**BatterUp**
An Educational Math Game

# *THE*

# *RESEARCH*

# *STUDY*

**Dr. S. David Vaillancourt**
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Automaticity of Basic Math Facts With a
D&P ILS Using Various Grouping Combinations in
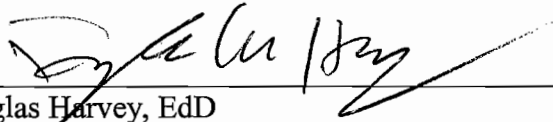Elementary School Classrooms

by
S. David Vaillancourt

An Applied Dissertation Submitted to the
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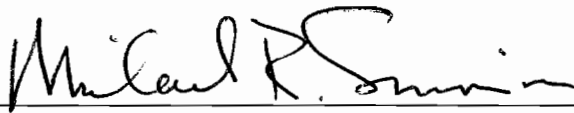
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Approval Page

This applied dissertation was submitted by S. David Vaillancourt under the direction of the persons listed below. It was submitted to the Fischler Graduate School of Education and Human Services and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Nova Southeastern University.


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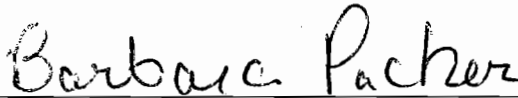Douglas Harvey, EdD                                        5/23/04
Committee Chair                                            Date


_____           _____
Michael Simonson, PhD                                     June 1, 2004
Committee Member                                          Date


_____           _____
Barbara Packer, EdD                                       June 1, 2004
Director of Applied Research                              Date

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Abstract

Automaticity of Basic Math Facts With a D&P ILS Using Various Grouping Combinations in Elementary School Classrooms. Vaillancourt, S. David, 2004: Applied Dissertation, Nova Southeastern University, Fischler Graduate School of Education and Human Services. Mathematics Instruction/Mathematics Achievement/Computer Assisted Instruction/Drills [Practice]/Instructional Innovation

This paper examined a research topic that has emerged from contradictory results of studies in the area of the effectiveness of drill-and-practice activities and the absence of research on the effectiveness of combining various grouping methods in computer-based instruction. Although drill-and-practice software and automaticity of basic skills have been studied in the classroom for many years, the research is inconsistent. Some of the more recent research suggested that drill and practice computer-based instruction should be abandoned for higher-level cognitive computer-based activities. Also, the striking deficiency of research investigating combinations of individual, competitive, and cooperative groupings with computer-based instruction provides an opportunity to advance the field of instructional technology in the areas of design and implementation.

This research examined indications of the effectiveness of drill and practice computer-based instruction toward automaticity of basic math facts when used in conjunction with various combinations of individual, competitive, and cooperative grouping activities. The study revealed a relationship between individualized instructional activity and automaticity. Based on the findings of this study, an eclectic approach that attempts to combine the grouping techniques at the lower levels of learning may not be the most effective method for some specific instructional goals. This implicates a possible relationship between the hierarchal level of the learning task and the effectiveness of using individualized or grouping methods.

Table of Contents

Appendixes

Tables

Figure

Chapter 1: Introduction

Thompson, Simonson, and Hargrave (1996) asserted that "Hearing the call from Clark and others . . . a number of researchers have designed studies that compare alternate methods of using a particular medium" (p. 20). One such researcher investigating the design of integrated learning systems (ILSs) stated, "Research also needs to examine various grouping strategies and structures to determine which are most effective for ILS instruction" (Brush, 1998, p. 16). It was the objective of the current study to continue investigation along this line of research, in the area of elementary mathematics.

An ILS is a specialized type of computer-based instruction (CBI) system. Brush (1998) described an ILS:

> An Integrated Learning System (ILS) is an advanced computer-based instructional system, generally consisting of a set of computerized courseware covering several grade levels and content areas, and complex classroom management and reporting features. . . . The design of most current ILSs is based on the theory that learning is best facilitated . . . by meeting the unique needs of each individual. . . . Thus, ILSs are designed primarily to be used by students individually so that learners can receive instruction, feedback, and remediation that is tailored to individual levels optimal for learning. (p. 5)

This study investigated various grouping methods with the use of drill-and-practice (D&P) activities of an ILS, as they relate to automaticity. Specifically, primary level students engaged in D&P learning games with an ILS over a 6-week period using individualized, competitive, and cooperative grouping methods as they attempted to improve their speed and accuracy in the calculation of basic math facts. This study investigated possible relationships pertaining to various combinations of the three identified grouping scenarios as they related to attainment of automaticity.

*Research Question and Statement of the Problem*

There was one research question investigated in this study. The question was: To what extent can various combinations of individual, competitive, and cooperative groupings in D&P CBI be related to an increase in automaticity of elementary students' computational skills with basic math facts?

During the past few decades, as computers have become more and more prevalent in classrooms (Alliance for Childhood, 2000; Jones & Paolucci, 1998; Megendollar, 2000), a massive amount of research and subsequent controversy has accumulated (Becker, 1992; Clark, 1994; Haffner, 2000; Hativa, 1988; Healy, 1999; Kearsley, 1998; Kulik, 1994; Wenglinsky, 1998), about various aspects of CBI. One of the controversies of interest entails the use of D&P CBI activities for mathematics instruction. There are several components involved in this debate, including motivational aspects, design components, grouping methods, cognitive levels to be addressed, the effectiveness of the D&P CBI toward academic achievement, and many others (Bahr & Rieth, 1991; Christensen & Gerber, 1990; Dixon, Carnine, Lee, Wallin, & Chard, 1988; Hasselbring, Goin, & Bransford, 1988; Salisbury, 1990).

For many years, the most popular CBI method for training students in basic math skills acquisition has been D&P software (Ashcraft, 1992; Becker & Hativa, 1994; Klein, 2001). Though D&P software has been studied in the classroom for decades, research on the effectiveness of D&P activities in CBI is inconsistent. An overwhelming accumulation of reviews spanning more than 3 decades of D&P CBI activities have indicated advantages when contrasted with traditional instruction (Alliance for Childhood, 2000; Bahr & Rieth, 1991; Becker, 1992; Berger, Belzer & Voss, 1994; Christensen & Gerber, 1990; Hativa, 1988; Kulik, 1994). However, the benefits are far

from indisputable. Many other authors disparage D&P primarily in favor of activities involving higher-level cognitive CBI interaction (Cardelle & Wetzel, 1995; Cognition and Technology Group at Vanderbuilt [CTGV], 1996; Hmelo, Guzdial, & Turns, 1998; Lehtinen, Hakkarainen, Lipponen, Rahikainen, & Muukkonen, 2000; National Council of Teachers of Mathematics, 1989). Most noteworthy, a recent nationwide study suggested that D&P CBI instruction may have a negative effect and possibly should be completely abandoned for higher-level cognitive activities (Wenglinsky, 1998).

An additional dimension to this controversy is the identification of various grouping techniques that may be implemented in conjunction with D&P CBI. Most D&P software is individualized to accommodate differences among individual learners (Ashcraft, 1992; Becker & Hativa, 1994; Klein, 2001). As a result, many earlier studies on D&P CBI were based on individual student interactions with the software (Christensen & Gerber, 1990; Hasselbring, Goin, & Bransford, 1988; Hativa, 1988, 1994; Vacc, 1991). An increasing number of studies investigating group interaction with D&P CBI have done so by comparing and contrasting the effectiveness of cooperative vs. individual and/or competitive grouping structures (Bahr & Rieth, 1991; Johnson, Johnson, & Stanne, 1986; Mevarech, 1994; Susman, 1998; Xin, 1996; Yueh & Alessi, 1988). A majority of the researchers found cooperative grouping to show an overall advantage over individualized or competitive, but some of the studies indicated otherwise.

As the research currently stands, there is no conclusive evidence for either of these two phenomena, the effectiveness of D&P CBI or the effectiveness of the grouping approaches. Also, in the midst of this indefinite set of findings, no studies have emerged investigating the possible effects of grouping scenarios when used in conjunction with

one another in a D&P CBI setting. This leaves a gap in the research data concerning the effectiveness of combining grouping techniques in an eclectic grouping approach to classroom use of D&P CBI activities.

*Rationale for the Study*

On their Web site discussion board, Johnson and Johnson (2002) stated, "Flexible classrooms where students are in many different kinds of groups and often work alone as well are ideal" (p. 19). This endorsement of an eclectic approach to grouping comes from researchers who identify that, "There are over 900 research studies validating the effectiveness of cooperative over competitive and individualistic efforts" (Johnson & Johnson, p. 2). Also, many educators often "recommend an eclectic approach to practice" (Heinich, Molenda, Russell & Smaldino, 1999, p. 17) by incorporating two or more instructional techniques that have been indicated by research as being effective.

