts have been made to differentiate instruction on the basis of sex; previous efforts have been in the direction of differentiation on the basis of various mental abilities.

In conclusion, the limitations of this study must be emphasized. Subjects were not randomly selected nor were males and females randomly assigned to treatments on the basis of sex. However, the results do suggest an interesting phenomenon which heretofore has not been effectively investigated. There is a definite need for further research in this area; it is unfortunately very possible that an important aspect of individualization has too long been overlooked.

APPENDICES

APPENDIX B

MEANS, STANDARD DEVIATIONS AND PERCENT

CORRECT FOR DR DATA

	VE GROUP		CHOICE GROUP		FIXED GROUP	
	M	F	M	F	M	F
$\bar{x}$	4.42	9.44	7.00	5.77	4.62	5.89
S.D.	1.88	3.13	1.67	3.19	2.83	2.80
% Correct	28	60	44	38	29	37

N = 53

APPENDIX A

MEANS, STANDARD DEVIATIONS AND PERCENT

CORRECT FOR IR SCORES

	VE GROUP		CHOICE GROUP		FIXED GROUP	
	M*	F*	M	F	M	F
$\bar{x}$	9.00	12.56	10.83	5.33	9.13	7.11
S.D.	3.95	2.46	2.79	5.27	2.90	2.20
% Correct	56	79	68	33	57	44

* M = Males
F = Females
N = 53

APPENDIX C

MEANS, STANDARD DEVIATIONS AND PERCENT

INCORRECT FOR ACQUISITION ERRORS

	VE GROUP		CHOICE GROUP		FIXED GROUP	
	M	F	M	F	M	F
$\bar{x}$	2.67	2.33	6.00	3.89	3.75	6.33
S.D.	2.99	2.29	2.76	1.83	2.31	3.00
% Incorrect	17	15	38	24	23	40

N = 53

APPENDIX D

MEANS, STANDARD DEVIATIONS AND PERCENT

CORRECT FOR DR SCORES OF VE GROUP

	5 EXAMPLES		10 EXAMPLES	
	M	F	M	F
$\bar{x}$	4.67	8.00	4.33	10.17
S.D.	2.08	2.00	1.94	3.49
% Correct	29	50	27	64

N = 21

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Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* Florida State University Computer-Assisted Instruction Center Tallahassee, Florida 32306	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
An Investigation into the Differential Effectiveness for Males and Females, of Three CAI Treatments, on Delayed Retention of Mathematical Concepts

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Tech Memo No. 12, November 15, 1969

5. AUTHOR(S) *(First name, middle initial, last name)*

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6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 15, 1969	33	33

8a. CONTRACT OR GRANT NO. N00014-68-A-0494 b. PROJECT NO. NR 154-280 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. DISTRIBUTION STATEMENT
This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Personnel & Training Research & Program Office of Naval Research Washington, D. C.

13. ABSTRACT

The purpose of this investigation was to evaluate the effectiveness of a pre-instruction retention index. The index was designed to maximize recall of mathematical concepts by predicting the idiosyncratic number of examples per mathematical concept required by each student.

53 high-intelligence eighth grade students (27 females and 26 males) were administered a retention measure via computer-assisted instruction (CAI). Subjects were then randomly assigned to 1 of 3 treatment groups. Although all Ss received the same CAI mathematical concepts, the treatment groups varied in the method of determining the number of examples per concept each student received. The treatments were as follows:

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT

DD FORM 1 NOV 65 1473 (BACK)

S/N 0101-807-6821

Security Classification

A-31409

13. *ABSTRACT (Continued)*

1. Variable example--Ss were presented concepts followed by an idiosyncratic number of examples as determined by each student's score on the pre-instruction retention measure;

2. Choice--Each S was allowed to determine the number of examples received per concept;

3. Fixed--Ss were given three examples per concept.

Since sex was found to be significantly correlated with retention, a series of two-way analyses of variance were computed in which sex and treatment were the independent variables and immediate retention and delayed retention were the dependent variables. Both analyses revealed a significant sex x treatment interaction. Females in the variable example group performed significantly better on both immediate and delayed retention measures than females in either the choice or fixed group. In contrast, males in the choice group performed better on both retention measures than males in the other 2 experimental conditions.

The use of the pre-instruction retention index resulted in better retention for females but not for males. Thus, it was concluded that use of the retention index for individualization of mathematics instruction will lead to more efficient retention for females.

Traditionally, individualization of instruction has been based primarily on differential mental abilities. Clearly, more research needs to be done in the area of sex x number of examples interactions and their implications for individualization.