THE EFFICACY OF MASSED VERSUS DISTRIBUTED PRACTICE AS A FUNCTION OF DESIRED LEARNING OUTCOMES AND GRADE LEVEL OF THE STUDENT

by

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ABSTRACT

The Efficacy of Massed Versus Distributed Practice
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The study examined the extent to which type-of-practice strategies (massed or distributed) had an effect on learning a verbal information (reading) or intellectual skill (math) task for second- and fourth-grade students. One hundred and ninety students from eight second- and fourth-grade classrooms participated in the study. Classrooms were randomly assigned to the two practice conditions and all students participated in a 9-week integrated learning system (ILS) intervention.

The present study found that intellectual skill tasks are learned slightly more effectively in a massed than distributed practice mode, though the difference was not statistically significant. Students also learned verbal information tasks more effectively in the massed practice mode, though the difference was not statistically significant. The differences between the two practice conditions were not as great on verbal information tasks, however, and no statistically significant differences were found. Additional analyses, using the number of lesson units completed, showed that having completed a greater number of math lessons had a positive effect on the math test scores. These analyses suggest that a stronger treatment or better adherence to the treatment could have caused a statistically significant effect for massed practice in intellectual skill domains. Replication is needed to provide a more solid foundation for this assertion.

It was concluded from this study, due to the moderate effect size differences and the identical cost factor for incorporating the two types of practice, that the use of massed practice would be more prudent for intellectual skill tasks. Massed practice is also more effective in the higher order verbal information area. Strong research inference suggests the continuance of distributed practice for "lower level" tasks, particularly in the verbal information areas. Further research is needed to discover factors that limit or negate the spacing effect.

(134 pages)

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CHAPTER I

INTRODUCTION

One of the most widely researched phenomena in the field of educational psychology is the area of massed versus distributed practice. Over 200 journal articles have been published documenting results from empirical studies comparing the efficacy of massed versus distributed practice. As early as 1885, Ebbinghaus was conducting laboratory studies investigating the effects of varying practice lengths on memorization of nonsense syllables (Ebbinghaus, 1913). Over 100 years later, studies continue. Certainly the body of research conducted on the massed versus distributed practice paradigm is an exception to the general rule that few replication studies can be found in educational research (Shaver & Norton, 1980).

Most published reviews and most psychology and educational psychology textbooks claim that we now have evidence (due to the large number of studies) that distributed practice (practice occurring over several periods of time, with breaks in between) is more effective than massed practice (uninterrupted practice occurring in one setting) (Benjamin, Hopkins, & Nation, 1987; Dembo, 1991; Feldman, 1990; Good & Brophy, 1986; Munn, Fernald, & Fernald, 1974; Slavin, 1991; Smith, 1978; Sprinthall & Sprinthall, 1990; Weiten, 1989; Woolfolk, 1990).

The supposed superiority of distributed practice has even led to a theory in psychology called the "spacing effect." The spacing effect is defined as "the tendency, given an amount of study time, for spaced presentations to yield much better learning than massed presentations" (Dempster & Farris, 1990, p. 97).

If we know this "fact" or have this "evidence," why do studies comparing massed versus distributed practice continue to proliferate? It would seem that due to the many research studies produced over decades, all possible research approaches in this area would be exhausted and all the important questions answered. Such is not the case, however, due to a variety of problems and limitations with (and conflicting results within) the body of past studies.

The Weight of the Evidence

There are a substantial number of studies (20 studies, or approximately 12% of the relevant studies) in which distributed practice has not been shown to be superior to massed practice (see, for example, Cook, 1934; Culler, 1912; Dellarosa & Bourne, 1985; DeRemer & D'Agostino, 1974; Elmes, Sanders, & Dovel, 1973; Gartman & Johnson, 1972; Kimble, 1949; Landauer, 1967; Naus, Ornstein, & Aivano, 1977; Naus, Ornstein, & Kreshtool, 1977; Reder & Anderson, 1982; Toppino & DiGeorge, 1984). Of course, this still leaves approximately 88% of the studies in this area that report distributed practice to be significantly better than massed practice in improving student learning. This preponderance of findings favoring distributed practice is what has apparently led many educators and psychologists to conclude that massed practice is inferior to practice distributed across time. Certainly it has prompted most reviewers of this body of literature to operate under the premise that "the majority rules." Because distributed practice is more effective than massed practice in a majority of the existing studies, the reviewers make the apparently logical claim that distributed practice is better than massed. However, such a conclusion is, at best, an oversimplification and at worst, misleading.

A Limitation of the Existing Evidence

In a recent review by Dempster (1988), he stated that the conflicting findings in the research on massed versus distributed practice make it clear that the spacing effect (the effect of spacing between practice sessions) is subject to certain not-yet-fully-understood limitations. Unfortunately, little research has been done to investigate the possible limitations and conditions under which the spacing effect holds true. Without such research, it would be difficult to predict with confidence the relative effectiveness of practice sessions with varying lengths between them. The purpose of this research is to begin such a series of programmatic research studies by (a) summarizing the findings of the literature and (b) investigating whether or not there are variables that may relate to the effectiveness of the spacing effect. Ultimately, such knowledge will assist in providing prescriptions for the most effective way for learners to grasp intended subjects.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter contains (a) a brief description of the methods for conducting this review of the literature, (b) definitions of terms presented in this study, and (c) an analysis of the literature in the massed versus distributed practice arena. In order to conduct a review of the literature on massed versus distributed practice, steps were taken to locate all reviews of the literature and primary research studies on spacing of practice in which the manipulation of practice lengths was used as an independent variable.

Method for Conducting the Literature Review

This section describes methods used to collect information for this analytical review. This review of literature takes a threefold approach. First, reviews are examined to see what has been discovered thus far. Second, all primary studies are analyzed. Third, those studies that use elementary age children in a classroom or lab-based learning environment are extensively reviewed.

The first step in conducting the literature review was to perform several computerized literature searches of the terms "massed practice," "distributed practice," "spaced practice," and "spacing effect," in the Psychological Abstracts, ERIC, and Dissertation Abstracts Online databases. Articles identified in each search were located. The branching bibliographic technique of checking and obtaining the references of each of the original articles was used to supplement the computerized search.

All studies that used human subjects (with the exception of those with handicapped, disabled, or specifically mentioned disadvantaged subjects) were included in the review of the literature. Although worthy of investigation, those studies dealing with such exceptional populations are viewed as beyond the purpose of this study, although they would be a useful future contribution to the literature. It is suggested that once a basic framework has been laid, further research be conducted with such populations.

Animal studies were excluded for the purposes of this review. Also, theoretical pieces of work, or studies that examine the possible reasons for the spacing effect, but did not explicitly study the result of spacing (see, for example, Bird, Nicholson, & Ringer, 1978; Bjork & Allen, 1970) were also excluded.

Two types of literature have been reviewed. First, secondary summaries of empirical studies conducted by others are reviewed, along with reviews of widely held beliefs evidenced by text authors and others who are viewed as knowledgeable in the area of massed versus distributed practice. Second, the actual empirical research studies dealing with massed versus distributed practice are reviewed. In the first category, those research studies that are reviews or syntheses of primary studies are included. Such reviews and publications provide a context for understanding and applying the results from the original research conducted in this area. They also provide an excellent bibliography to supplement computer searches.

The published reviews judged to be applicable include a variety of reviews published in (a) educational psychology, general introductory psychology, and instructional science textbooks; and (b) journal articles or ERIC documents. Typical general introductory and educational psychology textbooks were included in the review of secondary sources. Educational psychology texts were included due to the very direct nature of examining this area within the field of educational or learning psychology. General introductory psychology texts were used as many of them mention the research on the spacing effect in their introductions to the field of educational psychology.

After reading the reviews of the literature, and a few of the actual primary research studies, a coding sheet was developed for summarizing the main variables within the studies. A copy of the coding sheet is included as Appendix A.

Definition and Importance of Practice

The adage that "practice makes perfect" is commonly upheld in the writings of learning theorists and researchers. This theory of practice has become a very widely studied area within educational psychology and related disciplines. Before examining the relevant issues of practice, it is important to first lay the definitional framework for practice.

Webster's dictionary defines "practice" as "repeated performance or systematic exercise for the purpose of acquiring skill or proficiency" (Webster's, 1989, p. 1128). Practice is also defined in relevant textbooks as the repeated performance of a given task so as to become proficient at that task. DeCecco and Crawford (1974) have claimed that reinforced practice is one of the basic conditions of learning. Practice, they have said, is essential to retain units of information or learning and relationships among those units or associations for relatively long periods of time.

Underwood (1961) stated that the longer a person works at learning, the more that person will learn. Thorndike's (1916) main contribution to psychology was to formulate what is called the "law of effect." His law of "learning," termed "habit formation," is accomplished through repetition.

Bower and Hilgard (1981) asserted that for most academic skills such as reading, writing, and arithmetic, there is simply no substitute for repeated practice. Only with practice will these skills become automatic and be performed rapidly and effortlessly.

In the instructional science/technology arena, practice is included in the Gagne (1985) and Gagne and Briggs (1979) events of instruction. Four of the nine events of instruction (denoted by an *) are associated with practice elements. The events include:

1. Gaining the learner's attention
2. Informing the learner of the objective
3. Stimulating recall of prerequisite learning
4. Presenting the stimulus material

*5. Providing "learner guidance"

*6. Eliciting the performance

*7. Providing feedback about correctness

8. Assessing the performance

*9. Enhancing retention and transfer.

Additionally, event 4, "Presenting the stimulus material," can include elements of practice. Oftentimes, a subsection or module of the learning unit is immediately followed by practice. It is not possible to draw a line between event 4 and events 5 through 8, and, indeed, it is often most effective in instructional scenarios to continually recycle through events 4 through 8.

Merrill (1986) included practice in his list of what he termed the "cardinal principles" of instruction:

> The purpose of instruction is to provide the dynamic, ongoing opportunity for monitored practice that requires the student to demonstrate the desired learned performance, or a close

> approximation of it, while the instructor monitors the activity and intervenes with feedback both as to result and process. (p. 3)

There is a general consensus among psychologists, educational psychologists, educators, and instructional scientists that practice is essential for the learning and retention of information. Interestingly, this is common ground on which behaviorists and cognitivists share interests and inquiry activities. Debate arises, however, within and across such disciplines as to the type and amount of practice needed for a person to learn best. Simply saying that practice causes one to become proficient at a skill or knowledgeable in an area is not enough. The issues of what exactly practice is, how practice is best applied, quantity of practice, and in what way practice is best distributed have become areas of debate within the literature for well over a century.

Definition of Massed Versus Distributed Practice

Within the area of practice, the appropriate spacing of practice has become known as massed versus distributed practice, the spacing effect, the lag effect, or Melton's effect. Much research has been conducted to investigate the effectiveness of what has been termed "massed" and "distributed" practice. Before addressing the efficacy issues, however, once again a definitional framework must be laid. A typical definition of the two types of practice is provided in DeCecco and Crawford's (1974) classic educational psychology textbook. Massed practice is defined as the learning of tasks concentrated into one time period, and distributed practice as the learning of tasks spread out over several time periods alternated with periods of rest. This very general definition seems to be shared by many researchers.

Alarmingly, most journal articles do not give definitions of massed and distributed practice before embarking on a study of the relative efficacy of one over the other. Of the few that do, the following are some examples:

1. "Massed practice: to pay attention to one idea (a main point and its embellishments) for a long time" (Reder & Anderson, 1982).
2. "Distributed practice: intervening time, also called lag time" (Zimmerman, 1973; 1975).
3. "Massed practice: a minimal interval between successive learning trials" (Keppel, 1964).

Researchers tend to disagree about the exact timing of the massing and distribution of practice. All do tend to agree, however, that alternating subject areas or learning tasks does represent distributed practice. Researchers also apparently agree that massed practice (whether it be 10 seconds or 5 hours) refers to concentration on a single learning task.

Review of Widely Held Beliefs about Massed and Distributed Practice

All of the educational psychology and instructional science textbooks examined (Benjamin et al., 1987; Dembo, 1991; Feldman, 1990; Good & Brophy, 1986; Munn et al., 1974; Slavin, 1991; Smith, 1978; Sprinthall & Sprinthall, 1990; Weiten, 1989; Woolfolk, 1990) claim that distributed practice is more effective than massed practice. Typically, the texts quote from the findings of some of the seminal works within the field. Most of the texts indicate that of the 100, 200, or 300 studies reviewed, 80% of them support the spacing effect hypothesis. A few of the texts (Good & Brophy, 1986; Sprinthall & Sprinthall, 1990; Woolfolk, 1990) made mention that although there is more support in favor of the spacing effect, there are still substantial numbers of studies that do not lend support to the spacing effect. Generally no explanations or possible reasons are postulated in the textbooks for why there are many studies that do not show that distributed practice is better than massed practice.

The best and most recent published review in this area was written by Dempster (1988). Dempster claimed that the spacing effect is a scientific "fact" developed from decades of laboratory research in psychology. "The spacing effect," he wrote,

> which refers to the finding that for a given amount of study time, spaced presentations yield substantially better learning than do massed presentations--is one of the most remarkable phenomena to emerge from laboratory researchon learning. (Dempster, 1988, p. 627)

Although we know this fact, he contends, we are not applying it in our schools. Dempster listed possible impediments to application, including the fact that research on the spacing effect is not new. Most studies were published in the 60s and 70s (see reviews by Glenberg, 1979; Hintzman & Block, 1970; Melton, 1967). It has only been in the last few years (as evidenced by Cuddy & Jacoby, 1982; Dellarosa & Bourne, 1985; Dempster, 1988; Elmes, Dye, & Herdelin, 1983; Glenberg & Lehmann, 1980; Glover & Corkhill, 1987; Toppino & DiGeorge, 1984) that the spacing effect has received renewed attention.

There are, however, serious discontinuities in the literature on the spacing effect. Authors of the most recent studies, according to Dempster, seem to be unfamiliar with earlier studies:

> Why is it that we occasionally and perhaps frequently-- give up on, or simply lose interest in, a phenomenon before we have definitive answers to basic questions and, then much

> later, return to the phenomenon as though we had just recently discovered it? (Dempster, 1988, p. 629)

Incongruities in labeling of terms and incongruities in the mere definitions of massed versus distributed practice cause problems for those who wish to synthesize or replicate research. Many times the spacing intervals in distributed practice range from a few seconds to several days. Uniformly, "spacings" of zero are referred to as massed practice, while spacings of greater than zero are referred to as distributed practice. However, the spacing in researchers' distributed practice treatment does not equal real-world classroom types of spacings. Spacings of a few seconds to a few minutes are equal to typical, humane breaks in a massed practice condition. A student might be cramming for an exam the night before (massed practice) but still take breaks for a walk, a phone call, a snack, or some other quick activity that could be rejuvenating. Bloom and Shuell (1986) have said that distribution lags should equal 24 hours or more to equate a true distribution of practice. If this is the case, the majority of laboratory-based studies would not be applicable to educational practice, and calling the type of practice "distributed" may be a misnomer.