The efforts of this study provided research that "is needed to learn about relationships between modes of operations of CAI systems and their effectiveness . . ." (Hativa, 1988, p. 395) and "identifies and tests the specific dynamics and components of the teaching/learning process involving technology" (Jones & Paolucci, 1998, p. 14). Brush (1998) further specified the direction toward which these challenges should be directed in light of the topic at hand:

> While there have been a few studies examining the academic and social impact of delivering ILS instruction to students in cooperative learning groups (Brush, 1997; Mevarech, 1994), there needs to be a continuation of this research in order to determine which cooperative learning models are most effective when used with ILSs and whether various strategies for combining cooperative learning and ILS instruction (whether those strategies are embedded within the on-line activities or are supplementary to those activities) are more or less effective. Research also needs to examine various grouping strategies and structures to determine which are most effective for ILS instruction. (p. 16)

Given the prominent support for eclecticism in instructional strategies and the

above identified needs for continuing research into the various grouping strategies for

ILS instruction, the gap in the research data identified at the end of the previous section

provides ample opportunity for conducting research studies. This investigation pursued

information that was expected to indicate a direction for software designers and educators

to facilitate more effective combinations of grouping methods in elementary math

classrooms using D&P ILSs, through the implementation of effective, quantifiable blends

of grouping activity ratios (GARs).

*Elements, Hypothesis, and Theories To Be Investigated*

This paper describes research that measured indications of the effectiveness of

D&P CBI when used in conjunction with various combinations of individual,

competitive, and cooperative learning activities. Correlations in this study were expected

to indicate possible, optimum GARs of individual, competitive, and cooperative uses of

D&P in ILS activities toward student achievement. It was expected that the highest rate

of improvement in speed and accuracy would most strongly correlate to a GAR with the

cooperative activity as the highest percentage (Brush, 1998; Johnson, Johnson & Stanne,

2000; Slavin, 1997).

The elements central to this investigation include the following:

1. Automaticity of basic math facts is a disputed educational goal for elementary

school mathematics that is currently regaining favor with some educators and has a solid

basis in theory and research as a pedagogically sound instructional goal (Bloom, 1986;

Gagne & Medsker, 1994; Pellegrino & Goldman, 1987).

2. The effectiveness of individualized, D&P CBI has been indicated by a large

body of research to improve academic achievement (Alliance for Childhood, 2000;

Becker & Hativa, 1994; Kulik, 1994; Salpeter, 2000; Underwood et al., 1996). However,

contradictory results have also been obtained by some studies. (Hativa, 1994; Healy,

1999; Wenglinsky, 1998).

3. Individualized, competitive, and cooperative techniques have all indicated

positive gains in academic achievement. In particular, individualized and cooperative

activities have each accumulated a great deal of research indicating their respective

success (Hooper & Hannafin, 1988; Johnson et al., 2000; Slavin, 1997; Xin, 1996).

The hypotheses of this study are that:

1. Students using cooperative ILS practice most frequently over either

individualized practice or competitive practice will correlate to the highest rate of

automaticity attainment.

2. Students using individualized ILS practice in conjunction with cooperative

play, and using competitive play the least, will correlate to the highest rate of

automaticity attainment.

3. The majority of students with competitive play as their most frequently used

method will correlate to a lower rate of improvement in automaticity of basic math facts

than students in the two other categories identified above.

In order to adequately examine the elements and hypotheses listed above, several

well-established educational theories need to be investigated regarding

1. The relationships of individualized practice, competitive, and cooperative

grouping activities to academic achievement (Bahr & Rieth, 1991; Johnson et al., 2000;

Slavin, 1997) as they are foundational to the discourse concerning GARs.

2. The hierarchal nature of cognitive processes as identified by Bloom, Englehart,

Furst, Hill, and Krathwohl (1956) in relation to the setting of instructional goals and

subsequent identification of learning activities (Gagne, Briggs, & Wager, 1992).

3. Automaticity as investigated in the classic study of Shiffrin and Schneider (1977) is too broad for the purposes of this study. Therefore, this examination was more specific, attending only to the construct as it pertains to cognitive tasks as discussed by Anderson (1992), Bloom (1986) and others.

*Assumptions*

Several assumptions from educational theory and research were used as a foundation upon which the investigation was built:

1. Automaticity of basic math facts by elementary school students has a basis in instructional theory and research as a pedagogically sound instructional goal, but requires further study (American Enterprise Institute, 2002; Anderson, 1992; Bahr & Rieth, 1991; Bloom, 1986; Carnine, 1997; Cheng, 1985; Gagne et al., 1992; Hasselbring et al., 1988; Hativa, 1988; Klein, 2001).

2. Research supplies evidence that D&P CBI deserves a place in elementary mathematics curricula but requires further investigation (Gagne et al., 1992; Johnson & Johnson, 2002; Klinkefus, 1988; Yueh & Alessi, 1988).

3. Individual, competitive, and cooperative groupings are each useful instructional techniques when appropriately used (Johnson et al., 2000; Mevarech, Stern, & Levita, 1987; Xin, 1996).

4. An eclectic grouping approach for many educational settings is an acceptable instructional strategy (Gagne et al., 1992; Heinich et al., 1999; Johnson & Johnson, 2002; Yueh & Alessi, 1988).

*Limitations to the Study*

The following variables within the context of this study may have inherently imposed limitations to the study in the following areas:

1. It is possible that both history and maturation variables may have negatively impacted the internal validity of the study.

2. The ILS used presented the reinforcement activities in the format of a computerized baseball game. Since this was the only format offered, the findings may not be generalizable to other game or non-game ILS formats. Thus, a negative impact on external validity may be inferred.

3. The administration of a pretest may have impacted results on the second test by heightening the respondents' sensitivity to their individual accountability.

4. The selection of the participating school systems was conducted on a volunteer basis. Not being completely randomized, this sampling procedure may have had a negative impact on the validity of the results.

*Definition of Terms*

Several terms were operationalized to accommodate this investigation. Below is a listing of the terms that have not already been defined in this manuscript. With the exception of the single term coined for use in this study, the terminology used in this study will conform to the definitions provided by previous theorists and researchers:

1. Automaticity is a relatively complex concept. It includes a discussion of automated processes in physiology and cognition that may or may not require conscious attention to be utilized (Anderson, 1992). Anderson's concept of automaticity as discussed in relation to the ACT (Adaptive Control of Thought) theory will work well for the purposes of this study. The operational definition will be restricted to "phenomenon that accrue with practice of a particular skill . . . Skill speeds up with practice and reduces in error rate" (p. 165). The quantification of speed and error rates were established through the real-time calculation of a batting average (BA) for each student as depicted in

Appendixes A and B.

2. Cooperative activities are identified as including at least the following three characteristics: "positive goal interdependence, individual accountability and collaborative skills" (Brush, 1998, p. 9).

3. "Individualistic efforts were operationally defined as the lack of social interdependence between participants. Participants work alone or with a minimum of interaction and rewards were given according to set criteria so there was little opportunity for social comparison" (Johnson & Johnson, 2000, p. 6).

4. "Competition is operationally defined as the presence of negative goal or reward interdependence." (Johnson et al., 2000, p. 6).

5. GAR, has been coined for use in this investigation. GAR is operationally defined as the percentage ratio of use of specific activity types, i.e., individualized, competitive, and cooperative activities. For the purposes of this investigation, GAR is the percentage ratio of the three types of activities.

*Term Associations*

In this study, the acronyms CBI and ILS will sometimes be used interchangeably, where appropriate. Because an ILS is a particular type of CBI, whenever an ILS is used it is still accurate to refer to the software as CBI to maintain the flow of thought if the discourse is regarding CBI in general. However, when specificity is required or preferred, the ILS acronym will be utilized.

*Summary*

Several decades of research provide conflicting evidence as to the effectiveness of D&P CBI. Simultaneously, hundreds of studies have been conducted that compare and contrast individualized and/or competitive grouping scenarios with cooperative grouping.

While cooperative grouping has a great deal of collected data indicating its superiority over individualized and competitive groupings, several researchers contest these results. With inconclusive evidence plaguing the effectiveness of both D&P CBI and specific grouping techniques, there is a great deal of opportunity to investigate both of these areas.

   One possible outcome of the study could have been an identification of relationships between D&P CBI grouping combinations and the increase of automaticity of basic math facts for elementary students. This would have provided educators and software designers a basis for improvement in the design of reinforcement activities for elementary math classes. Certainly the findings of the investigation have added to the academic literature on the topics of classroom grouping and CBI. The next chapter will identify the context for the current investigation within a larger body of existing literature and research regarding the three central elements: (a) automaticity and hierarchal cognitive constructs, (b) D&P activities within integrated learning systems, and (c) individualized, competitive, and cooperative grouping strategies.

Chapter 2:  Review of the Literature

The following review of literature is organized according to the three central elements of this investigation as identified in the previous chapter: (a) automaticity of basic math facts, (b) D&P ILS instructional activities, and (c) individualized, competitive, and cooperative grouping. This review provides an historical overview of the context, theory, and research for each of these areas.

*Automaticity of Basic Math Facts*

The release of *Curriculum and Evaluation Standards for School Mathematics* by the National Council of Teachers of Mathematics (NCTM) in 1989 was the introduction of this national organization's first standards document. These new standards were promoted under the banner of constructivism (Klein, 2001). The document was a major catalyst in setting the stage for strong polarization during the next decade between the constructivist oriented math teachers and the teachers advocating cognitivist and behaviorist instructional methods. The "math wars" of the 1990s implicate two opposing theoretical positions relating to higher-level cognitive activities like using simulations for developing problem-solving skills, and the implementation of lower level learning activities, such as D&P for fostering automaticity with basic facts (American Enterprise Institute, 2002; Klein, 2001). Many educators, theorists, and researchers (Bloom, 1986; Carnine, 1997; Christensen & Gerber, 1990; Gagne & Medsker 1994; Hofmeister, 1998; Miller & Mercer, 1997; Wu, 1999) advocated that these two positions should not be viewed as mutually exclusive, but complementary.

> The truth is that in mathematics, skills and understanding are completely intertwined. In most cases, the precision and fluency in the execution of the skills are the requisite vehicles to convey the conceptual understanding. There are not 'conceptual understanding' and 'problem-solving skill' on the one hand and the 'basic skills' on the other. (Wu, 1999, p. 1)

As they reviewed research on mathematics instruction in problem solving, Gersten & Chard (1999) stated that the authors of the studies identified that conceptual understanding, computational speed, and computational accuracy had an impact on the efficiency of problem-solving strategy development. They asserted that in appropriate math instruction, all of these facets needed to be taken into account.

A second and equally prominent perspective supporting automaticity with math facts is that of the hierarchal nature of cognitive skills. This perspective maintains that cognitive development moves from lower to higher levels of cognition through six progressive steps; (a) knowledge, (b) comprehension, (c) application, (d) analysis, (e) synthesis, and (f) evaluation (Bloom, et al., 1956). In Bloom's (1986) noteworthy article, "Automaticity: The Hands and Feet of Genius," he reiterated the hierarchal nature of cognitive skills. He purported that the development of upper level cognitive skills is dependent upon the development of prerequisite subskills, beginning with knowledge retrieval.

Hasselbring et al. (1988) concurred: "The ability to succeed in higher-order skills appears to be directly related to the efficiency at which lower-order processes are executed" (p. 1). As automaticity is developed with subskills, expertise in the related higher order skill is advanced (Bloom, 1986). A general understanding of the concept is that automaticity is the attainment of a high level of proficiency in a particular skill so that speed and accuracy are maximized during execution, and the requirement for conscious monitoring is minimized. The obvious advantage is the reduction of effort and attention to the automatized task, allowing concurrent operation with other tasks and task components (Pellegrino & Goldman, 1987).

The phenomenon of automaticity became a popular topic for experimental

psychology with the work of Shiffrin & Schneider (1977). Since then, several researchers and theorists have debated different aspects and theories of the process, especially as it relates to cognition and learning (Anderson, 1992; Ashcraft, 1992; LaBerge, 1997; Logan, 1992; Treisman, Vieira, & Hayes, 1992). As he discussed research findings concerning adult retrieval of math facts, Ashcraft (1992) "rules out counting as the single mental process by which adults perform the basic math facts of addition and multiplication. Instead, such performance is attributed to retrieval processes operating on an organized, long-term memory network of fact knowledge" (p. 84). Hasselbring et al. (1988) identified that instructional strategies permitting the use of counting inhibit the development of automaticity and advocate using practice activities such as D&P. McCloskey & Macaruso (1995) purported that basic math fact retrieval is closely related to the fundamental components of mathematics education, arithmetic, and number systems instruction.

As indicated above, many researchers and theorists have supported the attainment of automaticity with basic math facts as one of the critical components in the area of cognitive arithmetic. Many researchers also identified D&P CBI as one of the most efficient instructional methods for attainment of math automaticity (Bahr & Rieth, 1991; Christensen & Gerber, 1990; CTGV, 1996; Hasselbring et al., 1988; Kulik, 1994; Kulik & Kulik, 1991; Underwood, Cavendish, Dowling, Fogelman, & Lawson, 1996; Vacc, 1991; Wood, Underwood, & Avis, 1999). In the next section of this chapter, the development and use of ILS software as it relates to D&P activities will be examined.

*D&P ILS Instructional Activities*

Mergel (1998) pointed out that "Computer-assisted instruction [CAI] was first used in education and training during the 1950s. Early work was done by IBM and . . .

CAI  grew rapidly in the 1960s, when federal funding for research and development in education . . . was implemented." CAI was a precursor to the contemporary term CBI and is sometimes still used when referring to D&P and tutorial software implementing behavioristic instructional techniques. In the 1960s, the federal funding for research caused CAI to grow rapidly with mainframe computers. Early in the 1970s, minicomputers were utilized but were being replaced by microcomputers by the end of the decade (Simonson & Thompson, 1997). The start of CAI in education correlated with the zenith of teaching machines, programmed instruction, and the behaviorist movement, which emphasized individualized training. CAI was almost exclusively D&P based and consisted of tutorials for lower level cognitive skills with a primary goal to individualize learning processes (Becker & Hativa, 1994).

Skinnerian operant conditioning supplied the contemporaneous learning theory, which provided the context of CAI from which ILSs evolved (Becker & Hativa, 1994; Mazyck, 2002). Becker and Hativa highlighted two psychologists of the time, Suppes and Atkinson at Stanford University, who were developing a comprehensive CAI system that provided individualized diagnostic and prescriptive instruction for elementary school children. The system was designed to reinforce basic math facts in a highly individualized process to best meet the needs of the individual learners at their own performance levels. This ILS design was effective for improving students' scores on standardized basic skills tests. Their success was met with a host of competitors based on variations of the original model.

According to Becker and Hativa (1994), ILSs had "become particularly prominent in recent years, with the spread of networkable microcomputers and pressures on schools to accomplish efficient teaching of basic skills for increasingly heterogeneous student

populations" (p. 5). Becker and Hativa provided a clear description of the attributes and functions that distinguished ILS programs from the many other contemporary CBI software types. As they described the characteristics of ILSs, the authors established distinctive boundaries to ascertain "what is and what is not within the purview of the concept" (p. 8). To start with, the constructivist model of instructional theory and its design implications for CBI are in competition with and "clearly distinct from those we call ILSs" (p. 8). The ILS epistemology stems from the behavioral and cognitive perspectives of knowledge as an objective body. Other distinctive features are the record keeping, assessment, progress reporting, individual task assignment, comprehensive multiyear contiguous instruction, and multiple content capability (Becker & Hativa).

Through the 1970s and 1980s, the software packages moved from dumb terminals to the more powerful PCs. Also, color graphics, along with more processing power, more storage, more memory, CD-ROMs, and PC networks enhanced the programs' abilities. The implementation of CBI in the classroom has developed beyond the utilization of basic D&P and tutorial software as identified with ILSs. A great deal of CBI now includes multiplayer games, tool-based learning activities, higher level cognitive activities, and many types of open-ended activities that exploit advanced networking technologies (Becker & Lovitts, 2000; Cardelle & Wetzel, 1995; Hativa, 1994; Keeler, 1996; Mergendollar, 2000; Newman, Johnson, Webb, & Cochrane, 1997; Sedighian, 1997; Valdez et al., 1999).

The dichotomy of the math wars of the 1990s and the advancement of constructivism is reflected throughout the educational software industry, with the emphasis on constructivistic activities for student learning ubiquitously reflected throughout the research on CBI in recent years (Becker, 1994; Cardelle & Wetzel, 1995;

Hakkarainen, 1998; Honey, Culp, & Spielvogel, 1999; Hmelo et al., 1998; Neiderhauser & Stiddart, 2001). As stated by Thompson, et al. (1996), "Current research tends to focus on computer environments that have the potential to improve student problem solving and information handling skills" (p. 51). However, with a current change back toward the prescribed inclusion of instructional activities for basic facts and lower level cognitive focus (California State Board of Education, 1999; NCTM, 2000), there continues to be a need for research into instructional technology with this approach.

According to Cuban (as cited in Alliance for Childhood, 2000), D&P has been indicated to be the only type of CBI to make a positive impact on academics. Some reviews of D&P CBI indicate nominal advantages over traditional instruction (Becker 1992; Berger et al., 1994; Roblyer, Castine, & King 1988). Other researchers have indicated that using instructional technology for D&P of basic skills can be highly effective according to a long history of use and a large body of data (Kulik, 1994; Kulik & Kulik, 1991; Underwood et al., 1996). One meta-analysis (Kulik, 1994) aggregated findings from over 500 research studies of D&P and tutorial CAI in a meta-analysis and concluded that students learn significantly more in significantly less time with computer-based instruction. As media comparison meta-analyses, Kulik's studies were scrutinized by many researchers because of flawed methodology (Becker & Lovitts, 2000; Clark, 1994; Wenglinsky, 1998). This meta-analysis did not provide acceptable evidence for media effect. Nevertheless, the many student performances measured in this assemblage of research provided abundant confirmation that improvement of basic skills did coincide with the use of individualized D&P software. Even if it does not provide evidence for media effect the data supported the instructional use of individualized D&P for skills attainment.