A very important impediment to the application of the spacing of practice that Dempster calls for is the fact that numerous studies fail to show the superiority of the distribution of practice (Gordon, 1925; Naus et al., 1977; Naus et al., 1977; Toppino & DiGeorge, 1984). A relatively recent finding is that younger subjects tend to do better in a massed rather than in a distributed fashion (Toppino & DiGeorge, 1984).

As mentioned earlier, the lack of clarity about what constitutes massed and distributed practice may contribute greatly to the confusion and, therefore, to the lack of application. Closely related to the lack of clarity is the fact that the spacing effect phenomenon is not well understood. Practitioners, and even researchers, do not have a clear picture of what exactly the spacing effect is and what causes it.

Dempster concluded his review by saying that we do not know enough about the effect of spacing to make a very strong argument for application without additional knowledge about the spacing effect as it directly relates to classroom practice. "Clearly," he said, "programmatic research on the effects of spacing in education settings is long overdue, as the results of such efforts would likely aid in its applications" (Dempster, 1988, p. 632).

Another interesting and very appropriate review is given by Salisbury, Richards, and Klein (1985). The authors examined the issue of practice from an instructional design standpoint, noting that various instructional theories include recommendations for designing practice activities for different types of learning. They cited Gagne's (1985) five conditions of learning varieties and prescribed some activities for practice. The researchers briefly reviewed the effects of spacing on practice, but they did not combine the definite ideas on incorporating practice in the learning types along with spacing of practice.

When reviewing the literature, Underwood (1961) concluded that we do know that spaced practice is better than massed, but the effects are quite small. The majority of studies do not report effect sizes or give any measures of practical or educational significance.

Published reviews of the spacing effect have not investigated studies in relation to possible impact of type of learning condition, developmental level, or length and type of spacing interval (see Dempster & Farris, 1990; Underwood, 1961). No systematic effort has been made to look at specific variables and covary outcomes. Instead, the reviewers typically take a section of studies from a certain period of time and report the results. Underwood's "Ten Years of Massed Practice on Distributed Practice" (1961) is a classic example.

Essentially, little is really known about the effects of massed versus distributed practice in practical, classroom-based situations. As mentioned, most textbook authors cite the vast body of literature supporting the superiority of distributed practice and claim that educators should encourage a distributed practice approach as much as possible. Recent reviewers, however, point out discontinuities in the published literature and incongruities in labeling of terms and definitions. Most prior studies are laboratory based and have questionable applicability or validity for classroom practice. The questionable validity occurs mainly from the lack of information on such important variables as type of learning condition, length, and type of spacing interval. It is essential at this stage of the investigation of prior research to examine the available primary research studies.

Review of Empirical Research Investigating the Efficacy of Massed Versus Distributed Practice

A useful contribution to our understanding of the vast amount of literature would be to summarize it in a way that would be understandable to practitioners and educational curriculum developers. In this section of the review of literature, original or primary studies are categorized according to age of subjects and type of learning outcome desired of the subjects.

Gagne's (1985) five conditions of learning is a well-respected and thorough typology of different types of learning. Gagne's five conditions include verbal information (rote memory for facts and ideas), intellectual skill (algorithm or procedure following), cognitive strategy (problem solving), motor (physical movement learning skills), and affect (attitudes toward a given subject matter). All classroom curricula can be categorized into one or more of Gagne's categories. Table 1 gives more detailed information for each of the conditions.

From the information presented on the table, math computations, for instance, could be an example of an intellectual skill; spelling would be an example of verbal information; and selecting a proper statistical tool for a research problem would, most likely, be an example of a cognitive strategy.

Table 1

Gagne's Five Conditions of Learning

Condition	Explanation
Intellectual skills	Making discriminations, knowing concepts, manipulating symbols; applying rules; following procedures; generating rules
Verbal information	Knowing and stating facts
Cognitive strategies	Regulating internal processes; synthesizing information; originating novel ideas; problem solving
Motor	Performing organized, smooth, regular, and precisely timed movements
Attitudes	Choosing between two or more situations, thoughts ideas, or actions

A major purpose in this review of literature and follow-up study is to examine what is known about the efficacy of massed versus distributed practice as a function of the types of learning conditions and the age or grade level of the student. Rather than reviewing the studies chronologically, it would seem more useful to categorize and synthesize the literature according to the types of learning and age of student. Table 2 gives a synopsis of the empirical studies in terms of the efficacy of the spacing of practice on achievement as a function of desired learning outcome and age/grade of the subject. This provides preliminary data on the possibility of age and type of learning variety influencing the effectiveness of type of practice. The columns of the matrix in Table 2 list the five types of learning outcomes. Three of the five learning conditions (including verbal information, intellectual skill, and motor) are represented on the table. No studies in the cognitive strategy or affective domains were found in the published literature. For this reason those major categories were left out of Table 2.

The rows in Table 2 give the grade level/age of the subjects. Author and dates of the study and the overall results of the studies are entered in the cells to which they refer. The key for the codes is given at the top of Table 2. Essentially, in the interest of space, massed practice is abbreviated as MP, distributed practice as DP. When one condition is greater than the other, the "greater than" (>) symbol is used. The > is used when there is a statistically significant difference at the $\underline{p} < .05$ level. When there is no statistically significant difference between the results, the = symbol is used. Toppino and DiGeorge (1984), for example, found that massed practice was equal to distributed practice for teaching verbal information to preschool subjects (MP=DP).

From Table 2, we can see that the vast majority of the studies (103 of 120, or 85%) occurred in the verbal information category. Eight studies (7%) were conducted in the intellectual skill arena and nine studies (8%) in the motor skill area. Additionally, we find that the majority of the studies (80 of 120, or 67%) occurred with college students. Three studies included middle school/junior high school students (Cuvo, 1975; Landauer, 1967; Wilson, 1976). Five studies used high school students (Bloom & Shuell, 1986; Drake, 1981; Marshall & Runquist, 1962; Murphy, 1916; Ross & Landauer, 1978). Seven studies used adults as subjects, often using themselves as subjects (Hintzman, Block, & Summers, 1973; Hintzman & Rogers, 1973; Lyon, 1914; Rothkopf & Coke, 1963, 1966; Tsao, 1948a, b). Several studies did not give age or grade of the subjects (Modigliani & Hedges, 1987; Mould, Treadwell, & Washburn, 1915; Underwood, 1951a, b; Underwood 1952a, b). Only eleven studies were conducted with elementary school age children (Cuvo, 1975; Hohn, 1964; Ornstein, Naus, & Liberty, 1975; Ornstein, Naus, & Stone, 1977; Rea & Modigliani, 1985; Resick & Payne, 1978; Toppino & DiGeorge, 1984

Table 2

Integration of All Applicable Massed Versus Distributed Practice Studies

Learning Variety Grade	Verbal Information	Intellectual Skill	Motor
Preschool	Toppino & DiGeorge, 1984 MP=DP (2)	—	—
K	Hohn, 1964 DP>MP	—	—

(table continues)

Learning Variety Grade	Verbal Information	Intellectual Skill	Motor
1	Toppino & DiGeorge, 1984 DP>MP	—	—
2	—	—	—
3	Rea & Modigliani, 1985 DP>MP	Rea & Modigliani, 1985 DP>MP	—
4	Wilson, 1976 DP>MP	—	—
5	Cuvo, 1975 DP>MP	—	—
6	—	—	—
Mixed Elementary	Ornstein, Naus, & Liberty, 1975 DP>MP;	—	Resick & Payne, 1978 DP>MP
	Ornstein et al., 1977 DP>MP	—	—
	Cuvo, 1975 DP>MP	—	—
	Toppino & DeMesquita, 1984 DP(LL)>DP(SL) (2)	—	—
7	—	—	—
8	Cuvo, 1975 DP>MP;	—	—
	Wilson, 1976 DP>MP	—	—

(table continues)

Learning Variety Grade	Verbal Information	Intellectual Skill	Motor
Jr. High/Middle	Landauer, 1967 DP>MP (paired assoc.), MP=DP (free recall)	—	—
9	—	—	Drake, 1981 DP>MP
10	—	—	—
11	—	—	—
12	Marshall & Runquist, 1962 DP>MP	—	—
Mixed High School	Bloom & Shuell (1986) DP>MP;	—	Murphy, 1916 DP>MP
	Ross & Landauer, 1978 DP>MP	—	—
College Freshman	—	—	McCaffrey & Payne, 1977 DP>MP
College Sophomore	Allen & Garton, 1970 DP>MP	Reed, 1924 DP>MP	—
College Junior	Elmes et al., 1973 DP>MP (2), MP>DP (2)	—	—
College Senior	Ausubel & Youssef, 1965 DP>MP;	—	—
	Ausubel & Youssef, 1965 DP>MP;	—	—

(table continues)

Learning Variety Grade	Verbal Information	Intellectual Skill	Motor
College Senior, con't.	Elmes et al., 1973 DP>MP (2), MP>DP (2);	—	—
	Marshall & Runquist, 1962 DP>MP	—	—
Mixed College Undergraduates	Bellezza, Winkler, & Andrasik, 1975 DP>MP (3);	Dellarosa & Bourne, 1985 MP=DP;	Archer, 1958 DP>MP;
	Bird et al., 1978 DP>MP (2); Bjork & Allen, 1970 DP>MP;	DeRemer & D'Agostino, 1974 MP=DP; Jacoby, 1978	Bourne & Archer, 1956 DP>MP; Dore & Hilgard, 1937 DP>MP;
	Borkowski, 1967 DP>MP;	DP>MP; Reder & Anderson, 1982 MP=DP	Dore & Hilgard, 1938 DP>MP
	Braun & Heyman, 1958 DP>MP;		—
	Bregman, 1967 DP>MP;	—	—
	Cain & Willey, 1936 DP>MP;	—	—
	Ciccone, 1973 DP>MP;	—	—
	Cuddy & Jacoby, 1982 DP>MP;	—	—
	Cuvo, 1975 DP>MP;	—	—
	D'Agostino & DeRemer, 1973 DP>MP, DP=MP;	—	—
	Dellarosa & Bourne, 1985 DP>MP;	—	—

(table continues)

Learning Variety Grade	Verbal Information	Intellectual Skill	Motor
Mixed College Undergrads, con't.	DeRemer & D'Agostino, 1974 DP>MP;	—	—
	Elmes et al., 1983 DP>MP;	—	—
	Elmes et al., 1973 DP>MP (2), MP>DP (2);	—	—
	Fischer & Cook, 1962 DP>MP;	—	—
	Garskof, 1969 DP>MP;	—	—
	Gartman & Johnson, 1972 MP=DP;	—	—
	Glanzer, 1969 DP>MP;	—	—
	Glenberg, 1977 DP>MP;	—	—
	Glenberg, 1979 DP>MP;	—	—
	Glenberg & Smith, 1981 DP>MP;	—	—
	Glover & Corkill, 1987 DP?MP;	—	—
	Gordon, 1925 DP>MP;	—	—
	Greeno, 1964 DP>MP;	—	—
	Hintzman, 1969a, b DP>MP;	—	—
	Houston & Reynolds, 1965 DP=MP;	—	—
	Hovland, 1938a, DP>MP;	—	—
	Hovland, 1938b, DP>MP;	—	—

(table continues)

Learning Variety Grade	Verbal Information	Intellectual Skill	Motor
Mixed College Undergrads, con't.	Hovland, 1939 DP>MP serial lists/DP=MP paired associates;	—	—
	Hovland, 1940a, b DP>MP;	—	—
	Hovland, 1949 DP>MP;	—	—
	Jensen & Freund, 1981 DP>MP (2);	—	—
	Rose, 1980, 84 DP>MP;	—	—
	Rose & Rowe, 1976, DP>MP;	—	—
	Rundus, 1971 DP>MP;	—	—
	Shaughnessy, 1976 DP>MP;	—	—
	Shaughnessy, Zimmerman, & Underwood, 1972 DP>MP;	—	—
	Underwood, 1953a, b, c, d DP>MP;	—	—
	Underwood & Archer, 1955 MP=DP;	—	—
	Zechmeister & Shaughnessy, 1980 MP>DP;	—	—
	Zimmerman, 1973 DP(LL)>DP(SL)> MP	—	—
Graduate Students		Culler, 1912 MP>DP	—

(table continues)

Learning Variety Grade	Verbal Information	Intellectual Skill	Motor
Mixed undergraduate and graduate students, cont'd.	Cain & Willey, 1936 DP>MP; Garskof, 1969 DP>MP;	—	—
	Jung, 1966 DP=MP;	—	—
	Johnston & Uhl, 1976 DP>MP (2);	—	—
	Keppel, 1964 MP>DP (initial), DP>MP (retention), DP>MP (3);	—	—
	Landauer & Ross, 1977 DP>MP;	—	—
	Maskarinec & Thompson, 1976 DP>MP (2);	—	—
	Marshall & Runquist, 1962 DP>MP;	—	—
	McClelland, 1942 DP>MP;	—	—
	McFarland, Rhodes, & Rowes, 1979 DP>MP (2), MP=DP;	—	—
	Peterson, Wampler, Kirkpatrick, & Saltzman, 1963 DP>MP (3);	—	—
	Pollatsek, 1969 DP>MP;	—	—
	Robinson, 1921 DP>MP & MP>DP;		
	Wilson, 1976 DP>MP	—	—

(table continues)

Learning Variety Grade	Verbal Information	Intellectual Skill	Motor
Adult Education	Hintzman et al., 1973 DP>MP;	—	—
	Hintzman & Rogers, 1973 DP>MP;	—	—
	Lyon, 1914 DP>MP;	—	—
	Rothkopf & Coke, 1963 DP>MP;	—	—
	Rothkopf & Coke, 1966 DP>MP;	—	—
	Tsao, 1948a DP>MP (2);	—	—
	Tsao, 1948b High meaning DP>High meaning MP>Low meaning DP>Low meaning MP	—	—
Not given	Hintzman & Block, 1973 DP>MP;	Cook, 1934 MP>DP, MP=DP	Kimble, 1949 MP=DP
	Hintzman & Block, 1970 DP>MP, MP>DP;	—	—
	Modigliani & Hedges, 1987 DP>MP;	—	—
	Mould et al., 1915 DP>MP;	—	—
	Tsao, 1951 DP>MP;	—	—
	Underwood, 1952a DP>MP;	—	—

(table continues)

Underwood, 1952b DP>MP;	—	—
Underwood, 1951a DP>MP on low similarity lists;	—	—
Underwood, 1954b MP>DP, DP>MP;	—	—
Underwood, 1951b, DP>MP;	—	—
Underwood & Eckstrand, 1967a, b DP>MP	—	—

Note. DP>MP = Distributed practice is statistically significantly ($p < .05$) more effective than massed practice.
MP>DP = Massed practice is statistically significantly ($p < .05$) more effective than distributed practice.
MP=DP = No statistically significant difference between the two conditions.
DP?MP = Difference was statistically significant, but the authors did not say how.
DP(LL)>DP(SL)>MP = Long lag distributed practice was more effective than short lag distributed practice, which was better than massed practice.

Numbers in parentheses indicate number of studies per article.

[two studies]; Toppino & DeMesquita, 1984 [two studies]; Wilson, 1976).

Figure 1 presents a summary of the findings of the effectiveness of massed or distributed practice as a function of the desired learning outcomes including verbal information, intellectual skills, and motor areas. Again, cognitive and affective were not included due to the lack of studies in these areas. Figure 1 presents a consolidation of the findings. Three clusters of graphs are shown.

The first cluster represents all studies that show that distributed practice is statistically significantly more effective than massed practice (DP>MP). From the clusters, we see that 81% of the verbal information studies, 33% of the intellectual skill studies, and 89% of the motor studies show that distributed practice is more effective than massed practice. This gives evidence from the literature that the superiority of distributed practice over massed practice generally holds true in the verbal information and motor skill areas, at the various age levels, and with the learning tasks included in the studies. A different finding exists in the intellectual skill

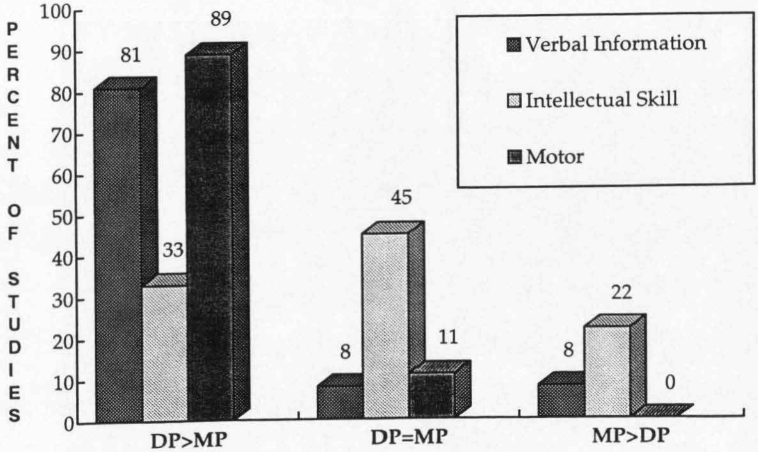

Figure 1. Findings of 120 coded studies on the relative efficacy of distributed and massed practice.

arena, however. In the majority (67%) of such studies, the spacing effect does not hold true. Only 33% of the intellectual skill studies provide support for the superiority of the spacing effect.

Looking at the second cluster of graphs on Figure 1, those showing that distributed and massed practice are equal (DP=MP), or that there is no statistically significant difference between the two, only 8% of the studies in the verbal information area show no difference. Conversely, 45% of the intellectual skill domain studies show the two practice conditions to be equal. Only 11% of motor skill studies fail to uphold the effectiveness of the spacing effect.

The last cluster of graphs in Figure 1 portrays the percentage of studies showing that massed practice is statistically significantly more effective than distributed practice. Eight percent of the verbal information studies and 22% of the intellectual skill studies actually found massed practice to be more effective than distributed. One study (Glover & Corkhill, 1987) indicated that there was a difference between the practice conditions, but did not indicate in which direction. Two studies (Toppino & DeMesquita, 1984; Wilson, 1976) in the verbal information category investigated the effect of longer (6 or 8 intervening items) or shorter (2 or 3 intervening items) "lag" or rest intervals in distributed practice. In both studies, distributed practice resulted in better outcomes than massing of practice. One study (Tsao, 1948b) showed that the meaning of the ideas to be learned was more crucial than the type of practice. Words that had high meaning to subjects were best learned in distributed practice; however, high-meaning massed word memorization was still better than low-meaning distributed practice.

But Are Such Studies Representative of Classroom Practice?

Only 4 of the 120 studies were conducted in classrooms rather than laboratories (Ausubel & Youssef, 1965; Bloom & Shuell, 1986; Cuvo, 1975; Landauer & Ross, 1977). One study conducted by Lyon (1914) on himself was done in his home or his office. In 7 studies, the setting was not specifically indicated, though the type of stimulus materials used were very much like lab-based studies. In the other 108 studies, the laboratory was the specifically mentioned setting.

The typical stimulus materials in the experiments include word lists, nonsense syllables, memorizing a variety of facts, puzzle solving, rotary pursuit tracking, and javelin throwing. An exhaustive list of types of stimuli used in the experiments is provided in Table 3.

Spacing intervals for the majority of the studies listed above included 0 seconds for the massed practice condition versus 8, 15, 24, 45, or 60 seconds for the distributed practice conditions. Occasionally the intervals would go to 0 seconds versus 2 or 3 minutes. Five researchers used longer spacings, including 1 day (Bloom & Shuell, 1986; Drake, 1981), 2 days (Ausubel & Youssef, 1965), 3 days (Bloom & Shuell, 1986; Gordon, 1925), and "varying" days (from 1 to 3) (Cain & Willey, 1936).

Often researchers did not count the interval time, but rather focused on the number of intervening items (usually unrelated to the task). No intervening items would represent a massed practice condition, while 1 to 45 (most often number used) would all represent varying degrees of a distributed practice condition.

While using intervals that consist of intervening items or short time

Table 3

Complete Listing of Stimuli Used in the MP Versus DP Experiments Included in the Review of the Literature

Type of Task	Authors
Verbal Information Tasks	
60 common words projected onto a screen with an automatic slide projector	Allen & Garton, 1970
Colored slides presented on a slide projector	Hintzman & Rogers, 1973
Common nouns	Zechmeister & Shaughnessy, 1980
Contained in sentences	Rothkopf & Coke, 1963
On a slide projector	Glenberg & Smith, 1981 Hintzman, 1969a, b
	Hintzman & Block, 1973, 1970 Hintzman et al., 1973
	Rose, 1984, 1980
On a tape recorder	Elmes et al., 1983
Memorizing poetry	Lyon, 1914
Memorizing prose	Gordon, 1925; Lyon, 1914
Memorizing sentences	D'Agostino & DeRemer, 1973 Dellarosa & Bourne, 1985 DeRemer & D'Agostino, 1974
Memorizing telephone numbers	Landauer & Ross, 1977
Memorizing text	Reder & Anderson, 1982

(table continues)

Monosyllabic nouns presented on a tape recorder	Glanzer, 1969; Glenberg, 1977
Multiplication facts	Rea & Modigliani, 1985
Nonsense syllables	Keppel, 1964 Landauer, 1967 Tsao, 1948a, b, 1950,1951
Enclosed in geometric forms	Fischer & Cook, 1962
In serial arrangement	Hovland, 1938a, b, 1939,1940a, b Lyon, 1914
	Marshall & Runquist, 1962
On cards	Mould et al., 1915
Paired associate lists	Houston & Reynolds, 1965 Hovland, 1949 Jung, 1966
Pairs of related words	Cuddy & Jacoby, 1982
Pairs of words using a carousel projector	Glenberg, 1979
Presentation of word lists on a high speed memory drum	Bjork & Allen, 1970 Garskof, 1969
Presentation of word lists on a Hull type memory drum	Braun & Heyman, 1958 McClelland, 1942 Underwood, 1951 a, b, 1952 a, b, 1953a, b, c; 1954 Underwood & Archer, 1955 Underwood & Eckstrand, 1967a, b
Presentation of word lists on a Lafayette IBM memory drum	Bellezza et al., 1975 Bregman, 1967 Ciccone, 1973 Jung, 1966
Presentation of word lists on a mechanical memory drum	Cain & Willey, 1936 McFarland, Rhodes, & Frey, 1979 Robinson, 1921; Shaughnessy, 1976

(table continues)

Reading word passages	Ausubel & Youssef, 1965 Glover & Corkhill, 1987
Slide presentation of homographs	Gartman & Johnson, 1972
Spelling lists	Rea & Modigliani, 1985
Vocabulary words	Bloom & Shuell, 1986
Word lists	Cuvo, 1975 Garskof, 1969 Hohn, 1964 Jensen & Freund, 1981 Petersen, Wampler, Kirkpatrick, & Salzman, 1963 Pollatsek, 1969 Toppino & DeMesquita, 1984 Zimmerman, 1973
On flash cards	Elmes et al., 1973 Rose & Rowe, 1976 Ross & Landauer 1978 Rowe & Rose, 1977 Rundus, 1971
On slide projectors	Wilson, 1976
On tape recorders	Bird et al., 1978 Elmes et al., 1973 Maskarinec & Thompson, 1976 Modigliani & Hedges, 1987 Shaughnessy, Zimmerman, & Underwood, 1972
Through stereo headphones	Johnston & Uhl, 1976
Words and numbers	Greeno, 1964
Motor Tasks	
Koerth Pursuit rotary task	Dore & Hilgard, 1937, 1938

(table continues)

Mirror drawing	Tsao, 1948a
Printing the alphabet upside down	Kimble, 1949
Rotary pursuit task	Resick & Payne, 1978
Stylus to track a target revolving on a disc	Archer, 1958
Throwing a javelin at a target with the left hand	Murphy, 1916
Intellectual Skill Tasks	
Addition in math	Reed, 1924
Mazes	Culler, 1912
Puzzle cards	Jacoby, 1978
Puzzle solving	Cook, 1934

lapses of seconds to minutes is easy to manipulate in a lab setting and may be meaningful there, it is important to point out that merely differentiating by a few minutes, seconds, or items bears little relationship to real-world, classroom-based massing or distributing of practice. Often a person practicing learning tasks in a "massed mode" classroom setting will take breaks of a few seconds or even a few minutes, just due to fatigue.

A crucial problem illustrated here is that in many studies (see, for example, Jensen & Freund, 1981; Keppel, 1964; Kimble, 1949; McClelland, 1942), the distinction between massed and distributed practice in the laboratory does not equal a real-world, classroom-based distinction between massed and distributed practice. Many times the distributed practice laboratory condition is repeated alternations of 15 (or fewer) minutes of study and 5 (or fewer) minutes of rest, until 1 hour of study is completed. In real-world, classroom-based learning, this would be--or at least resemble--a massed practice approach. Longer intervals of study and "rest" would have to occur to simulate a true distributed practice approach in the classroom setting.

In short, most of the existing studies that examine the spacing effect in laboratory settings have little, if any, relevance for classroom practice, where "spacing" is more relevant to intervals of hours or days. However, because few studies of massed versus distributed practice have occurred in a classroom-based arena (Dempster, 1988), little is really known about the more typical distribution of practice versus massing of practice that takes place in the classroom. Thus, most of the previous studies do not shed light on the relative efficacy of massed versus distributed practice. The information they do provide is summarized in the following section.

Review of Studies with Elementary Children

This section contains information on the studies most directly relevant to this research. Most of the studies within the elementary school-age category are not true classroom-based studies; rather, they are replications of the laboratory studies conducted with college-age students, with the main difference being age of subjects and type of stimulus materials. Additionally, most studies of elementary school children are not clean tests of massed versus distributed practice. The authors seem to take for granted that distribution of practice has been proven to be effective and they design their studies to look at intricacies or further detail within practice conditions. Table 4 lists briefly the major variables within the studies. Unfortunately, only 9 of the 11 studies were directly relevant in that they directly tested massed versus distributed practice. These studies are summarized briefly in Table 4.

Table 4

Summary of Studies with Elementary School Age Children

Study	N	Grade of subjects	Stimulus condition	Spacing interval	Variable(s) of interest	Results
Cuvo, 1975	60	20 from fifth, 20 from eighth, 20 from college	Word lists (6 lists of 20 singular nouns)	5 seconds for distributed practice; 1 second for massed practice	Practice (Rehearsal), Gender, Grade	DP>MP, F (1, 48)=72.14, $p<.001$
Hohn, 1964	40	K (5.5 yrs old)	Word list of high- and low-frequency words	Not given in time; # of intervening words indicate practice condition; 9 words=massed; 3 rounds of 3 words with 4 intervening items=distributed	Type of frequency, Amount of repetition, Type of practice	DP>MP; High frequency word > Low frequency; More repetitions> Fewer reps; F (1, 38)=56.56, $p<.01$

(table continues)

Study	N	Grade of subjects	Stimulus condition	Spacing interval	Variable(s) of interest	Results
Rea & Modigliani, 1985	44	Third (8.5 yrs old)	5 multiplication facts; spelling lists of 4 words	Intervening (called here "distracting events") in between presentation and practice; spacing intervals in terms of time not given	Practice ("expanded" vs. massed)	Math: DP>MP F (1, 36)=24.35, p <.01 Spelling: DP>MP F (1, 36)=4.55, p <.05
Resick & Payne, 1978	40	Third & fourth (9.3 yrs)	USAF SAM Rotary Pursuit Test	MP=20 30 second trials; DP=20 30 second trials separated by 30 seconds	Practice; gender	DP>MP t(1, 35)=1.72, p <.05; Females "benefited more from DP than males"
Toppino & DiGeorge, 1984 (1)	20	Nursery (4.5 yrs old)	Word lists	Not given in time; No intervening items = massed; 3 intervening items = distributed	Practice; number of presentations	MP=DP, 47% recall for both
Toppino & DiGeorge, 1984 (2)	36	Nursery First	Word lists	Not given in time; No intervening items = massed; 3 items intervening = distributed	Practice; number of presentations	MP>DP (Nursery) DP>MP (First) F (1, 34)=7.56, p<.01

(table continues)

Study	N	Grade of subjects	Stimulus condition	Spacing interval	Variable(s) of interest	Results
Toppino & DeMesquita, 1984 (1)	36	First Third Sixth	Word lists	Not given in time; Lags of 0 (massed); 3 and 6 (distributed)	Practice; number of intervening items	6 lags (longer lags) > 3 (shorter lags) > massed (0) F (2, 102) = 7.26, p<.01
Toppino & DeMesquita, 1984 (2)	48	Third Sixth	Word lists; "Orienting questions" (asked subjects "Is it nice? Would you like to have it?" "Can you put it in a breadbox?")	Not given in time; Lags of 0 (massed); 3 and 6 (distributed)	Practice; number of intervening items; type of orienting questions	6 lags (longer lags) > 3 (shorter lags) > massed (0) F (2, 92) = 4.71, p<.05; Different orientation > same
Wilson, 1976	72	Fourth Eigth College	Word lists of 26 common, unrelated nouns from a pre-reader	Lags of 0 (massed), Lags of 2 (short), and 8 (long) (distributed)	Practice; lag length, age of S's	DP (LL) = DP (SL); DP (SL) > MP; DP (LL) > MP; F (1, 92) =23.97, p<.001

In summary, all studies were conducted in laboratory type settings, with none of them being classroom based. Most (five of the nine, including Cuvo, 1975; Hohn, 1964; Toppino & DiGeorge, 1984; Toppino & DeMesquita, 1984; Wilson, 1976) studies were in the verbal information domain, with word lists being the most typical stimulus condition. One study (Resick & Payne, 1978) used motor tasks. Rea and Modligliani (1985) possibly used a "lower level" intellectual skill task, specifically multiplication facts. This classification is hard to determine, since we have no thorough description of the treatment. Spacing intervals were not given in time, but rather in numbers of intervening items.