An important point to note is that there are still some dissenting opinions about the effectiveness of D&P activities in CBI (Roschelle, Pea, Hoadley, Gordin, & Means, 2000; Wood et al., 1999). One researcher (Wenglinsky, 1998) found that using D&P CBI to teach basic mathematics skills was inversely correlated to academic achievement. He inferred that computer use in schools should be primarily dedicated to higher order learning, such as problem solving or concept application, to promote student achievement. However, the overwhelming majority seem to agree with Becker, who was quoted in a recent interview with Salpeter (2000), the editor of *Technology and Learning*, as stating that ". . . drill and tutorial software can help with math computation. . . . Most research shows effects of 5 to 10 percentile over several months of practicing math skills at the computer" (p.1). Even Cuban (as cited in Salpeter), who is known for not over-rating the effectiveness of computers in schools, stated to the same interviewer that "there is a long research history that shows that tutorial and drill software . . . can improve test scores" (p. 1). This is the same type of tutorial and drill activities around which ILSs are built (Becker & Hativa, 1994).

Becker and Hativa (1994) indicated that many studies on the effectiveness of ILSs have been conducted since the mid-1970s. They declared, "Unfortunately, most studies have had one or more features which weaken any inference about the effectiveness of current ILSs" (p. 9). Becker and Hativa (1994) acknowledged the methodological weaknesses of the findings as they related to media comparison studies with this declaration, but they also identified ample opportunity for research about the effectiveness of ILSs in a multitude of contexts. One such context is the examination of individualized, competitive, and cooperative interactivity in instructional settings. In recent years, several researchers have investigated these grouping scenarios with learners

using ILSs. The next section of this chapter will examine the research regarding individual, competitive, and cooperative grouping and establish its context in the current study on D&P with CBI and ILSs.

*Individualized, Competitive, and Cooperative Grouping*

The social-educational ramifications concerning the classroom use of computers were of great concern to many educators while abundant contemporary research emphasized the success of grouping techniques such as cooperative learning through the 1970s and 1980s (Lehtinen et al., 2000). "Still in the late eighties most experiments on computer-supported learning were based on the so-called solo-learner model, and the opportunities to individualize learning processes were supposed to be the crucial feature of computers" (Lehtinen et al., p. 4).

In general, educational technology practitioners, researchers, and theorists agree that interactivity is a significant component of most successful instructional settings (Dalton, Hannafin, & Hooper, 1987; Davidson & Kroll, 1991; Rysavy & Sales, 1991). Yet, Simonson, Smaldino, Albright, and Zvacek (2000) pointed out an important parallel to the Clark (1994) and Kozma (1991) technology debate when they examined research on mediated distance education "However, similar to comparison studies examining achievement, research comparing differing amounts of interaction showed that interaction had little effect on achievement" (Simonson et al., p. 61). Though, in a recent journal article, Hurumi (2002) commented on the conclusions indicated by Simonson et al.:

> It is important to note that, like media comparison research (c.f., Clark, 1994), these conclusions are based on investigations that compare the effects of interactivity across delivery systems (e.g., traditional vs. two-way audio and video vs. two-way audio). The effects of interactivity may be better ascertained by studying varying degrees or types of interactions within one, rather than across, delivery systems. (p. x)

A large body of research regarding interactivity has been accomplished during the last 30 years specifically focusing on cooperative learning (Johnson et al., 2000; Slavin, 1997). Laboratory and field studies have been conducted in every major subject and at all grade levels on the effects of cooperative grouping on academic achievement (Slavin). Confirming the general agreement among educators, both Johnson et al. and Slavin recognized that the overwhelming majority of this research identified cooperative learning activities as being powerfully effective. "There are over 900 research studies validating the effectiveness of cooperative over competitive and individualistic efforts" (Johnson et al., p. 2). However, there are still many disagreements about why cooperative grouping works. Also, numerous unanswered questions remain about what conditions are required for cooperative grouping to have these effects (Slavin).

Slavin (1997) has identified four theoretical perspectives attempting to explain the achievement effects of cooperative grouping: (a) developmental, (b) cognitive elaboration, (c) social cohesion, and (d) motivational. The first perspective, developmental, maintained heavy contributions from both the Piagetian and Vygotskyan traditions of social development and individual readiness. The second viewpoint, cognitive elaboration, has some resemblance to the first. This point of view identifies the effectiveness of cooperative learning to be derived from learners elaborating their cognitive structures in a social context. Often, this is in the form of explaining the information to someone else such as peer tutoring.

The third and fourth perceptions identify affective grounds for the technique's success as opposed to the cognitive activities identified with the two previous perspectives. Social cohesion emphasizes the intrinsic motivation of group members helping their colleagues learn because they care about the group. The final perspective,

motivational, subscribes to the notion that extrinsic factors such as positive goal interdependence and individual accountability are the source of motivation to the cooperative learner. They focus primarily on the goal or reward structures used to foster cooperation (Slavin).

This study is primarily aligned with the motivational perspective. Both goal interdependence and individual accountability are imposed into the design of the cooperative play used in the current research. The idea of goal interdependence is a system whereby the only way group members can attain their own personal goals is if all the members of the group are successful. Therefore, the group as a whole has a vested interest in the achievement level of each member, and each group member is accountable to the rest of the group for their individual achievement (Slavin, 1997). Because cooperatively structured learning tends to promote higher achievement than competitive and individualistic learning situations (Johnson et al., 2000) and the computer is only a vehicle (Clark, 1994), it stands to reason that cooperative CBI would promote achievement better than the traditional individualized CBI, or even competitive CBI, scenarios.

As the computer movement has grown, so has the amount of research into group learning activities with CBI (Bahr & Rieth, 1991; Brush, 1997, 1998; Carrier & Sales, 1987; Mevarech, Silber, & Fine, 1991; Rysavy & Sales, 1991; Susman, 1998). For more than 15 years, a portion of this specialized research has targeted mathematics CBI and ILSs utilizing grouping techniques (Becker, 1992; Hativa, 1994; Hooper, 1992; Hooper & Hannafin, 1988; King, 1989; Xin, 1996). Nevertheless, two trends in the field of instructional technology have diminished the amount of research investigating student grouping with D&P CBI.

The first of these two trends was the popularity of the individual-learner design for early mathematics software with computers in the classroom. This fostered the ubiquitous use of D&P software to reinforce knowledge level learning (Becker & Hativa, 1994). Consequently, many of the studies on D&P CBI were based on individual students interacting with the software (Christensen & Gerber, 1990; Hasselbring et al., 1988; Hativa, 1988, 1994; Vacc, 1991). The other trend shows that a large majority of the studies on learner grouping with CBI and ILSs have focused their investigations on higher-level learning activities. This tendency has remained consistent within the specific subset of research regarding interactivity and grouping with CBI mathematics instruction (Carrier & Sales, 1987; Cox & Berger, 1985; Hooper & Hannafin, 1988; King, 1989; Mevarech, 1993, 1994; Xin, 1996).

Nevertheless, a few researchers in recent years have worked outside of these trends to investigate the particular segment of mathematics instruction being examined in the current study, D&P CBI with regard to individualized, competitive, and/or cooperative grouping (Bahr & Rieth, 1991; Hooper, 1992; Johnson et al., 1986; Klinkefus, 1988; Xin, 1996). Overall, the findings from this limited research area have been consistent with findings on cooperative learning in general. Yet, as identified in chapter 1, this study delved into an area where an absence of research was acknowledged, specifically in the use of combinations of grouping activities to reinforce basic math facts through D&P CBI.

*Summary*

In the first section of this chapter, the literature concerning this study has identified substantial theory and research to warrant the teaching of basic math facts to the level of automaticity for elementary school students. Further, this review has

identified substantial research to indicate that D&P CBI is an effective classroom technique for teaching basic math facts to elementary level students. The third section examined research concerning individual, competitive, and cooperative grouping techniques. While there has been a great deal of research in this area, with and without computers, none of the research prior to this investigation has attempted to combine these techniques and identify subsequent correlations.

The following chapter will describe in detail the method of investigating the identified gap, where combinations of grouping activities are used to reinforce basic math facts through D&P CBI with an ILS.

Chapter 3: Method

The current study employed a descriptive, quantitative approach. This research established the presence of specific qualities (variables) within the learning environment and analyzed possible relationships among them through correlational analyses.

*Research Design*

The correlational design was selected primarily to discover potential relationships between changes in the automaticity (the dependent variable) of basic math facts and specific combinations (the independent variables) of individual, competitive, and cooperative grouping activities. Because this was a descriptive study, there was no differentiation or assignment of individual subjects or groups of subjects. Specific grouping activities were not prescribed for the subjects in this study. The measurements of student performance during the study were recorded in normal classroom settings (Gall, Borg, & Gall, 1996).

A pretest/posttest design was used to quantify changes in automaticity of the subjects over the course of the 8-week study. The quantification of the combinations of grouping activities were identified as ratios according to the number of math problems answered during practice in each classification of activity. Each time a subject logged in to play the game, the ILS recorded the type of grouping activity selected, the number of math problems completed, and speed and accuracy during the session. In addition, demographic information was requested upon the setup of the login account for each subject. As a secondary interest, correlational analyses were run on collected demographic characteristics (independent variables) to identify possible relationships with grouping choices and automaticity.