The first study that is directly relevant to the present study is one conducted by Cuvo (1975). One third of Cuvo's students were elementary aged (fifth graders). Cuvo assigned students to distributed practice conditions of 5 seconds or massed practice conditions of 1 second. Students in the distributed practice condition recalled more words ($\underline{F}$ (1, 48) = 72.14, $\underline{p}$ <.001).

The next relevant study is conducted by Hohn (1964). Forty kindergarten children were randomly assigned to high- and low-frequency word groups and massed versus distributed practice conditions. Frequency word groups referred to types of words used often in typical everyday English (for example, high-frequency words included such words as "mother," "horse," "table") versus what have been classified as lower frequency words (e. g., "witch," "candy," "monkey"). No information was presented on length of spacing interval. The dependent variable was number of words recalled. The author concluded that type of practice schedule was "highly significant" ($\underline{F}$ (1, 38) = 56.56, $\underline{p}$ < .01).

The exact recall per spacing condition is given below:

Two repetitions, massed practice	15% recall
Four repetitions, massed practice	27% recall
Two repetitions, distributed practice	29% recall
Four repetitions, distributed practice	50% recall

Distributed practice was more effective than massed practice in either the two or four repetitions mode.

The study conducted by Rea and Modligliani (1985) contained information most relevant to classroom practice. The researchers gave 44 third graders multiplication facts and spelling lists to learn in a massed or "expanded" (distributed) fashion. Though they used typical school content, they used a laboratory-type setting by using distracting or intervening events to determine the practice conditions. Rea and Modligliani found that distributed practice was more effective than massed in either spelling (F (1, 36) = 24.35, $p < .01$) or math conditions (F (1, 36) = 4.55, $p < .05$).

Resick and Payne (1978) used 40 students in third and fourth grade for a motor task (the USAF SAM Rotary Pursuit Test). The researchers did not describe or give reference to the exact treatment. The spacing intervals were twenty 30-second trials for massed practice and twenty 30-second trials, separated by 30 seconds for distributed practice. Resick and Payne were investigating the results of practice, with an additional covariate for gender. They found that distributed practice was more effective than massed practice (t (1, 35) = 1.72, $p < .05$) and that females "benefitted more from distributed practice than males" (p. 381).

Toppino and DiGeorge (1984) conducted and published two studies on nursery and first-grade students. They used word lists with intervening variables (0 intervening items indicated a massed practice condition and 3 intervening items comprised a distributed practice condition). Toppino and DiGeorge found in their first study that massed and distributed practice were equal (both groups recalled 47% of the words correctly). In study two, results showed that massed practice was superior to distributed practice with nursery school children and that the effect diminished and the spacing effect (favorability of distributed practice) emerged for first graders (F (1, 34) = 7.56, $p < .01$).

Toppino and DeMesquita (1984) also conducted and published two studies with the intent of replicating the results of the 1976 Wilson study. Wilson's earlier study used fourth-grade and older students and gave them no lags (massed), lags of 2 intervening items (short lag), or lags of 8 intervening items (long lag). The stimulus materials were word lists of 26 common, unrelated nouns from a pre-reader. Results showed that longer lag distributed was more effective than shorter lag distributed, and that shorter lag distributed was more effective than massed (F (1, 92) = 23.97, $p < .001$). Toppino and DeMesquita's first study (1984) showed an identical finding with spacings of 0, 3, and 6 (F (2, 102) = 7.26, $p < .01$).

The second Toppino and DeMesquita (1984) study coupled type of practice with the effects of "orienting questions." When memorizing word lists, subjects (third and sixth graders) were asked such questions as "Is this nice?" for the "nice" orienting questions, or "Can you put it in a breadbox?" for the "size" orienting questions. Results showed that longer lags were more effective than shorter lags. Both lags were more effective than massed practice (F (1, 92) = 23.97, $p < .001$). Orienting questions produced greater recall, regardless of type of orienting question or type of practice.

Final Implications of Prior Research

As can be seen in the literature cited in the prior sections, the majority of the previous studies on massed versus distributed practice must be viewed with caution due to the limitation of their not being a true test of how massed and distributed practice may affect learning in typical, real-world educational settings. Additionally, and equally important, the studies failed to examine possible limiting conditions (e. g., type of learning condition, age of the subject, intervening activities, length of spacing, and the like) of the spacing effect. The present study was designed to avoid these limitations.

CHAPTER III

METHODS AND PROCEDURES

Purpose and Objectives

The general purpose of this study is to test the effectiveness of massed versus distributed practice with early elementary (second-grade) and late elementary (fourth-grade) school children. Two conditions of learning were used and compared to each other. The two conditions include verbal information (reading) and intellectual skills (math) within a computer-assisted instructional integrated learning system (ILS). The rationale for selecting these particular conditions is that they represent conditions most typically taught in the school setting. While some schools have recently been exploring and including the cognitive strategy domains within their curriculum, verbal information and intellectual skills areas are the most typical learning tasks and are always present. The computer system (specifically, the ILS) was chosen to assure identical presentation of stimuli to subjects, except for the manipulation of the variable of interest.

The specific objectives of this study are as follows: (a) to determine the appropriate practice spacing intervals for elementary school-age children with regard to the verbal information and (b) to determine the appropriate practice spacing intervals for elementary school-age children with regard to the intellectual skill learning conditions. It is important to note here that practice and presentation have been termed "practice" throughout the literature. This is possibly due to the previously mentioned fact that it is difficult, if not impossible, to separate presentation from the actual practice. Throughout the earlier review of literature and the discussion of this study in this section, the label of massed or distributed "practice" is used rather than massed or distributed "learning." The rationale for this is to tie this study back to its most applicable antecedent literature and for parallelism with similar studies. Nonetheless, it is important to point out that either terminology is correct and acceptable.

Since relatively few studies have been done on elementary school children, second and fourth grades were selected. The rationale for selecting those grades was to select grades representing earlier elementary and later elementary school-age performance. Such representation would require that one class should come from either first, second, or third grade and one from fourth, fifth, or sixth grade. Second and fourth grade were selected because (a) they were the least often included in prior studies and (b) they do represent both the earlier and later elementary school years.

Research Questions

The research questions posed for this study were as follows:

1. In the learning of a verbal information task by second and fourth grade students, is the massed or distributed practice mode more effective in recall of content?

2. In the learning of an intellectual skill by second and fourth grade students, is the massed or distributed practice mode more effective in recall of content?

Although there is insufficient theory in this area to warrant the statement and testing of true research hypotheses, per se, it seems reasonable to predict that in verbal information areas (question 1), distributed practice will be more effective in the recall of content, while in the area of intellectual skills (question 2), massed practice will prove to be more effective in the recall of content.

Study Design

This section presents the basic study design for this experiment. Two learning conditions were used in this study: verbal information and intellectual skills. These two were selected due to the fact that they are the learning tasks most typically used in most public schools. Table 5 shows the design for the study.

The columns at the top of Table 5 give the two conditions of learning that are included in this study. Verbal information is represented by a reading task. Intellectual skills are represented by a math task. While it can be argued that reading does not necessarily represent a verbal information task (reading, may, in some instances, be an example of an intellectual skill or even a cognitive strategy), the principal investigator and a cognitive psychologist jointly coded the type of learning and the items on the test for their learning condition. A discussion of the finding will be given hereafter, after the specific learning stimulus has been presented. Suffice it now to say, however, that reading was most reflective of a verbal information task and math of an intellectual skill task. A posttest only, comparison group experimental design was used, with classes being randomly assigned to two treatment conditions (distributed and massed practice). A comparison group was used rather than a "control" group. Because it is axiomatic that practice of any type is better than "no practice," the control or absence of treatment was not considered to be necessary. The comparison, or A versus B design, allows for testing the relative efficacy of one type of treatment over another.

The rationale for selecting and randomly assigning classrooms instead of individual students to the treatment is to replicate true classroom practice and to facilitate the treatment by causing less disruption for the teachers or

Table 5

Study Design

	Learning Condition			
	Verbal Information (Reading)		Intellectual Skill (Math)	
	Practice Type			
Grade Level	DP	MP	DP	MP
2	Group A (N=60)	Group B (N=60)	Group A (N=60)	Group B (N=60)
4	Group C (N=60)	Group D (N=60)	Group C (N=60)	Group D (N=60)

Note. DP = Distributed practice
MP = Massed practice

classes, and therefore, ensuring treatment fidelity.

The independent variable is type of practice (massed or distributed). The dependent variables are performance on (a) a verbal information task and (b) an intellectual skill learning task.

Approximately 60 students (two classes) from second grade and 60 students from fourth grade were selected to be included in each of the two practice conditions. A total of 190 subjects actually participated in the study. Each student was tested on each of the learning conditions. Using the same subjects for both learning tasks reduces the need for larger numbers of subjects and causes less disruption in the classrooms when students are dismissed for the experiment.

Population and Sample

The target population for this research includes all school children throughout the United States in second and fourth grades. The experimentally accessible population consisted of students at Elizabeth Vaughan Elementary school in Woodbridge, Virginia.

Second- and fourth-grade students at Elizabeth Vaughan Elementary school were selected for the experiment. Students at that school come from a variety of socioeconomic status (SES) levels. Table 6 gives information on the demographics of Elizabeth Vaughan compared to national demography. These data are presented to provide a measure of degree of population validity in this study.

As shown in Table 6, this school is generally equivalent to the typical U. S. grade school. There is a slightly greater SES variety in this school than the national norm due, in large part, to the fact that it is a suburb of Washington, DC. Teachers at the school had a higher level of education, yet fewer years of teaching than the national average.

Learning Stimuli

Due to the previously mentioned limitation in prior studies that stimuli were not reflective of actual classroom tasks, the challenge of this research was to prepare and present actual classroom material. An integrated learning system (ILS) was selected to provide the stimulus or educational material for the study.

Table 6

Comparison of Demographics of Elizabeth Vaughan Elementary School and Average Elementary Schools Throughout the United States

Demographic characteristics	Elizabeth Vaughan	Typical U. S. elementary school
Geographic locale	Suburban	Suburban
Percent minorities	29.3%	29.6%
Percent female	55%	54%
Socioeconomic status	Mixed (Upper Mid - Low)	Middle
Number of students	610	609
Teacher:student ratio	1:24.8	1:18.1
Education of teachers	B. S.+ (42% M. S.)	B. S.
Years teaching experience	7	10 - 12

Note. Data in this table concerning the typical U. S. elementary school are from the Digest of Education Statistics, produced by the National Center for Education Statistics, 1992. Washington, DC: Office of Educational Research & Improvement.

Using such a computer-assisted instruction package helped to ensure that the material presented is (a) typical classroom instruction and (b) identical except for the spacing of the practice sessions. Each ILS learning unit has a test that has been developed for the learning task. Only one prior research study (Dellarosa & Bourne, 1985) mentioned using a personal computer; in that study, computer technology was used to present the stimulus to be learned by placing the sentences to be memorized on a computer screen. It should be noted that the intent is not to study the computer presentation as a variable, but rather to use the computer technology to keep all lesson presentations equivalent except for the spacing of presentation and practice under consideration in this study.

To maintain the integrity of the design for this study, it was imperative that the learning stimulus be one that the teachers were not planning to teach in that particular year. This was important to assure that the only exposure the students had to this content area was their exposure in the experiment, thus controlling as much as possible for the "history threat" to internal validity. To ensure that teachers were not going to cover the material, the school's teachers and lab manager met with the principal investigator to select lessons that were slightly advanced from where the students would be by the end of the year. The difficult task was to select lessons free from contamination, yet not too far beyond where the children would be by the end of the school year.

The lessons selected were on topics the teachers felt confident they would not cover, but that the students could comfortably grasp. A copy of the outlines of the learning units used is provided in Appendix B.

The principal investigator and a cognitive psychologist reviewed all lessons and tests and coded them according to the learning condition they represent. The two coders worked in unison to determine the type of learning condition as they worked through the tests. Most of the items were very straightforward and coders agreed 97% of the time on categorization of the items. Table 7 provides the results of the coding of the tests for the practice units selected.

Table 7

Percent of Test Items Within Each of the Possible Conditions of Learning

Grade/Condition	Verbal information	Intellectual skills	Cognitive strategy
Grade 2 Reading	94%		6%
Grade 2 Math	8%	72%	20%
Grade 4 Reading	83%	17%	
Grade 4 Math		100%	

Second and fourth grade reading have the majority of their items in the verbal information category (94% in grade 2 and 83% in grade 4). Second and fourth grade math have the majority of their items (72% and 100%, respectively) in the intellectual skill areas. Therefore, it can be concluded that in this case, math and reading are, respectively, good representations of intellectual skill and verbal information tasks. It is important to note, however, that reading has elements of higher order tasks such as intellectual skills and cognitive strategies, and math has elements of cognitive strategy as well.

Procedures

The presentation of the stimulus material occurred two times a week for 9 weeks. Table 8 shows how the material was presented in the distributed and massed conditions.

The study was designed so that each group (A-D) would include 60 students, 30 in each of two classes. Groups A and B were second-grade students, while C and D were fourth-grade students. In Group A, second-

Table 8

Stimulus Presentation Schedule (Per Week)

Day 1		Day 2	
Massed Practice (Groups B and D)			
Reading (30 mins)		Math (30 mins)	
Distributed Practice (Groups A and C)			
Reading (15 mins)	Math (15 mins)	Reading (15 mins)	Math (15 mins)

grade students received the distributed practice condition (15 minutes of reading, followed by 15 minutes of math) each day at the computer, twice a week, until the unit was completed. Their second-grade counterparts, Group B, received the massed practice mode of 30 total minutes of reading for 1 day at the computer, and 30 total minutes of math for another day.

The same design was repeated for fourth graders, with Group C members receiving the distributed mode and Group D members receiving the massed practice condition.

Students went to the computers during their normal 30-minute time block assigned to them. Most classes arrived on time due to the eagerness of the students to participate with the ILS. Students did not know that they were part of an experiment. The lab manager was there to assist students. Just prior to students arriving or as students got settled, the lab manager prepared for the ILS lessons. The lab manager programmed the computers the night before to conform to the study design and to ensure that students received their 30-minute allocated schedule. Students interacted with the computer during their lessons. Appendix B shows an outline of the content students were learning and practicing on the computers.

Instrumentation

Outcome measures used in previous studies were examined; most were simple repetition tasks (oral or written). No formal measures were used; hence no published tests were available to use in this study, and no reliability or validity data were available.