*Subject Characteristics and Sampling*

The sample consisted of students in first-grade through fifth-grade from several elementary schools in various schools systems throughout central Alabama. The schools were provided the opportunity to volunteer during January and February 2003 to participate in The BatterUp Initiative, an academic math tournament conducted during the spring of 2003. This tournament was the basis for data collection in the current study. The students who volunteered to participate in the tournament were the subjects in the study.

Schools were encouraged to include as many students as possible in Grades 1 through 5, with no restrictions. However, the basis for identifying volunteers was ultimately left up to the staff and faculty of each school. This sampling procedure provided a wide variety of ability levels and demographics represented within the sample. It was expected the sample number would be well over 100 participants.

*Timeline*

This study was conducted over an 8-week period from March 2003 through April 2003, in three phases. Phase 1 consisted of each subject completing the pretest during week 1. Phase 2 extended over the next 6 weeks with the participants interacting with the software as prescribed by their teacher. The teachers were encouraged to allow student choice whenever appropriate, but to make use of the software as they saw fit. Phase 3 entailed completion of the posttest during week 8.

*Instrumentation*

The data collection instrument was a D&P ILS called *BatterUp*, created by the author. The software package provided practice with math facts in a computerized, baseball game format facilitating individual, competitive, and/or cooperative play. The

software interfaced with a newly constructed, back-end database designed to collect student responses and game-play conditions. Individual math problems were presented to the student in the format depicted in the figure below.
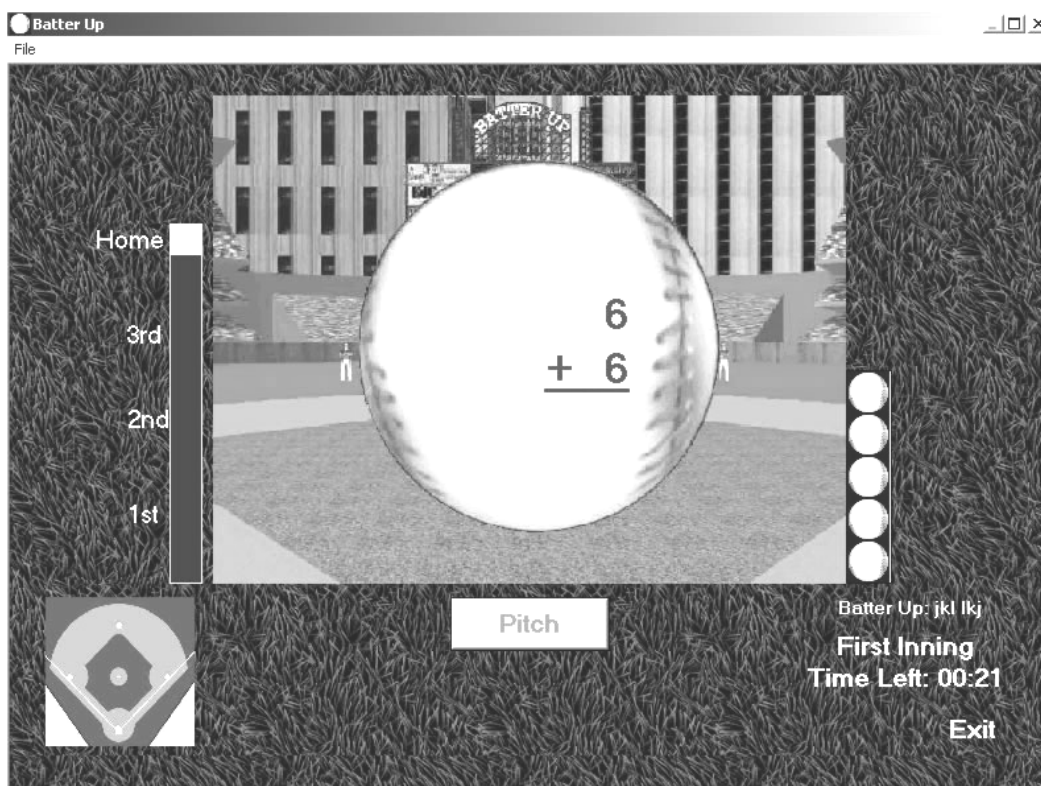


*Figure.*  Screen shot of math problem presentation.

The original computerized version of *BatterUp* was used in multiple schools and homes during the 1990s. The current version is an update of the original with the addition of a built-in, backend database that was constructed to accommodate data collection and transfer the collected data to a Web-based database for this study.

A 3-month pilot study of the updated program was conducted in four elementary schools during the fall of 2002 to verify functionality, content validity, and interface design. During this pilot study, students at the three pilot sites accomplished over 2000 plays. The teachers at each site were asked to provide feedback that would allow the programmers to improve the software and make it more appropriate for use in their

classrooms. Subsequent discussions about the graphics, interactivity, content appropriateness, reporting features, and other topics provided direction for minor enhancements to be applied to the software. Adjustments and improvements to the ILS were implemented in an ongoing basis during the pilot from suggestions proposed by students and teachers, and agreed upon by the programming team.

*Validity and Reliability*

Consistency of the instrument, the Web-based ILS, was well established during the pilot in several ways. The presentation of the content was standardized by the computer interface and presented in and elemental, equation format. Consistency of content presentation was precise because of the microcomputer. In addition, the content was non-subjective and in numerical format, thus eliminating subjective interpretation of the meanings of words. Therefore, the burden of consistency rested on the consistency of the data collection and the computer systems that were used. The raw data that were collected and measured consisted only of computer-measured empirical occurrences and data that (a) counted the number of grouping activity occurrences, (b) tracked speed performance in seconds, (c) tracked correct and incorrect responses, and (d) maintained demographic information for each subject. As long as each computer system was functioning properly and collected this raw data accurately, the reliability of measurement was high (Gall et al., 1996).

Face validity and content validity were used to establish the validity of the measurement instrument during the pilot study. Based on the expert judgments of the appropriateness of the content by experienced teachers, face validity was verified by all participating educators. The expert panel indicated that the content, format, clarity and speed of the presentations were very adequate for each of the accommodated grade

levels. Content validity was further verified with acknowledgement of the entire content domain of the well-defined, limited content of basic math facts was available from within the instrument (Leedy & Ormrod, 2001).

In consideration of the validity of the overall investigational approach, both internal validity and external validity concerns were recognized. Internal validity is the extent to which the investigative method allowed accurate conclusions to be drawn about the relationships among the data in the current study (Campbell & Stanley, 1963). Four potential threats to internal validity were indicated for this research. A pretest/posttest procedure was utilized in the study. This is often identified as a threat to internal validity because of the reactive effect. Because the selection process was on a volunteer basis, as opposed to random sampling, a bias may have affected the validity. It is also possible that both history and maturation variables may have had negative effects on the internal validity of the study. However, the short duration of the study and the diversity of the sample countered these effects to some degree. The large, varied sample and the consistency of the instrumentation gave support to the internal validity (Campbell & Stanley).

External validity refers to the extent to which the findings of the current study may be generalized to other contexts. One possible hindrance to the transferability of these findings to other contexts is that the ILS is in the format of a computerized baseball game. Conclusions from this study may or may not be generalizable to other game or nongame platforms. Finally, the content area and performance behaviors were more accessible to empirical measurement than many others. This would make confirmation of the transferability of results to other content areas and/or performance behaviors somewhat difficult (Campbell & Stanley, 1963).

*Data Collection and Analysis Procedures*

Before implementing any portion of the study, Institutional Review Board (IRB) approval from the university was obtained. Prior to acquiring IRB approval, initial consent needed to be gained from participating school systems to allow voluntary participation from individual students within the school systems. Upon receipt of the completed Initial Consent Form from appropriate school system personnel, the district was identified as a participating school system. This enabled any school within the system to permit students to volunteer to participate in the study once it was approved by the IRB. Each volunteer was required to submit a completed Child Assent Form and a completed Parent/Guardian Informed Consent Form before being allowed to participate. Once the teacher had received the appropriate assent and consent forms, the student login account within the ILS was setup by the teacher.

The study tracked the performance of students, who worked on classroom D&P activities in the ILS, through the secure Web site database. Upon the first use of the software, each participant's performance level was determined by a set of predesigned, grade-specific problems that were used as the pretest. The students subsequently interacted in the assigned activities for a 6-week time frame, during which participants used the D&P CBI networked program to reinforce basic math facts. The database on the back end of the ILS collected the following data: (a) pre- and posttest scores; (b) percentage of each type of play--individual, competitive, and cooperative; (c) demographic data to include age, grade, gender, and ethnicity; and (d) achievement data to include speed and accuracy. At the end of the designated time frame, the students participated in a posttest comprised of identical problems in the same presentation format as the pretest.

The raw data collected in the database was exported to SPSS (1999), with which the statistical analyses were accomplished. The analysis procedure implemented for this investigation was a simple Pearson correlation for the dependent variable against each independent variable. Each primary independent variable (the percentage of total number of times played in each mode) was correlated against the dependent variable (automaticity). Automaticity was tracked with a calculated percentage figure known by the students and teachers as a batting average (BA). The BA was a score that changed as the measured speed of accurate responses changed (see Appendixes A and B for the complete calculation procedure).