The computerized ILS unit tests for the learning materials chosen were the tests used for this study. These tests were developed for the corporation's ILS by a team of instructional designers and measurement specialists. Tests cover 8 to 10 units of instruction and contain 20 to 25 multiple-choice items. The tests were administered on the computer. The exact tests used are those that accompany the lessons chosen for the study.

Students were posttested immediately after the treatment on the next assigned computer time after the conclusion of the study. Such data provide information on initial learning. Follow-up testing was not feasible due to the limitation of having just one version of the test. Using the same test for follow-up would have caused a testing threat to the validity of the study.

Pilot Study

A pilot study was conducted at Pleasant Green Elementary School in Magna, Utah to test: (a) the requirements to program the computer; (b) the approximate time it would take students to complete the experiment; and (c) difficulties encountered that would guide the actual experiment to be held subsequently in Virginia. The pilot study used third- and sixth-grade students for a reading and math task appropriate to their grade levels. Duration of the pilot was 7 weeks. Intensity of the treatment was three times a week for 45 minutes at the computers.

Several findings from the pilot were used to facilitate the actual study being carried out successfully. Findings included the necessity to have a lab manager take responsibility for programming computers and to assist in encouraging teachers to have their students attend the lab. Additionally, it was necessary to hire the lab manager for evening work to program the computers for the experiment. The level of involvement required time tracking and financial reimbursement to encourage the lab manager to continue to operate within the prescribed experiment.

CHAPTER IV

RESULTS AND DISCUSSION

Duration of and Fidelity to the Treatment

The actual duration of the experiment was 9 weeks. All classes assigned to participate in the study attended the computer sessions twice per week as intended, with the exception of occasional assemblies, field trips, or technical problems with the computers. The experimenter visited the school once per week at unannounced times to check for treatment fidelity. Visits occurred at various times ranging from early morning to late afternoon, Monday through Friday, so that no pattern of visitation could be detected. Rationale for this was so that the lab manager would not be able to predict the visit and would thus be more on target with the treatment. Additionally, treatment fidelity was empirically assessed by measuring the percentage of completion of the review modules prior to the test. Analyses are presented later in the chapter comparing various levels of adherence to treatment conditions.

As was learned from the pilot study, a lab manager must take responsibility for programming the computers and helping to ensure that the students remain within their assigned experimental conditions. Therefore, the principal investigator worked closely with the lab manager at the Elizabeth Vaughan School to assure adherence to the prescribed experimental treatment.

The vast majority of the students did participate in the experiment. The only exceptions included those participants lost due to normal attrition, caused by factors such as illness or other causes for absence during the testing time, or a move from the area.

The independent variable in this study is the type of practice condition (massed vs. distributed). Dependent variables were scores on a reading and math test. Data were keypunched and proofed by two persons to assure accuracy. Data were analyzed using the Statistical Package for the Social Sciences (SPSSPC for Windows) and the Statistical Analysis System (SAS) for the mainframe.

Results for the Verbal Information (Reading) Test

Table 9 shows the reading test score means, standard deviations, and number of students for each class involved in the experiment. The reading test scores for the second grade fell within the 60% - 70% range. Fourth-grade

Table 9

Descriptive Information for Scores on the Reading Test

Teacher	Grade	Practice Type	M	SD	N
Mosby-White	2	Massed	69.94	24.79	18
Spillers	2	Massed	65.13	20.13	24
Morris	2	Distributed	62.43	18.91	21
Dorton	2	Distributed	67.09	21.87	22
Jackson	4	Massed	87.33	15.95	18
Atwood	4	Massed	96.00	5.05	13
Hickles	4	Distributed	90.61	13.47	23
Weiggands	4	Distributed	88.70	10.50	20

reading scores ranged from high 80% to mid 90%. Table 10 shows the consolidation of the classroom data within grades and provides the comparison of massed versus distributed practice.

Contrary to typical findings summarized in the review of the literature, these findings show that the spacing effect does not hold with either the second- or fourth-grade students. Indeed, from inspection of the means we see that massed practice is slightly superior in both grades. Students in the fourth grade scored higher than students in the second grade on different tests, with each expressed as a percentage. One test for the difference between means is shown in the effect size (ES) column in Table 10.

Effect sizes (Glass, 1976) give the practical or educational significance of the results of a study. They are equivalent to the number of standard deviation differences between two or more groups. If the effect size (ES) of a

Table 10

Means, Standard Deviations (SDs), Ns, and Effect Sizes for Scores on the Reading Test

	Practice Condition						
	Massed			Distributed			
Grade	M	SD	N	M	SD	N	ES
2	67.19	22.09	42	64.81	20.37	43	+.11
4	90.97	13.16	31	89.72	12.08	43	+.10

comparison was +.50, the first group (group A) would be larger than the second group (group B) by approximately one half of a standard deviation. Taking IQ as an example, the published test standard deviation of an IQ test is typically 15 points. If an experimental group's effect size were +1.00 over the comparison or control group, individuals within the experimental group are, on average, one standard deviation, or 15 points higher, than their counterparts in the comparison group. If the effect size were -1.00, the comparison group students were, on average, 15 points higher that those involved in the experiment. The formula for computing a standardized mean difference effect size is: Experimental group mean minus the control or comparison group mean, divided by the standard deviation of the control group (or the pooled standard deviation of the comparison and experimental groups).

$$ES\,(\Delta) = \frac{\underline{M}\ \text{EXPERIMENTAL} - \underline{M}\ \text{CONTROL OR COMPARISON}}{\sigma\ \text{CONTROL OR POOLED EXPERIMENTAL \& COMPARISON}}$$

The primary impetus to use effect sizes is that such indices of between-group differences are meaningful, irrespective of sample sizes. Since statistical significance tests are a function of sample size, the effect size provides a clearer picture of differences.

Effect sizes calculated from this study show a tenth of a standard deviation favorability to massed practice. This is a small difference, although it can be seen as practically or educationally significant, since the cost of implementing either of the two practice strategies is the same. The key to the determination of the practical or educational significance of an effect size is really a cost-benefit decision. If a teacher takes 5 seconds to write "Please stay in your seats" on the chalkboard and makes a +.25 effect size difference (with one standard deviation equal to 8 students) in in-seat classroom management behavior, the intervention has been worth its while (at least 2 students have been affected), and the effect size is practically or educationally significant. Conversely, if a new cancer treatment promises additional time to a terminally ill patient, with a standard deviation equal to 3 years of life, and the treatment costing $800,000, an effect size of +1.00 (or an additional 3 years of life) may not be practically significant. An individual might want an average of 10 or more years before investing such money. Since the treatments "cost" the same amount of money and time in this experiment, one tenth of a standard deviation difference could arguably be considered practically or educationally significant.

A multivariate analysis of variance (MANOVA) was performed to answer the research questions of the study and to test for the statistical significance of the differences found between the two practice conditions. Such an analysis allows for testing main effects and potential interactions of the main effects for two or more dependent variables. Potential interactions of practice condition by grade level were not tested in this study because different tests were used for each grade. If the same test or a standardized test had been used, such interaction effects could have been tested. Because the intent of the research was to look at actual classroom practice, the identical or standardized test would not be typical, nor, in this case, feasible.

MANOVA was chosen over repeated-measures analysis of variance (ANOVA) since there was only one testing time per dependent measure per student. Repeated-measures ANOVA would be more appropriate for multiple testing times per dependent measure, such as an immediate and delayed posttest.

The MANOVA test for the main effect of practice for second graders ($p = .2321$) was not statistically significant. The MANOVA test for practice for fourth graders ($p = .8605$) was also not statistically significant. To break the MANOVA down to examine the data more fully, a one-way analysis of variance (ANOVA) was performed for each grade level on both dependent measures. Table 11 shows results of the analysis of variance for the reading test dependent measure.

Table 11

Analysis of Variance for Practice for Second and Fourth Grade Scores on the Reading Test

Source of Variation	SS	df	MS	F	p
Second grade					
Between Groups Practice	120.00	1	120.00	.2661	.6073
Within Groups	37430.99	83	450.98		
Total	37550.99	84			
Fourth grade					
Between Groups Practice	28.00	1	28.00	.1781	.6743
Within Groups	11323.62	72	157.27		
Total	11351.62	73			

As can be seen in Table 11, there is no statistically significant difference for the main effect of practice for either second- ($\underline{F}$ (1, 83) = .2661 , $\underline{p}$ = .61) or fourth-grade students ($\underline{F}$ (1, 72) = .1781, $\underline{p}$ = .67).

Results for the Intellectual Skill (Math) Test

Math test means, standard deviations, and numbers of students are given in Table 12. Second-grade math scores ranged from high 60% to mid 70%. Fourth-grade scores ranged from high 40% to mid 50%.

Table 13 shows the overall grade by practice condition comparison for math scores. As shown in the effect size on Table 13, the difference is +.19, or one fifth of a standard deviation higher than the distributed practice

Table 12

Descriptive Information for Scores on the Math Test

Teacher	Grade	Practice Type	M	SD	N
Mosby-White	2	Massed	72.83	17.63	23
Spillers	2	Massed	75.50	14.79	24
Morris	2	Distributed	69.77	14.60	22
Dorton	2	Distributed	72.27	20.63	22
Jackson	4	Massed	50.92	16.01	24
Atwood	4	Massed	50.71	9.76	7
Hickles	4	Distributed	49.09	13.94	22
Weiggands	4	Distributed	54.41	10.59	17

Table 13

Means, Standard Deviations (SDs), Ns, and Effect Sizes for Scores on the Math Test

	Practice Condition						
	Massed			Distributed			
Grade	M	SD	N	M	SD	N	ES
2	74.19	16.12	47	71.02	17.70	44	+.19
4	50.87	14.68	31	51.41	12.72	39	-.04

condition. This is consistent with the advantage of massed practice over distributed practice shown in prior intellectual skill areas. Also important to note is the fact that second graders consistently scored higher in math, regardless of placement within practice condition. Once again, this could be due to the more engaging earlier grade lessons or the better fit of the curriculum to the ability level of the students.

The MANOVA test for practice for second graders ($p = .2321$) was not statistically significant. The MANOVA test for practice for fourth graders ($p = .8605$) was also not statistically significant. Table 14 shows results of the analysis of variance for the math test dependent measure for second and fourth grades.

Again we see that there are no statistically significant differences with regard to practice condition in either second grade (F (1, 89) = .7985, $p = .3739$)

Table 14

Analysis of Variance for Practice for Second- and Fourth-Grade Scores on the Math Test

Source of Variation	SS	df	MS	F	p
Second grade					
Between Groups Practice	228.19	1	228.19	.7985	.3739
Within Groups	25432.25	89	285.76		
Total	25660.44	90			
Fourth grade					
Between Groups Practice	5.02	1	5.02	.0271	.8698
Within Groups	12612.92	68	185.48		
Total	12617.94	69			

or fourth grade (F (1, 68) = .0271, p = .8698). In this case, as mentioned earlier, second-grade students outperformed their fourth-grade peers.

Additional Analyses

Beyond the research questions of the study, additional analyses were performed for the purpose of exploring the data to see what other patterns or findings evolve. The first analysis was a comparison of unit practice items with the overall test.

While in the computer sessions, students were actively engaged in practice as material was presented to them. The engagement came in the form of questions or problem-solving opportunities. Scores on the questions or items embedded within the unit questions are provided in Tables 15 and 16.

Table 15 shows the individual unit and total test scores for the reading units. The unit/grade is presented on the far left-hand side of the table. Means, standard deviations, and frequency (N) per cell are given for both the massed and distributed practice conditions. Separate one-way analyses of variance were calculated for each of the unit tasks per grade. The probability level (p) from the ANOVAs is given, followed by a standardized mean difference effect size (ES). A positive effect size means that massed practice is superior, while a negative effect size connotes the superiority of the distributed practice condition. The correlation (Pearson product-moment correlation coefficient, represented in the table as r) of that unit to the overall test is given after the effect size. The last column to the right in the table is the probability level for the unit-total test correlation. Table 16 presents the same information for the math learning units.

From both tables we see that there is a very high and statistically significant correlation between most individual unit scores and the total test scores. This provides an index of reliability, specifically equivalence, of unit tasks and the overall test. Students are performing in a similar fashion for both the unit tasks and the test.

The next set of analyses was performed to determine if greater adherence to the treatment (being defined as number of units completed prior to the test) produced better scores and, if so, had an effect on the statistical significance of the main effects. To do so requires examination of the frequency of number of units completed and mean scores for those

Table 15

Means, Standard Deviations, Ns, Probability Ratios, Effect Sizes, and Correlation Coefficients for the Different Practice Exercises Within Reading Units

	Practice Condition									
	Massed			Distributed						
Unit/ grade	M	SD	N	M	SD	N	p	ES	r	p
1/2	88.52	12.03	44	88.09	11.46	47	.86	+.04	.47	<.01
4	79.54	19.34	39	82.17	14.31	42	.49	-.16	.43	<.01
2/2	88.53	8.85	45	87.40	10.10	47	.57	+.12	.60	<.01
4	90.45	12.68	38	92.10	9.83	41	.52	-.15	-.12	.33
3/2	95.60	4.60	42	93.96	7.50	46	.22	+.27	.20	.09
4	80.83	21.09	35	79.05	23.44	42	.73	+.08	.41	<.01
4/2	95.67	5.94	33	95.89	5.24	44	.86	-.04	.54	<.01
4	91.63	12.88	32	93.78	7.84	41	.38	-.21	.52	<.01
5/2	79.00	13.17	21	75.20	16.20	41	.36	+.26	.63	<.01
4	86.83	8.77	23	87.65	9.94	34	.75	-.09	.53	<.01
6/2	93.52	8.17	17	94.46	7.41	37	.68	-.12	.32	.03
4	75.83	19.69	18	69.81	17.53	32	.27	+.32	.20	.19
7/2	86.28	14.93	18	92.37	12.21	27	.14	-.45	.57	<.01
4	82.50	20.39	12	86.35	17.41	26	.55	-.20	.50	<.01
8/2	98.45	5.13	11	97.73	5.98	15	.75	+.13	-.06	.79
4	75.50	18.36	10	84.35	17.57	20	.21	-.49	.45	.02
9/2	93.40	7.00	10	94.43	10.03	7	.81	-.12	.43	.11
4	67.00	22.80	4	78.50	11.33	10	.22	-.97	.04	.90
10/2	88.38	14.51	8	100	--	1	.47	-1.60	.77	.02
/4	66.00	48.08	2	84.43	11.34	7	.31	-.62	-.09	.83
Test 2	67.19	22.09	42	64.81	20.37	43	.61	+.11	--	--
Test 4	90.97	13.16	31	89.72	12.08	43	.67	+.10	--	--

Note. Ns for the correlation will be smaller than the total Ns shown because the correlation shows the relationship of the completion of each task with the total test score.

Table 16

Means, Standard Deviations, Sample Sizes, Probability Ratios, Effect Sizes, and Correlation Coefficients for the Different Practice Exercises Within Math Units

	Practice Condition									
	Massed			Distributed						
Unit/ grade	M	SD	N	M	SD	N	p	ES	r	p
1/2	88.02	10.14	47	86.02	11.92	47	.38	+.18	.50	<.01
4	75.64	7.41	42	79.55	9.28	33	.05	-.47	.50	<.01
2/2	72.17	12.72	48	74.13	14.44	46	.49	-.14	.42	<.01
4	78.17	10.22	42	80.30	10.46	33	.38	-.21	.57	<.01
3/2	91.57	6.48	44	92.15	6.62	46	.67	-.09	.47	<.01
4	75.64	9.62	42	77.64	8.37	33	.35	-.22	.48	<.01
4/2	66.51	18.65	43	62.67	16.37	46	.30	+.22	.16	.14
4	73.39	11.77	36	68.97	14.37	32	.17	+.34	.59	<.01
5/2	62.24	11.96	41	62.93	14.78	46	.81	-.05	.17	.13
4	63.05	13.43	19	62.54	11.24	28	.89	+.04	.41	.01
6/2	72.50	15.87	36	74.78	12.43	36	.50	-.16	.40	<.01
4	71.50	10.08	4	73.42	7.40	24	.65	-.22	.13	.54
7/2	75.97	12.13	29	80.26	11.97	31	.17	-.35	.40	<.01
4	79.00	--	1	75.16	9.64	19	.70	+.80	.60	.01
8/2	75.04	13.58	24	80.95	13.43	20	.16	-.43	.43	<.01
4	--	--	--	--	--	--	--	--	-.05	.87
9/2	82.00	8.07	21	85.00	12.52	9	.44	-.32	.38	.04
4	--	--	--	--	--	--	--	--	.32	.40
Test 2	74.19	16.12	47	71.02	17.70	44	.37	+.19	--	--
Test 4	50.87	14.68	31	51.41	12.72	39	.87	-.04	--	--

Note. Ns for the correlation will be smaller than the total Ns shown because the correlation shows the relationship of the completion of each task with the total test score.

completing the different numbers of units.

Table 17 shows the percentage of completion of individual reading units. The number of reading units completed prior to the test varied greatly. Mean scores and standard deviations are given per number of units completed. Upon inspection of the data, there is no clear pattern of "greater adherence" to the unit lesson tasks producing higher reading test scores. To

Table 17

Descriptive Information on Reading Units Completed

Number of units completed	Number of Students	Percent of Students	Cum-ulative %	M	SD
0	13	6.8	6.8	75.28	26.39
1	2	1.1	7.9	100.00	--
2	8	4.2	12.1	66.25	25.20
3	12	6.3	18.4	86.20	11.65
4	35	18.4	36.8	79.75	18.96
5	15	7.9	44.7	74.18	28.42
6	25	13.2	57.9	62.85	26.17
7	29	15.3	73.2	74.04	19.50
8	25	13.2	86.3	80.85	17.76
9	13	6.8	93.2	91.64	9.64
10	13	6.8	100.0	84.42	15.96

test this notion, an analysis of covariance (ANCOVA) was performed (see Table 18). The number of reading units completed was used as the covariate in this analysis. The analysis permits the comparison of the various test scores as a function of number of units completed. The purpose of the analysis was to statistically test the difference in reading test scores as a function of the number of reading test units completed. The potential impact of the number of units completed on total test score was not statistically

Table 18

Analysis of Covariance for Individual Unit Reading Tests for Second- and Fourth-Grade Students

Source of Variation	SS	df	MS	F	p
Second Grade					
Covariates					
Number of Reading Units	1122.77	1	1122.77	2.56	.115
Main Effects					
Practice	354.02	1	354.02	.800	.374
Fourth Grade					
Covariates					
Number of Reading Units	124.41	1	124.41	.789	.377
Main Effects					
Practice	4.898	1	4.898	. 031	.861

significant in either the second ($F = 2.56$, $p = .115$) or fourth ($F = .800$, $p = .374$) grades. This finding is not surprising due to the fluctuation of scores as shown in Table 17. Essentially, there was not a statistically significant pattern of greater achievement with number of lessons completed.

Table 19 shows the percentage of completion of individual math units. Means and standard deviations per number of units completed are also shown. From these data, we see that scores increased with the number

Table 19

Descriptive Information on Math Units Completed

Number of units completed	N	Percent of students	Cumulative %	M	SD
0	18	9.5	9.5	58.33	21.19
1	1	.5	10.0	100.00	--
2	4	2.1	12.1	64.00	6.93
3	8	4.2	16.3	43.75	15.06
4	24	12.6	28.9	52.22	13.42
5	36	18.9	47.9	58.46	15.25
6	21	11.1	58.9	64.12	20.10
7	22	11.6	70.5	65.24	17.64
8	20	10.5	81.1	74.12	15.74
9	36	18.9	100.0	72.94	18.30

of units completed, beginning with unit 3 and continuing through unit 8.

Once again an ANCOVA was performed to show the statistical significance of number of math units completed compared to the total test score. This time, however, the effect was statistically significant ($F = 4.10$, $p = .047$) for fourth graders. The effect approached significance for second graders ($F = 1.75$, $p = .189$) (see Table 20). The statistically significant effect for fourth graders and the near statistically significant effect for second graders give credibility to the fact that greater adherence to the math treatment potentially

Table 20

Analysis of Covariance for Individual Unit Math Tests

Source of Variation	SS	df	MS	F	p
Second Grade					
Covariates					
Number of Math Units	496.96	1	496.96	1.75	.189
Main Effects					
Practice	175.48	1	175.48	.619	.433
Fourth Grade					
Covariates					
Number of Math Units	726.73	1	726.73	4.10	.047
Main Effects					
Practice	.584	1	.584	.003	.954

may produce higher scores. These findings give credence to the notion that a more intense treatment might have produced a statistically significant effect for massed practice in intellectual skill domains.

CHAPTER V

SUMMARY AND CONCLUSIONS

This chapter presents a summary of the major findings of this study. Also presented are implications for educational practice and delimitations to the present study, as well as calls and suggestions for further research.

Key Findings

Two research questions were addressed. Each research question will be reiterated and major findings pertinent to each question will be summarized in this section.

1. In the learning of a verbal information task by second and fourth grade students, is the massed or distributed practice mode more effective in recall of content?

Given the weight of the evidence in the research literature cited in Chapter II, one might have anticipated that the distributed practice mode would be more effective in recall of verbal information content. Results of the present study, however, show massed and distributed practice to be fairly equally effective with a very slight advantage in massed practice (effect sizes of +.11 for second graders and +.10 for fourth graders). The spacing effect does not hold in this instance. Although this does not confirm prior findings, these results are not entirely suprising for two major reasons. First, there is some evidence in the literature that the spacing effect emerges with development (see, for example, Toppino & DeMesquita, 1984; Toppino & DiGeorge, 1984) and that younger children perform better in a massed rather than in a distributed mode (Toppino & DiGeorge, 1984). Previous researchers have shown the spacing effect to become noticeable and replicable at approximately grade nine (Ornstein et al., 1975, 1977).

Secondly, the assigned reading tasks were coded as verbal information; however, they are higher order verbal information approximating intellectual skills much more so than the typical tasks in the massed versus distributed practice literature. Typical tasks found in previous studies include reciting words or memorizing spelling. Reading, while still being verbal information in this case, assimilates several verbal information subcategories and forms the top of the list of competence in this area. It can be concluded from this study, therefore, that given the choice, reading tasks are just as effective, and slightly preferable, in a massed mode. Caution should be taken not to discount prior studies and to continue to use distributed practice for "lower level" verbal information tasks, such as memorization of facts.

2. In the learning of an intellectual skill by second and fourth grade students, is the massed or distributed practice mode more effective in recall of content?

Because 67% of the literature dealing with intellectual skills showed that massed practice was equal to or greater than distributed practice, one could expect that massed would also be greater in the present study. Though the differences were not statistically significant (probably due in large part to the small Ns), they were in the direction expected. These findings show a moderate effect size difference for second graders (+.19) and for massed practice to be fairly equal to distributed practice in fourth-grade math (-.04). Much like the Toppino and DeMesquita (1984) study, we again see the superiority of massed practice diminish as age increases.

Additional exploratory analyses show a high and statistically significant correlation between the majority of the individual unit tasks and unit tests. It was also shown that greater adherence to the treatment produced higher math test scores. The practice main effect for intellectual skills more closely approximated statistical significance when the number of unit tasks completed was used as a covariate in the analysis. This finding, along with the moderate effect size favoring massed practice for the math test, warrants serious consideration of the use of massed practice in higher order skills, such as intellectual skills.

Implications for Educational Practice

From the literature review and analysis presented earlier in this manuscript, accompanied with the findings of this study, several implications for practice within the school setting should be noted. First, this study shows that massed practice is equal to or greater than distributed practice for intellectual skill-type learning. It is important, therefore, to note such in educational psychology textbooks and apprise teachers while in training to incorporate a massed practice approach in this type of learning in their classrooms whenever possible. Second, massed practice is acceptable as a means for performing higher level verbal information tasks, such as reading. Third, as upheld in the literature, students should continue to use distributed practice when memorizing facts, learning simple ideas, learning new vocabulary, and the like.

Teachers should be taught the categorization of different conditions of learning and be provided with guidelines for the appropriate types of practice within each learning condition.

Limitations of This Study

No research study is perfect, and there are lessons learned from this study that need to be identified and taken into consideration when planning further similar educational research. Some of the very strong points of this study led to trade-offs in other areas. The best example of this trade-off is the fact that using a treatment isolated from historical effects through an ILS lessened the opportunities for flexibility in measurement, and therefore analysis.

In looking back on the whole experience, the experimental design and the actual experimentation, critiquing this study in terms of threats to internal and external validity will enable a close examination of possible weaknesses. With this in mind, each of the potential threats is examined. Limitations and suggestions for how to avoid them in further studies are also given.

Differential selection. Selection is not a threat to validity nor a weakness in this study. Classrooms were heterogeneous and were randomly assigned to treatment conditions.

History. History was controlled for in two ways, including: (a) using an integrated learning system that would assure the equivalent presentation of the material and keep extraneous factors constant and equal for both comparison groups, except with regard to the variables of interest, and (b) selecting curricula in advance of what the students were expected to know. Topics were chosen that were not covered and were not planned to be covered within the class curriculum. The teachers verified that the subjects should not be too far beyond the mastery of the children. Given the low test scores in several areas, it does appear that the teachers overestimated the ability of the students. This is not a threat to history, but should be considered when critiquing this study.

Maturation. Due to the short nature of the treatment, maturation should not be a threat to the validity of this study. Most importantly, there is no evidence that the two groups "matured" at a differential rate.

Experimental mortality. The vast majority of the subjects did complete the treatment. Somewhat fewer of the subjects completed the experiment in the massed mode, however. This represents a potential threat to validity because there was differential mortality in this one practice condition. The threat is small, however, due to the very high percentage of completion of the lessons overall. The worst case scenario here is the potential that the loss of data could have caused lessened statistical power and increased the chance of a Type II error.

Testing. Testing was not a threat to the validity of this study because students received the test one time only. Having used the same test as a pretest or a follow-up measure would have warranted concern for potential practice effects of testing. Practice effects would have been very likely considering the unique way of presenting the tests. There is good cause to believe the students would have remembered the items.

Preferably, in future studies, use of a pre-/posttest with alternative forms will give pre-/posttest gain scores, while controlling for potential practice effects of testing.

Instrumentation. Instrumentation may be a moderate threat to the validity of this study. Published tests that were judged to possess adequate content validity were used. Due to the nature of the computerized testing process and its inability to provide item-by-item scores, the reliability of this measure (specifically, internal consistency) in this experimental situation is not known. We do have evidence, however, of the equivalence of the unit tasks with the overall tests.

The worst case scenario here is the fact that rather than tests not being adequate or misused, we simply are not given as much flexibility in terms of data analysis and cannot probe for item or subtest differences. It is suggested that for future studies a paper-and-pencil test or a more sophisticated computerized test reporting procedure be used.

Regression toward the mean. Because there was only one testing period, regression toward the mean is not an issue.

A positive case for external validity is the evidence of population validity given in Table 6 earlier in this manuscript. Demographics for students at Elizabeth Vaughan School in Virginia are very similar to the demographics of the typical U. S. elementary school student. This strengthens the generalizability of the findings.

The most significant threat to the external validity of the experiment would be in terms of a weaker-than-anticipated treatment. Due to the size of the school and the limited number of computers, students could only attend the computer lab twice per week. While the experiment continued until a unit was completed, having the students attend more frequently and having gone through several units would have provided stronger data. While this is a potential concern, it is important to keep in mind that this study goes well beyond most published studies involving only a few minutes to 2 hours of intervention. Despite some of the limitations of the present study discussed previously, this study does more closely approximate practice in the school setting than most of the vast literature published in this area. Still, if we are to make the case for the students in the schools, we must replicate those situations as closely as possible.

Calls for Further Research

This study helps to shed light on many areas for further research within educational psychology. First, replication using different age learners and differing learning conditions would be of merit. Keeping in mind the suggestions from the limitations section would help to overcome some of the weaknesses of this research. Additionally, recalling from Table 2, there are several areas that are barren of research and lie waiting to be explored.

Before proceeding, however, it would be optimal to have a proper and standard definition of massed versus distributed practice. This will provide a better framework for the research design. Secondly, studies must continue to be brought out of the lab and conducted within the school settings. Researchers could design more studies in the elementary, middle, and high-school settings; as well as look at adult learners and learners in corporate training environments. The entire cognitive strategy and affective areas are promising new areas for research. Cognitive strategy practice research would be a very interesting and timely area, given the fact that more schools are recognizing and teaching such strategies.

Additionally, with the popularity of learning styles research, it would be most appropriate to add (once we have usable, valid measures) and counterbalance for not only age and learning condition, but learning styles as well. After examining these variables, we will be in a position to provide prescriptions to practitioners and be better able to assist learners of all ages, learning styles, and conditions to best learn their intended subjects.

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Zimmerman, J. S. (1973). The effect of massed and distributed presentations in free-recall learning: A test of the attentuation-of-attention hypothesis. Unpublished doctoral dissertation, Northwestern University, Evanston, IL.

Zimmerman, J. S. (1975). Free recall after self-paced study: A test of the attention explanation of the spacing effect. American Journal of Psychology, 88(2), 277-291.