A secondary statistical analysis to identify possible correlations among collected demographic data and the dependent variable was also run. The correlations in this study were expected to indicate a relationship between the use of cooperative D&P in ILS activities and student improvement in automaticity of basic mathematics skills. The relationship between cooperative D&P and student performance was expected to be stronger than the correlation of either individual or competitive D&P with student performance.

*Summary*

The current research utilized a correlational design to identify the existence of relationships among several variables within a specific instructional setting. This study was designed to measure indications of the effectiveness of drill and practice, computer-based instruction toward automaticity of basic math facts when used in conjunction with various combinations of individual, competitive and cooperative grouping activities. Intentionally, the no grouping activities were assigned by the study parameters. The intent was to measure the grouping variables as they occurred spontaneously within the

sample population.

It was expected that relationships would be identified between specific combinations of cooperative, individualized, and competitive practice and various rates of automaticity attainment. Moreover, it was expected that students using cooperative ILS practice more frequently than individualized and competitive practice would correlate to a higher rate of automaticity attainment.

Chapter 4: Results

This chapter presents the data and the analyses of the data obtained during the 8-week, correlational study investigating the possibility of relationships among various grouping techniques with attainment of automaticity of basic math facts using a D&P ILS. The available pool of potential participants was 819 students, of which 178 students chose to participate. Of the 178 participants, computer errors resulted in loss of data for 71 participants such that their data was not usable. Many errors consisted of data dropped or corrupted from unreliable transmission and untimely session terminations. It was determined the unreliability of some of the schools' digital subscriber line (DSL) and integrated services digital network (ISDN) connections required omission of their data. Also, several errors were determined to have originated from database inconsistencies due to initial programming errors within the database setup and data collection functions. This reduced the final number of participants to 107. Of the 107 participants remaining, 45 had complete data for all four mathematical processes (addition, subtraction, multiplication, and division). The other 62 participants had usable data for some, but not all four, processes.

Of the 107 subjects, 55 were female and 52 were male. Ages ranged from 7 to 16 years, and students were enrolled in Grades 1 – 5. Subjects included 86% Caucasians, 12% African Americans, and 2% Native Americans.

*Analysis*

The primary dependent variable was the difference between pretest and posttest automaticity scores (delta). This variable was calculated for each of the four mathematical processes. Also, all four mathematical conditions were summed (collapsed) across the beginning averages, ending averages, deltas, individual mode, competitive

mode, and cooperative mode. This procedure provided the values needed to accomplish the t-test for determining the occurrence of increases in automaticity. Next, the instances of automaticity increase were correlated with the three primary independent variables. Finally, the increase in automaticity was correlated with each of the secondary, demographic variables.

*Findings*

Prior to conducting the correlational analyses, it was necessary to establish the presence, or lack, of increases in automaticity following game play with the D&P ILS. Paired *t*-tests were employed to determine if these increases in automaticity existed as operationally defined for the study. This step was necessary to establish the presence of automaticity improvement in order to correlate the other variables to it. Table 1 shows improvement of all conditions.

Table 1

*T-Test Comparing Pretest With Posttest Automaticity Scores*

| Mode | Means | | | *t*-test | | | Direction |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | Pre | Post | Delta | *T* | Df | Sig | Automaticity |
| Addition | .36 | .43 | .07 | -.96 | 100 | <.001 | Increased |
| Subtraction | .44 | .47 | .03 | -4.06 | 72 | <.001 | Increased |
| Multiplication | .32 | .38 | .06 | -5.33 | 59 | <.001 | Increased |
| Division | .38 | .48 | .10 | -5.20 | 52 | <.001 | Increased |
| Collapsed | .38 | .44 | .06 | -11.67 | 284 | <.001 | Increased |

*Note.* Collapsed indicates all modes combined.

The establishment of significant improvement in automaticity across all analyses provided the foundation and impetus for further delineation of the findings as they related to the primary research question: To what extent can various combinations of individual, competitive, and cooperative groupings in D&P CBI be related to an increase in automaticity of elementary students' computational skills with basic math facts? These analyses provided the indication of significant improvement of automaticity that was needed to correlate with the other variables identified for this study. Table 2 provides the descriptive statistics of the *t*-test analyses.

Table 2

*Descriptive Statistics of the T-Test Comparing Pretest With Posttest Automaticity Scores*

| Mode | N | Mean | Median | Mode | Std. Dev. | Range |
|---|---|---|---|---|---|---|
| Addition-pre | 105 | .36 | .37 | .33 | .12 | .49 |
| Addition-post | 99 | .43 | .44 | .43 | .10 | .51 |
| Subtraction-pre | 104 | .42 | .44 | .56 | .12 | .52 |
| Subtraction-post | 72 | .47 | .50 | .57 | .10 | .48 |
| Multiplication-pre | 78 | .30 | .30 | .27 | .14 | .52 |
| Multiplication-post | 59 | .38 | .40 | .37 | .13 | .57 |
| Division-pre | 77 | .35 | .40 | .29 | .17 | .57 |
| Division-post | 53 | .48 | .51 | .57 | .10 | .56 |
| Collapsed-pre | 364 | .36 | .38 | .48 | .14 | .57 |
| Collapsed-post | 285 | .44 | .46 | .57 | .11 | .57 |

*Note.* Collapsed indicates all modes combined.

Examination of the collected data pertaining to combinations of different grouping procedures revealed findings that indicated relatedness to the previously discovered increases in automaticity. The three hypotheses developed for this investigation provide a starting point for discussing this portion of the findings.

*Finding for Hypothesis 1*

Hypothesis 1 was: Students using cooperative ILS practice most frequently over either individualized practice or competitive practice will correlate to the highest rate of automaticity attainment. This hypothesis was rejected. As illustrated in Appendix C, cooperative practice actually correlated to the least amount of improvement in automaticity attainment.

*Finding for Hypothesis 2*

Hypothesis 2 was: Students using individualized ILS practice in conjunction with cooperative play, and using competitive play the least, will correlate to the highest rate of automaticity attainment. Investigation required that Hypothesis 2 should be rejected. Although individualized practice did maintain the highest correlation with the rate of attainment, as displayed in Appendix C, it was not in conjunction with cooperative play that this effect prevailed. Overall, the cooperative play signified a negative correlation to automaticity.

*Finding for Hypothesis 3*

Hypothesis 3 stated: The majority of students with competitive play as their most frequently used method will correlate to a lower rate of improvement in automaticity of basic math facts than students in the two other categories identified above. This hypothesis also was rejected. As indicated above, it was cooperative play, not competitive play, which correlated to the lowest rate of automaticity of the three modes.

Following the initial analysis, it became of interest to identify the level of contribution of speed and accuracy to the automaticity measurement. The correlational analyses indicated the relationship between speed and automaticity to be stronger than the relationship between accuracy and automaticity in the overall effect of this study. Table 3 illustrates the analysis of the individual mode of play with multiplication.

Table 3

*Correlation of Percentage of Play, Automaticity, Accuracy, and Speed in Multiplication (Students:  n = 57)*

| Variables | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. MuIndPer | -- | .23* | .03 | -.32** |
| 2. MuPostBA | | -- | .68** | -.94** |
| 3. MuPostAc | | | -- | -.57** |
| 4. MuPostTi | | | | -- |

*Note.* MuIndPer = Multiplication, individual play percentage; MuPostBA = Multiplication, posttest automaticity score; MuPostBA = Multiplication, posttest accuracy score; MuPostBA = Multiplication, posttest time in seconds. * significant at the 0.05 level ; **significant at the 0.01 level.

*Secondary Analysis*

The secondary analyses run on the demographic variables indicated that there were no significant gender differences on any of the dependent or independent variables. However, a significant trend appeared in the age and grade correlations. Age (paralleled by grade) produced significant correlations suggesting that as age increased so did the percentage of cooperative activity. The increase of age also coincided with a reduction of individual play, as well as a decrease in automaticity attainment. Table 4 illustrates the correlations associated with this finding.

Table 4

*Correlation of Age, Automaticity Improvement, Individual Play, and Cooperative Play in the Stacked File (+, -, x, l)*

| Variables | 1 | 2 | 3 | 4 |
|-----------|---|---|---|---|
| 1. AGE | -- | -.13* | -.20** | .19** |
| 2. DELTA | | -- | .09 | -.08 |
| 3. INDIV | | | -- | -.65** |
| 4. COOP | | | | -- |

*Note.* AGE = Subject's age in years; DELTA = posttest minus pretest; INDIV = individual play;  COOP = cooperative play. * significant at the 0.05 level; **significant at the 0.01 level. Students (n = 285).

*Summary*

Individualized practice was associated with the highest performance across the four mathematical modes. The strongest positive correlation (*r* = .21, *p* < .04) was obtained in individualized activity. Additionally, the strongest negative correlation (*r* = -.15, *p* < .07) was found in cooperative activity. This evidence is completely contrary to each of the research and theory-based hypotheses investigated in this study. The next chapter will explore possible explanations for the discrepancies between these well-substantiated hypotheses and the evidence uncovered here.