APPENDICES

APPENDIX A

Review of Literature Coding Form

Coding Sheet for MP/DP Literature Review

Bibliographic information:

Study Number: ____________ *Page*______*of*________

	Massed	*Distributed*	*Comparison*
1. Grade/Age of subjects			
2. Number of subjects			
3. Percent female			
4. Setting (L=Laboratory; C=Classrom; O=Other -- explain)			
5. CAI application (Y=Yes; N=No)			
6. Intensity of practice (minutes)			
7. Duration of practice (days)			
8. Intensity of spacing interval (minutes)			
9. Duration of spacing interval (days)			
10. Activity during spacing interval			
11. Outcome measure(s) used			

Definition of massed practice:

Definition of distributed practice:

Definition of comparison group:

Subject area used:

Learning stimulus used:

Type(s) of learning varieties involved: (Circle all applicable varieties)
Verbal information
Intellectual skill
Cognitive strategy
Motor
Attitude

Type of experimental design: ______________________________

Blind testing? _____Yes _____No

Individual testing______ or Group testing________
Time of testing:________Pre/_______Post/______Follow-up

Reliability evidence of test(s):

Validity evidence of test(s):

Source of subjects:________________Sample_____or whole population_____
Random selection?__________Yes__No Random assignment?___Yes
_____No__

Threats to Internal Validity (0=not a threat; 1=minor threat; 2=major threat; 3=critical flaw --could have accounted for all of the results)

_____History
_____Maturation
_____Mortality
_____Regression
_____Selection
_____Testing
_____Instrumentation

_____Inappropriate statistical procedures
_____Description of sample/tmt/analysis
Adequacy of info about:
_____Subjects
_____Treatment
_____Design and analysis
_____Other (specify)__________________

Overall index of **validity of study** (1=excellent; 2=good; 3=fair; 4=poor; 5=very poor) ______

Comparison	Statistical	ES	Source of ES
1.			
2.			
3.			
4.			
5.			
6.			

Author's comments:

APPENDIX B

Outline of the ILS Learning Units

READING ABOUT ANIMALS: Science

03ER0601
PLURALS

- reviews how to make words plural by adding s, es, or changing y to i and adding es
- teaches plural endings for words ending with f
- teaches words that are exceptions to the above rule
- vocabulary: beds, boxes, balloons, parties, cars, trucks, buses, foxes, puppies, rabbits, wolves, loaves, calves, shelves, leaves, roots, chiefs, wives, lives, knives

----

03ER0602
WORDS IN CONTEXT:
SPIDERS

Vocabulary

- explains how to use context to determine word meaning
- provides practice with determining word meaning using context
- provides practice with comprehension utilizing a close format
- vocabulary: enemies, covering, hatch

03ER0603
MAIN IDEA & DETAIL:
GARTER SNAKE

Comprehension

- defines main idea
- teaches how to find the main idea in parts of a story
- provides practice with identifying the main idea in parts of a story

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03ER0604
VOCABULARY
DEVELOPMENT:
GARTER SNAKE

Vocabulary

- teaches how to use context to determine word meaning
- provides practice with using context to determine word meaning
- utilizes a multiple-choice format

03ER0605
FOLLOWING
DIRECTIONS:
BIRDSEED GARDEN

Comprehension

- provides practice with comprehension of expository text
- provides practice with literal comprehension
- focuses on sequencing and following directions
- branches to reteaching and enrichment

03ER0606
CAUSE & EFFECT

Comprehension

- teaches how to identify cause-and-effect relationships
- provides practice identifying cause-and-effect relationships

---

03ER0607
CAUSE & EFFECT

Comprehension

- reviews how to identify cause-and-effect relationships
- provides practice with identifying cause-and-effect relationships
- text: *The True Book of Bacteria,* by Anne Frahm.
  Copyright: 1963, Children's Press, 1224 West Van Buren St., Chicago, IL.
- utilizes hypervoice to hear difficult words

03ER0608
CONTENT AREA
READING: MUDSKIPPER

Comprehension

- explains how to identify irrelevant information in a story
- provides practice with identifying irrelevant information in a story
- presents a factual story about the mudskipper fish

03ER0609
CONTENT AREA
READING: CAVES

Comprehension

- provides practice with literal comprehension of expository text
- presents questions in a true/false format before and after the student has read the text

---

03ER0610
TABLE OF CONTENTS

Study Skills

- teaches how to use a table of contents for locating information in a book
- provides practice with locating information in a table of contents

---

03ER0680
UNIT TEST

MEASUREMENT: Chronological Order, Days of the Week

01EM0601
SEQUENCING EVENTS

Lesson Activities

- identifying the activity that takes the most time
- identifying the activity that takes more or less time than a given activity
- comparing lengths of time using shaded circles
- recognizing the concept that a complex design takes more time to copy than a simple design

---

01EM0602
ORDERING ACTIVITIES

Lesson Activities

- sequencing activities according to which takes the least time, a little more time, even more time, and the most time
- numbering four activities from least time to most time typing name, a store name, numbers 1 to 10, and address while being timed on a circle timer

---

01EM0603
ORDERING THREE OR FOUR EVENTS

Lesson Activities

- identifying which train car appeared first, second, third, fourth, fifth
- identifying which noise was heard first, second, third
- identifying which pictures appeared first, second, third
- sequencing the events comprising various activities, such as going to school in the morning

----

01EM0604
ORDERING FIVE EVENTS

Lesson Activities

- sequencing the events comprising various activities, such as planting a garden

----

01EM0605
PARTS OF THE DAY

Lesson Activities

- identifying activities occurring during daytime or nighttime
- identifying activities occurring during morning, noon, afternoon, evening, or night
- identifying the time of day from clues, such as the time a new day begins

----

01EM0606
DAYS OF THE WEEK

Lesson Activities

- identifying the number of days in a week
- identifying the missing day of the week using a list as reference
- recognizing the ordinal position of the days of the week
- calculating a certain day of the week from clues, such as the day two days prior to a given day

----

01EM0607
YESTERDAY, TODAY,
AND TOMORROW

Lesson Activities

- identifying the day that comes before or after a given day on a days-of-the-week wheel
- assigning events to yesterday or tomorrow, given a picture of today's event; such as today's picture being an egg cracking open, yesterday's the egg being whole, and tomorrow's being a chick
- identifying today, given that yesterday was a particular day of the week

----

01EM0608
DAYS OF THE WEEK

Lesson Activities

- understanding the short names (abbreviations) for the days of the week
- ordering the names of the months of the year
- using a month calendar to find the day of the week on a given date
- identifying a date relative to another date; e.g., one week later or just before the 25th

----

01EM0609
REVIEW UNIT 6

01EM0680
TEST UNIT 6

ESTIMATION AND MENTAL COMPUTATION:
Rational Numbers/Number Sense/Estimation Strategies

03EM0801
ESTIMATING WITH FRACTIONS

Lesson Activities

- identifying fractions in part/whole models
- identifying fractions in part/whole models without partition lines
- identifying a given fraction with the shape that is shaded that amount
- identifying the fraction that most closely matches a part/whole model
- identifying the fraction that most closely matches a part/group model

---

03EM0802
ESTIMATING AND COMPARING FRACTIONS

Lesson Activities

- identifying the closest fraction for a representation
- comparing fractions with representations
- comparing unit fractions with and without representations
- comparing fractions with like denominators
- identifying the largest and smallest fractions in a set

03EM0803
ESTIMATING WITH DECIMALS TENTHS

Lesson Activities

- associating decimal and fractional tenths
- recording distance traveled in tenths: both fractions and decimals
- estimating the fullness of a container to tenths
- estimating distance on a line to tenths
- associating decimal tenths with each other

03EM0804
MAINTAINING FACTS

Lesson Activities

- practicing addition and subtraction for facts and multiples of 10
- practicing multiplication and division facts
- associating all four operations
- identifying fractions from part/whole models

03EM0805
NUMBER SENSE

Lesson Activities

- comparing distances
- estimating mileage on a map
- estimating distances using fractional amounts
- estimating distances using decimal amounts
- determining four-digit numbers within a range
- recording fraction and decimal parts of a whole
- using Guess and Test to determine a decimal sum
- comparing large multi-digit numbers

03EM0806
USING FRONT-END
ESTIMATION: ADD/SUB

Lesson Activities

- introducing the need for estimation
- identifying numbers that represent estimations
- introducing front-end estimation
- adding and subtracting three- and four-digit numbers with front-end estimation
- using estimation to identify the correct exact answer
- using estimates to identify incorrect answers
- applying estimation skills

03EM0807
USING ROUNDING TO
ESTIMATE

Lesson Activities

- associating front-end and rounding strategies
- reviewing and testing rounding
- adding and subtracting rounded numbers
- comparing estimates: rounded and front-end
- using rounding to identify the closest estimate
- using rounding to determine whether an answer is reasonable
- applying estimates involving rounding

03EM0808
FACT MAINTENANCE

Lesson Activities

- Presenting computation chains involving all four operations, using a number machine format
- using the machine to display a series of compartments for a brief time, with each compartment requiring a new computation in the sequence

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03EM0809
ESTIMATING LENGTHS
WITH DIFFERENT UNITS

Lesson Activities

- estimating with feet
- identifying reasonable answers for lengths reported in inches and feet
- estimating lengths in centimeters
- identifying reasonable answers for lengths reported in centimeters and meters

---

03EM0810
ESTIMATING WEIGHTS WITH DIFFERENT UNITS

Lesson Activities

- estimating scale readings
- selecting appropriate units: ounces or pounds
- reviewing the relationship between grams and kilograms
- identifying reasonable answers reported in grams and kilograms

---

03EM0811
REVIEW UNIT 8

03EM0880
TEST UNIT 8

VITA

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PRESENT POSITION

Senior Consultant & Project Manager, Evaluation & Research, Worldwide Education and Learning, Corporate Strategic Services, Xerox Corporation. Place of assignment: Xerox Document University, Leesburg, VA. October 25, 1993 to present.

As a senior consultant and project manager in program evaluation, research, and educational psychology at Xerox corporation, I project lead and provide consulting for several projects within Xerox. Additionally, I consult with organizations external to Xerox, including Digital Equipment Corporation, Enterprise Rent-A-Car, The Southern Company, International City Management Association, and GartnerGroup.

Current projects include:

- Ongoing evaluation of sales, technical school, institute for customer education, and external customer training courses both at Xerox Document University and de-centralized locations
- Overseeing the testing processes within the training organizations
- Conducting ongoing distance learning and Xerox Educational Network Evaluations
- Conducting a national evaluation (including Europe and Canada) of a new initiative, Market-to Collections, within Xerox Corporation

- Writing work plans and proposals
- Conducting front end evaluation, including performance enhancement, needs, and requirements analyses
- Developing and validating measures
- Conducting site visits, focus groups, telephone, and personal interviews
- Analyzing data and writing reports
- Designing instruction and presentations
- Evaluating curriculum
- Conducting training in evaluation and measurement processes

EDUCATION

Ph.D. in Psychology, Utah State University; Logan, UT
Major Emphasis: Research and Evaluation Methodology
Minor Emphasis: Instructional Technology
Anticipated date of graduation: June, 1995.
Dissertation: "The Efficacy of Massed versus Distributed Practice as a Function of Desired Learning Outcomes and Grade Level of the Student"

M.S. in Educational Psychology, Brigham Young University, Provo, UT
Major Emphasis: Instructional Science
Major Emphasis: Research and Evaluation
Completion date: December, 1988.
Thesis: "The Development and Validation of an Attitude toward Year-Round School Scale"

B.S. in Psychology, Brigham Young University, Provo, UT
Minor: Sociology/Extra-Major Skill: Social Research and Statistics
Completion date: April, 1983.

Prior undergraduate work in psychology at:

Northern Virginia Community College, Sterling, VA; 1978-1979.

Radford University, Radford, VA; 1976 - 1978.

Graduate of Loudoun Valley High School (with seven honors), 1976.

ADDITIONAL PROFESSIONAL TRAINING

- **SpeechCrafters**, Xerox Document University, Leesburg, VA; January - May, 1995.
- **Leadership Through Quality**, Xerox Document University, Leesburg, VA; December, 1994.
- **Writing Competency Grids,** Xerox Document University, Leesburg, VA; October, 1994.
- **Distance Learning Workshop**, Xerox Document University, Leesburg, VA; May, 1994.
- **FoxPro: Introduction, Intermediate, Advanced, Programming I,II,III**, Northern Virginia Community College, Sterling, VA; Spring quarter, 1994.
- **Computer Adaptive Testing,** WICAT Education Institute, Provo, UT; January - April, 1985.
- **Practical Guidelines for Conducting Educational Evaluations**, AERA Post Session, New Orleans, LA; April, 1984.
- **Several specialized Geological and Computer Courses** at the National Center of the U. S. Geological Survey, Reston, VA; June 1976 - November, 1980; June 1982 - August, 1983.
- **Journalism**, Virginia Commonwealth University, Richmond, VA; July, 1975.
- **General University studies on a non-credit, workshop basis**, Virginia Polytechnic Institute and State University, Blacksburg, VA; summers during high school years of 1972-1975.

Computer skills: Am proficient in MS Word, FoxPro, Excel, PowerPoint, SPSSPC+, WordPerfect, SPSS for the mainframe, and ParScore Testing.

PREVIOUS EMPLOYMENT

Evaluation Specialist, Western Institute for Research and Evaluation, Logan, UT; January 1984 - October 22, 1994.
Participated in the grant writing, evaluation design, data collection, data analysis, and report writing for several external formative and summative evaluations. See the detail on the individual projects in the Selected Consulting Experiences section, beginning on page 111.

Temporary Assistant Professor, Utah State University, Logan, UT; September 30, 1992 - August 15, 1993.

As a sabbatical replacement for Dr. Blaine Worthen, I taught the following graduate courses:

- *Introduction to Educational and Psychological Research*
- *Introduction to Evaluation Models and Guidelines*
- *Internship in Program Evaluation*

as well as the following undergraduate course:

- *Scientific Thinking in Psychology*

Graduate Teaching and Research Assistant, Utah State University; Drs. Blaine R. Worthen & Karl R. White, Department of Psychology; June, 1987 - June, 1991.

Assisted in teaching the following graduate courses:

- *Introduction to Educational and Psychological Research*
- *Designing and Conducting Educational and Psychological Research*
- *Introduction to Evaluation Models and Guidelines*

- *Alternative Evaluation Methodologies*

- *Grantsmanship in Education and Psychology*

Assisted in teaching the following undergraduate course:

- *Educational Psychology*

Research Assistant, Early Intervention Research Institute, Utah State University; Dr. Karl R. White; September, 1985 - September, 1988.

Assisted in an integrative review of the efficacy of early intervention with disabled, disadvantaged, and at-risk youth.

Instructor, Microcomputers in the Schools, Brigham Young University; April - August, 1985.

Director, Computer Day Camp, Brigham Young University; April - June, 1985.

Teaching Assistant, Doctoral Colloquium, Drs. D. William Quinn & Adrian Van Mondfrans, Brigham Young University; May, 1984 - September, 1985.

Graduate Research Assistant, Drs. Adrian Van Mondfrans & Ralph Smith, Deans, College of Education, Brigham Young University; May, 1984 - September, 1985.