Chapter 5: Discussion of Results

Chapter 4 presented results indicating an unforeseen answer to the research question being investigated and subsequent rejection of all three of the offered hypotheses. To assist the reader, this chapter restates the original research question, reviews the methods implemented to conduct the study and summarizes the results. Further, this final chapter will reflect on these results and propose conclusions, possible implications, and recommendations for instructional implementations and future work.

*Statement of the Problem and Reviewing the Method*

There was one research question investigated in this study: The question was: To what extent can various combinations of individual, competitive, and cooperative groupings in D&P CBI be related to an increase in automaticity of elementary students' computational skills with basic math facts?

Two of the themes developed during the review of literature were used to further refine the direction of this study: (a) the overwhelming support for an eclectic approach to instructional practices, the grouping practices in this case, and (b) the general pedagogical superiority of cooperative grouping for all types of learning, as professed by a significant number of researchers. These two themes heavily influenced the formulation of the three hypotheses that further refined the direction of this study. The hypotheses of this study are that:

1. Students using cooperative ILS practice most frequently over either individualized practice or competitive practice will correlate to the highest rate of automaticity attainment.

2. Students using individualized ILS practice in conjunction with cooperative play, and using competitive play the least, will correlate to the highest rate of

automaticity attainment.

3. The majority of students with competitive play as their most frequently used method will correlate to a lower rate of improvement in automaticity of basic math facts than students in the two other categories identified above.

The current study employed a descriptive, quantitative approach. A correlational design was selected primarily to discover the existence of potential relationships between changes in the automaticity of basic math facts and specific combinations of individual, competitive, and cooperative grouping activities. Measurements of student performance during the study were recorded in normal classroom settings as students in grades one through five participated in a Web-based, math, baseball tournament among seven school systems. A pretest/posttest design was used to quantify changes in automaticity of the subjects over the course of the 8-week study. Each time a subject logged in to play the game, the Web-based ILS recorded the type of grouping activity selected, the number of math problems completed, and speed and accuracy during the session. In addition, demographic information was recorded upon the setup of the login account for each subject. As a secondary interest, analyses of the demographic characteristics were performed to identify possible relationships with grouping choices and automaticity.

*Summary of the Results*

The first of three notable results was the unexpected answer to the research question. The answer provided by this study indicated that combinations of individual, competitive, and cooperative groupings in D&P CBI could not be related to an increase in automaticity of elementary students' computational skills with basic math facts. This study identified the most useful approach for this specific instructional goal was the implementation of individualized practice without competitive or cooperative grouping.

The second result was a side-note of interest indicating that an increase in speed had a stronger relationship to attainment of automaticity than did an increase in accuracy. This was identified in this study's correlational analysis and supported by Anderson (1992). It is a relatively simple implication, but it provides bearing for the design of instructional activities with the objective of improving automaticity.

The final result dealt with the secondary analysis using the demographic data that was collected; (a) grade, (b) age, (c) gender and (d) ethnicity. This analysis was conducted to expose possible correlations among the three sets of data collected: (a) demographic data, (b) automaticity improvement, and (c) use of grouping methods. The only significant finding revealed that an increase in age coincided with increased time spent in the cooperative setting and, simultaneously, a decrease of improvement in automaticity.

*Conclusions*

The first conclusion to be drawn from this study is the direct answer to the overall research question: To what extent can various combinations of individual, competitive, and cooperative groupings in D&P CBI be related to an increase in automaticity of elementary students' computational skills with basic math facts? Among the significant outcomes of this research was an unexpected answer to the initial research question. A significant increase in automaticity was found with only one of the practice methods rather than an optimal combination of two or all three as was postulated for the design of the study. Furthermore, the two other grouping methods provided no indication of increase in automaticity. These two findings effectively negate the postulate that various combinations of grouping methods influence attainment in varying degrees.

The second conclusion was derived from the rejection of all three hypotheses.

Clearly, the individual practice method was identified to be singularly the most advantageous activity toward attainment of automaticity without utilizing competitive or cooperative grouping in conjunction with it. In direct opposition to all three hypotheses, the cooperative grouping method tested out to be the least effective of all three techniques.

A third conclusion was drawn from a side-note interest in investigating which of the two components, speed or accuracy, was the stronger determinant of automaticity. Correlations indicated that an increase in speed had a stronger relationship to attainment of automaticity than did an increase in accuracy. This direct relationship signified that an increase in speed of response is the stronger determinant of attainment of automaticity.

The final conclusion focused on the secondary analysis to find possible correlations on the three sets of data collected: (a) demographic data, (b) automaticity improvement, and (c) use of grouping methods. The research utilized in the literature review identified demographic variables such as age, gender and ethnicity as important in their studies. Some of these studies, such as the E-GEMS series (Sedighian & Sedighian, 1996) reported findings that indicated relationships between such demographics and specific instructional conditions. These studies, discussed in chapter two, suggested a possibility that some learner characteristics may correlate to some of the measured variables in the instructional implementation of the current study. It was on this basis that demographic information was collected and the secondary analysis was run.

The correlations of age, automaticity improvement, use of individual play, and use of cooperative play demonstrated that an increase in age coincided with increased time spent in the cooperative setting and, simultaneously, a decrease of improvement in automaticity. This finding reinforces one aspect of Wenglinsky's (1998) study which

investigated the achievement test scores of 6,227 fourth-graders and 7,146 eighth grade

students. Among other variables, the study examined "the use of computers to teach

lower-order thinking skills . . ."(p. 3). He identified D&P as the foremost CAI method of

teaching lower-order skills. Wenglinsky's study concluded that fourth grade students

improved slightly in performance, while the eighth-graders significantly decreased in

performance with this type of computer use in the classroom.

The inverse correlation of math improvement with D&P CBI to age level of the

learner was indicated in both Wenglinsky's study and the current study. Current theory

and research in the areas of social psychology, developmental psychology and various

learning theories provide additional explanations of learning differences among age

groups and different social settings. One plausible explanation for this correlation comes

from the developmental psychology camp, which identifies cognitive developmental

stages professed by the neo-Piagetian view. According to this view, the ages of the

children in these studies indicate they are developing their logical-mathematical

knowledge from the Concrete Operational Period to the Formal Operational Period. In

discussing this development, Driscoll (2000) stated:

> The cognitive result, therefore, of schemes enabling the invention of logical-mathematical knowledge is a coherent set of mental operations. These operations exist within relational structures or networks of operations that are considered to be the highest order mental organizations (also called schemata; Wadsworth, 1978, 1996). (p. 190)

This developmental progress does not preclude learners from the simpler

cognitive operations, but only stimulates them toward higher levels of cognitive activity

resulting in a reduction of attention and motivation toward the lower levels. Another, less

sophisticated, explanation may purport that since the older children overall entered the

study at an higher level of automaticity, there was not as much available room for

improvement for them as there was for the younger children. Many opinions could provide feasible explanations. However, since it is of secondary interest to the current study, the occurrence is noted as data to be examined in future investigations.

*Implications*

The first implication came from the assumption, used to formulate the research question, that an eclectic approach of combining all three methods into particular GARs would reveal optimum grouping ratios involving two or three of the methods. This postulation was derived from supporting literature discussed in the rationale for this study and the review of literature. However, the 8-week study found that a singular method of practice was the most efficient means to attain automaticity over any combinations of two or three of the grouping techniques. This finding was contradictory to the central postulation used to originate the research. Numerous studies discussed in the literature review provided inconclusive evidence on the issue. Since the studies to date have not addressed the gap in research data concerning the effectiveness of combining grouping techniques in an eclectic grouping approach to classroom use of D&P CBI activities, the inconclusive results left the possibility for an optimum combination of techniques, which is what this study was unable to identify.

One specific factor brought out in the literature review is that many recent studies have indicated positive relationships between CBI group-work and higher level learning (Becker & Lovitts, 2000; Cardelle & Wetzel, 1995; Hativa, 1994; Keeler, 1996; Mergendollar, 2000; Newman, Johnson, Webb, & Cochrane, 1997; Sedighian, 1997; Valdez et al., 1999). Also brought out in the literature review were many CBI studies that indicated a positive relationship between individualized work and lower level cognitive learning (Becker 1992; Berger et al., 1994; Kulik, 1994; Kulik & Kulik, 1991; Robyler,

Castine, & King, 1988; Underwood et al., 1996). Though these two characteristics are validated in the majority of the studies, there were still contradictory findings among some of the studies which made the evidence inconclusive. However, when these majority evidences from the literature review are combined with the findings of this study, the implication exists that there is a probable relationship between the hierarchal level of the learning task and the effectiveness of using individualized or grouping methods.

The second conclusion further defined the measured effect. It identified that the singular method of individualized practice was most successful over both competitive and cooperative play. A strong advantage with exclusive use of individualized practice is implied for the attainment of automaticity of math facts. This implication refuted all three of the hypotheses established for this study, which prompted a reexamination of the literature used to establish the hypotheses. The subsequent examination revealed several contributions of cognitive learning theory that provided some explanations of specific aspects of the current findings. While the various cognitive learning theorists had several points of divergence among them, there are a few noteworthy coinciding elements throughout their works that bear relevance to this specific study. Cognitive learning theory is based on the work of eminent theorists like Vygotsky, Piaget, Bloom and many others. The constructs they provided offer insight into the effects of grouping techniques on the construction of mental schema concerning the findings of the current study.