Teaching Assistant, Quantitative Reasoning, Dr. D. William Quinn, Brigham Young University; September, 1984 - May, 1985.

Field Research Director, Computer-Assisted Preschool Instruction, Dr. Harvey B. Black, Brigham Young University; January - May, 1984.

Geological and Computer Technician, National Center, U. S. Geological Survey, Reston, VA; June, 1976 - August, 1983.

Research Assistant, Computer-Assisted Preschool Instruction, Dr. Harvey B. Black, Brigham Young University; September - December, 1983.

Geological Technician, Utah Geological and Mineral Survey, Salt Lake City, UT; August - December, 1983.

Data Entry Operator, Brigham Young University; April, 1978 - April, 1979.

Teaching Assistant, Radford University; September, 1977 - May, 1978.

Bookkeeping Assistant, Radford University; September, 1976 - May, 1977.

SELECTED CONSULTING EXPERIENCES

Junior Achievement, Incorporated, Colorado Springs, CO; February, 1993 - August, 1993.

I was responsible for instrument development and conducting nationwide site visits to determine the effectiveness of the Junior Achievement curriculum on elementary students.

Jostens Learning Corporation, San Diego, CA; July, 1991 - November 30, 1992.

I assisted in writing the two-year grant (see grants section, on p. 118), conceptualizing the evaluation plan, developing instruments, collecting the data through site visits, analyzing the data, and writing the final report.

Educational Technology Initiative Evaluation Coordinator, Logan and Cache County School Districts, UT; September, 1990 - December 18, 1993.

After writing the three grants to conduct these evaluations, I worked with sixteen graduate and two undergraduate students in the evaluation design, instrument development, data collection, data analysis, and final report writing for these projects.

McDonnell-Douglas, Inc., San Diego, CA

Social psychology research of human factors aboard long duration space flights; September, 1989 - August, 1990.

Utah State Office of Education, Salt Lake City, UT

Evaluation of USOE's Productivity Projects; September, 1989 - August, 1990.

Office of the Surgeon General, Washington, DC

Research in the early identification of hearing impaired children. Designed brochure which has been distributed nationally; September, 1988 - April, 1989.

Utah State University, Department of Elementary Education, Logan, UT

Program evaluator for the "Frameworks for Teaching Thinking Conference;" July - October, 1988; July - September, 1989.

Utah Developmental Disabilities Council, Salt Lake City, UT

Program evaluator for the Columbus Community Center; April - October, 1988.

The Church of Jesus Christ of Latter-day Saints, Salt Lake City, UT

Assisted with a study to determine members' and leaders' needs in temple and family history work; August, 1987 - August, 1988.

Illinois State Department of Education, Dunlop, IL

Assisted with the evaluation of the K-12 math curricula in the Dunlop School District; November - December, 1987.

Citibank Corporation, Chicago, IL; March, 1987.

Conducted phone interviews with customers.

Utah State Office of Education, Salt Lake City, UT

Assisted with the program evaluation of Utah's Distance Education Project; June - November, 1986.

Provo School District, Provo, UT

Program evaluator for the implementation of year-round schooling; September, 1984 - September, 1985.

Utah State Office of Education, Salt Lake City, UT

Assistant to the program evaluators of the career ladder programs in Utah; August - December, 1984.

WICAT Education Institute/The Waterford School, Provo, UT

Program evaluator for The Waterford School's Summer Education Workshops; March - August, 1985.

Jordan School District, Jordan, UT

Assisted with the evaluation of the Jordan School District's Technological Competencies Curricula; May - August, 1984.

Worldwide Learning Enterprises, Salt Lake City, UT

Developed curricula; September, 1983 - May, 1984.

PRESENTATIONS

1995

Moss, V. D. (1995, April). An examination of the effect of telephone and letter prenotification on the return rate of mailed questionnaires. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.

1990

Kiewra, K. A., DuBois, N. F., Mayer, R., Christensen, M., Kim, S., Lindberg-Risch, N. E., Mayerhoffer, M., & Moss, V. D. (1990, April). The effects of repetition and organizers on notetaking and achievement. Paper presented at the Annual Meeting of the American Educational Research Association, Boston, MA.

Worthen, B. R., & Moss, V. D. (1990, April). An empirical examination of criticisms of standardized testing. Paper presented at the Annual Meetings of the American Educational Research Association and the National Council for Measurement in Education, Boston, MA.

1989

Moss, V. D., & Sudweeks, R. (1989, March). Practical guidelines for the development, validation, and utilization of affective measures in the schools. Paper presented at the Annual Meeting of The National Council for Measurement in Education, San Francisco, CA.

White, K. R., Taylor, M. J., & Moss, V. D. (1989, April). Parent involvement in early intervention: Does research support current practice? Paper presented at the Biennial Meeting of the Society for Research in Child Development, Kansas City, MO.

White, K. R., & Moss, V. D. (1989, March). Cutting down test score pollution: controlling the influence of extraneous factors. Paper presented at the Annual Meeting of the National Council for Measurement in Education, San Francisco, CA.

Worthen, B. R., White, K. R., & Moss, V. D. (1989, March). Testing misuses and criticisms of testing: are they causal or casual companions? Paper presented at the Annual Meeting of the National Council for Measurement in Education, San Francisco, CA.

PUBLICATIONS

Books and Chapters in Books

Worthen, B. R., Moss, V. D., & Hock, M. D. **Evaluation Simulation: Mountain View Elementary School Mathematics**. (Workbook and videotape; recently accepted for publication with Longman Publishers).

Van Mondfrans, A. P., Smith, R. B., & Moss, V. D. (1986). Chapter 14: Education. In T. F. Martin, T. B. Heaton, & S. J. Bahr (Eds). **Utah in Demographic Perspective**. Salt Lake City: Signature Books.

Journal articles

Moss, V. D., & Worthen, B. R. (1991). Do personalization and postage make a difference on response rates to surveys of professional populations? **Psychological Reports, 68**, 692-694.

White, K. R., Taylor, M. J., & Moss, V. D. (1992). Does research support claims about the benefits of involving parents in early intervention programs? **Review of Educational Research, 62** (1), 91-125.

Moss, V. D. (1994). Education Services and XDU-Net team up to offer decentralized testing. **Leesburg Journal** (4), 3.

TECHNICAL REPORTS

1994

250 six page evaluation reports for individual training sessions, seminars, and workshops.

30 eight page evaluation reports for distance learning events.

Moss, V. D., & Sasaki, J. (1994). El Segundo 1993 CSMS Results. Research and Evaluation Services, XDU, Leesburg, Va. 96 pages.

Moss, V. D., & Sasaki, J. (1994). Xerox Services Division: Site Services East 1993 CSMS Results. Research and Evaluation Services, XDU, Leesburg, Va. 75 pages.

1993

Moss, V. D. (1993). Evaluation of XDU-Net as a Medium for Training Delivery. Research and Evaluation Services, XDU, Leesburg, Va. 210 pages.

Moss, V. D., Forsyth, S., McClun, L., Pratt, C. D., & Worthen, B. R. (1993). Cache County School District's Educational Technologies Initiative. Logan, UT: Utah State University (Final report of a two-year study, 220 pp.).

Moss, V. D., McClun, L., Pratt, C. D., Forsyth, S., & Worthen, B. R. (1993). Final report of a two-year assessment of Logan City School District's Educational Technology Initiative. Logan, UT: Utah State University (160 pp.).

1992

Moss, V. D., Van Dusen, L. M., Worthen, B. R., & Allen, E. (1992). Report of the findings of a pilot study for the two-year comprehensive assessment of Jostens Basic Learning Systems Implementation models.

Worthen, B. R., Van Dusen, L., Leopold, G. D., Sailor, P. J., & Moss, V. D. (1992). Two-year comprehensive assessment of Jostens Learning

Corporation's Basic Learning System's Implementation Models. Logan, UT: Western Institute for Research and Evaluation/Utah State University Department of Psychology (54 pp.).

1991

Moss, V. D., Napper, V., England, R. T., Browning, C., & Worthen, B. R. (1991). An evaluation of Logan City School District's ETI Implementation. Year One: Formative evaluation. Final report submitted to the Logan City School District.

Worthen, B. R., Anderton, G. M., Van Mondfrans, A., Moss, V. D., Toohill, M. J., & Cook, R. W. (1991). Statewide evaluation of Utah's Productivity Project Studies Program. Logan, UT: Utah State University Department of Psychology. (Two-volume final report of Utah State Office of Education Contract #89-3433, 616 pp.) (ERIC tracking #TM015990)

Worthen, B. R., Van Dusen, L. M., Van Mondfrans, A., Ferguson, T. J., Leopold, G. D., Moss, V. D., Sailor, P. J., Williams, D. D., White, K. R., & Allen, E. (1991). Summary of Year-One Findings of a two-year comprehensive assessment of Jostens Basic Learning Systems Implementation Models. Logan, UT: Western Institute for Research and Evaluation/Utah State University Department of Psychology. (Final report, 580 pp.).

1990

Ferguson, T. J., Higham, J., Moss, V. D., Palmer-Kerbs, C., Parthsasarthy, A., Stone, M., & Taylor, M. J. (1990). Crew stability and efficiency aboard the Manned Aircraft Supply and Refueling Station. Final report submitted to McDonnell-Douglas Corporation.

1989

Moss, V. D. (1989). Evaluation of the Frameworks for Teaching Thinking to Children and Youth Conference. Final report submitted to the Department of Elementary Education, Utah State University.

1988

Moss, V. D. (1988). External On-site Evaluation Report of the Living Support and Training for Men and Women who are Mentally Retarded. Final report submitted to the Utah Council for Handicapped and Developmentally Disabled Persons.

Moss, V. D. (1988). Evaluation of the Frameworks for Teaching Thinking to Children and Youth Conference. Final report submitted to the Department of Elementary Education, Utah State University.

1987

Quinn, W. D., Worthen, B. R., & Moss, V. D. (1987). An evaluation of the Dunlap K-12 Math Program. Final report submitted to the Dunlap Illinois School District.

1986

Van Mondfrans, A. P., Moody, J., & Moss, V. D. (1986). An evaluation of Provo School District's Implementation of Year-Round Schooling. Year Two. Final report submitted to the Provo School District and the Utah State Office of Education.

1985

Van Mondfrans, A. P., & Moss, V. D. (1985). An evaluation of Provo School District's Implementation of Year-Round Schooling. Year One. Final report submitted to the Provo School District and the Utah State Office of Education.

ERIC Document

Moss, V. D., & Black, H. B. (1985). Teacher as learner in the academic nursery school. (Report number PS - 041 - 546 Urbana-Champaigne, IL, University of Illinois Clearinghouse on Elementary and Early Childhood Education. ERIC Document Reproduction Service No. ED 248 044)

GRANTS AND CONTRACTS

As a senior consultant my first year with Xerox Corporation, I was the project leader and principle investigator in **$250,000.00** worth of contracts in 1994. Additionally, I was a key team member on an additional **$300,000.00.** The vast majority of our projects require a proposal, design document, or statement of work. Our organization works within the "preferred supplier" philosophy and, though we are an internal supplier, we must continually compete for projects.

As a graduate student and consultant with the Western Institute for Research and Evaluation, I assisted in writing the grant proposal, executing the grant in all areas, and writing the final report for each of the following:

Van Mondfrans, A. P., & Moss, V. D. (1984). An evaluation of Provo City School District's Year-Round Schooling. **$25,000.00**

Worthen, B. R., Anderton, G. M., & Moss, V. D. (1987). An evaluation of USOE's Productivity Projects. **$48,000.00**

Moss, V. D., & Worthen, B. R. (1990). An evaluation of Logan City School District's ETI Implementation. **$5,000.00**

Worthen, B. R., Van Dusen, L., Soriano, B. R. S., & Moss, V. D. (1991). An evaluation of Jostens Basic Learning Systems Implementation. **$700,000.00 for 1991 and 1992.**

Moss, V. D., & Worthen, B. R. (1991). An evaluation of Logan City School District's Educational Technologies Initiative (ETI) Year Two Implementation. **$5,200.00**

Moss, V. D., & Worthen, B. R. (1991). An evaluation of Cache County School District's Educational Technologies Initiative (ETI) Implementation. **$7,000.00**

Moss, V. D., & Worthen, B. R. (1993). A follow-up evaluation of Cache County School District's Educational Technologies Initiative (ETI) Implementation. **$10,000.00**

Worthen, B. R., Van Dusen, L. M., Cutler, C., Shuster, T., & Moss, V. D. (1993). An evaluation of Junior Achievement's Economics Curriculum. **$586,000.00**

PRODUCTS

Brochure

Designed brochure which has been nationally distributed from the Office of the Surgeon General. The purpose of the brochure is to assist parents in identifying hearing loss in their children.

Scales

Moss, V. D., Distance Learning Evaluation Scale. Xerox Corporation. Used in evaluation studies. Copyright: 1995.

Moss, V. D., Xerox Educational Network Evaluation Scale. Xerox Corporation. Used in evaluation studies. Copyright: 1995.

Moss, V. D., Co-Supplier Survey. Xerox Corporation. Used in CSMS studies. Copyright: 1994.

Moss, V. D., Instructor Evaluation of Lab Support. Xerox Corporation. Used in CSMS studies. Copyright: 1994.

Moss, V. D., Instructor Assessment Form. Xerox Corporation.

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Course development

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Moss, V. D. (1985). Computer Day Camp for Youth. Brigham Young University: Division of Conferences and Workshops.

Moss, V. D. (1985). CIS 791R. Doctoral Colloquium. Brigham Young University: Department of Educational Psychology.

Worthen, B. R., Worthen, B. A., & Moss, V. D. (1988). Promises to Keep. Logan, Utah University Third Stake Family History Training. Includes teacher's manual, course handouts, and videotape.

UNIVERSITY APPOINTMENTS AND HONORS

Student Representative to the Faculty, Psychology Department, Utah State University, 1986 - 1993.

Search Committee, Psychology Department, Utah State University, 1990.

College of Education Dean's Scholarship, Brigham Young University, 1984-1985.

Loudoun-Robey Scholarship, Radford University, 1976-1978.

Dean's and President's Advisory Committee, Radford University, 1977-1978.

Academic Policies and Procedures Committee, Radford University, 1977-1978.

Campus Judicial Board, Radford University, 1977-1978.

Journalism Scholarship, Virginia Commonwealth University, 1975.

AWARDS

Merit cash award and letters of commendation for outstanding performance within Xerox Corporation, 1994; received "excellent" performance 1994 appraisal with raise for 1995.

Merit cash awards for outstanding service to the U. S. Geological Survey, 1976-1980.

Daughters of the American Revolution Good Citizen of the Year Award, 1976.

4-H All Star, 1976.

PROFESSIONAL AFFILIATIONS

American Educational Research Association

American Evaluation Association

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