Vygotsky and Piaget understood cognitive development to be comprised of social and biological activities. Both of these theorists identified learning as an active process to construct knowledge that necessitated the interaction of the individual with others in society. Vygotsky professed that all learning takes place in the zone of proximal

development. He identified the zone as the place between what the child can do on his/her own and what he/she cannot do. This gap is where capabilities are being developed and is manifested in what the child is able to do with assistance from an instructor who may be an adult or a more capable peer. One core component "of Vygotsky's theoretical framework…the claim that higher mental processes in the individual have their origin in social processes . . ." (Driscoll, 2000, p. 241) is of particular significance to this discussion. This provides a basis for the idea that cooperative grouping will work best with higher-level learning tasks and individualized training needs to be reserved for lower-level tasks. This coincides with the findings that the correlations of the current study indicate the lower-level cognitive process of automaticity attainment seems to be best accommodated by individualized practice.

  Piaget and Bloom were both strong advocates of hierarchal steps of learning. From this perspective, cognitive development occurs from simple learning through stages of more complex learning in specific sequences. For Piaget, the stages were associated with age ranges. Both Bloom and Piaget purported that the simpler, or lower levels, of learning were prerequisite to the higher levels. Cognitive theory proposes that learners actively construct a hierarchal knowledge structure based on previous experience. They use the term schema to identify the "internal knowledge structure. New information is compared to existing…schema. Schema may be combined, extended or altered to accommodate new information" (Mergel, 1998, p. 7). While Piaget did not coin the term schema, he subscribed to using it to refer to the ever-changing, increasingly complex cognitive structure of the learner. This diverges from current schema theory as it relates to the constructivist viewpoint that identifies schema as not necessarily hierarchal. However, contemporary cognitive theorists generally identify schema as the malleable,

hierarchal, mental framework for understanding and remembering information. The concept of increasing complexity of information acquisition was central to both Piaget and Bloom. Bloom, et al. (1956) provided a now famous nomenclature system for his idea of hierarchal configuration of cognition that identifies the acquisition of knowledge, or facts, as the simplest form of cognition. This study provides evidence that the simplest practice method correlated most strongly with the simplest level of cognition.

Another important consideration for this discussion is Sweller's (1989) cognitive load theory. His theory identifies two important components for maximizing working memory capacity: (a) schema acquisition and (b) automaticity of procedural knowledge. These two concepts are important to this discourse because they further differentiate important concepts to automaticity. Schema acquisition is the compiling, or chunking, of simpler subsets of information into a single unit of information in long-term memory for efficient retrieval and use. This is commensurate with the hierarchal nature of knowledge purported by several other cognitive theorists. The automaticity of procedural knowledge is the similar submission of processes to long-term memory for skill acquisition. Sweller (1989) also purports that attempting to perform cognitive tasks with higher-level schema before the sublevels are well developed will cause extraneous cognitive load and thwart learning. Overall, cognitive theory advocates using appropriate instructional techniques from an objectivist, social context progressing from lower-level cognitive skills toward higher-level skills. This, again, coincides with the findings of this study that significantly correlate the lower-level cognitive process of automaticity attainment to individualized practice.

Newell (1990) provided a cognitive model of schema in four bands of cognition: (a) biological, (b) cognitive, (c) rational, and (d) social. Even though the focus of this

model is unifying cognitive effects measured in multiple milliseconds to learning

outcomes measured in multiple hours, it has a coincidental implication with the outcome

of this study. The structure of this model subscribes to the hierarchal structure of human

cognition and coincides the lower-levels of cognition with the individual while the

higher-levels are associated with society. Using Newell's (1990) Bands of Cognition,

Anderson (2002) provides evidences for the dependency of higher-level learning on the

strength of learning at lower levels based on three theses:

> The Decomposition Thesis claims that learning occurring at the Social Band can
> be reduced to learning occurring at lower bands. The Relevance Thesis claims
> that instruction outcomes at the Social Band can be improved by paying attention
> to cognition at the lower bands. The Modeling Thesis claims that cognitive
> modeling provides a basis for bridging between events on the small scale and
> desired outcomes on the large scale. (p. 1)

Anderson's (2002) article analyzing Newell's (1990) cognitive bands provides an

analysis that substantiates the widely held "postulate that success of higher-level

cognition depends on the fluency with which these lower-level processes can progress"

(p. 99). He goes on to describe that practice, like that of D&P in an ILS, decreases the

retrieval time according to the ACT, now ACT-R, theory. This increase in automaticity of

a chunk like the multiplication fact 3 x 7 = 21, can have an impact on higher-level

cognition (Anderson, 2002). Again, this concurs with the findings of the present study

that the lower-level cognitive processes of the first two cognitive bands may well be

improved with individual practice.

These models provide support for the conjecture that indicates individualized

practice to be the most effective method for lower-level cognitive processes. Yet as the

learner moves through the cognitive schema building process to higher levels of

cognition, more reliance is placed on both efficient chunk retrieval from declarative

memory and social interaction for facilitation of higher-level cognitive development.

The third conclusion, which identified speed to be more strongly related to automaticity implied the change in automaticity, was controlled by a change in speed rather than accuracy. This implication merely emphasized the alignment of characteristics. While accuracy is the foundational measurement for automaticity, it is measured by one of two states. The answer is either correct or incorrect. Once that characteristic is determined, no further contribution to the measurement of automaticity is made, whereas there are many states in which speed is measured just as automaticity. Once the prerequisite of the accuracy measurement is identified to be correct, the change in speed constitutes any and all changes in automaticity that are measured. Anderson (1992) identified this quality in his description of the ACT theory and this is the basis for the operational definition identified in chapter 2. It is a relatively simple implication, but it is important in that it provides the focus for designing instructional activities with the objective of improving automaticity (Anderson, 2002; Ashcraft, 1992; Gersten & Chard, 1999).

The fourth, and final, implication comes from the secondary analysis of the three sets of data that found an indirect relationship between increase in age and increase in automaticity, while there was a direct relationship between increase in age and increase in time spent in cooperative activities. The implication is that using D&P CBI for the attainment of automaticity may be better accomplished with younger children. This corresponds to Wenglinsky's (1998) analysis described in chapter two where his findings with math test scores of fourth-grade and eighth-grade students were expressed. As indicated earlier, this is a secondary finding for this study and is noted as having occurred for reference in future investigations.

The predominant impact of this study has been to provide additional evidence to confirm that specific instructional techniques can be identified as being more, or most, effective with specific levels of cognitive tasks is implicated by the different approaches to instruction and cognitive theory discussed above. Based on the findings of this study, the generally accepted eclectic approach implicated by the reviewed literature may not be the most effective method for this specific instructional setting. An approach that combines grouping techniques at the lower levels of learning was indicated to be less effective than the individualized method alone.

The identification of a demonstrable, pedagogically sound, ILS reinforcement technique affords a great opportunity to advance the field of instructional technology. First, the identification and clarification of a validated ILS technique provides additional avenues of investigation for refinement of the field. These investigations will further provide information to software designers, helping them maximize the facilitation of sound instructional techniques through improved software functionality. Thereby, with a clearer understanding of successful ILS techniques and properly designed software, classroom teachers will be able to correctly implement software design components that facilitate the most appropriate use of techniques into classroom activities so as to optimize their teaching effectiveness and learning opportunities for their students.

*Recommendations*

Based on the implications derived above, it is generally recommended that individualized activities, regardless of media (human, manual, or electronic) should be used primarily with younger students as they construct the lower levels of their cognitive schema. Subsequently, as students get older and need to more frequently facilitate the construction of the higher levels of learning, once the foundational subskills are in place,

the teachers should probably make more frequent use of cooperative grouping activities. Likewise, software designers need to facilitate the appropriate grouping scenarios with the proper levels of learning activities.

It is evident that additional research investigating automaticity and group vs. individual practice in a variety of settings would be beneficial to confirm these results. Also of benefit might be studies examining what kind of individualized CBI activities work best for automaticity. Another important focus would be investigation of the relationship of schema building and automaticity. The current research suggests the foundational components of cognitive schema may be best obtained with individualized activities. Further research to correlate age, schema types (levels), and automaticity may reveal relationships to be investigated for even more insight to the construction of the foundational layers of cognitive schema.

*Summary*

This study has revealed a probable relationship between individualized instructional activity and an important type of learning, automaticity of basic math facts. The contemporary trend of many educators is to teach toward high-level cognitive goals using popular social instructional techniques such as collaborative/cooperative activities with CBI. This study has shown that some educators advocate the abandonment of lower-level, individualized CBI activities such as D&P. This study provided substantiation for continuing to use individualized D&P CBI in skill-building activities toward at least one specific instructional goal. Much more research needs to be accomplished to best determine the optimum application of this and other instructional methods to be used in newly developed instructional technologies.

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Appendix A

BatterUp Tournament Point System

BatterUp Tournament Point System

The tournament point system is based on improvement in automaticity as demonstrated within the ILS practice/play. The measurement of automaticity is accomplished with the system identified below:

1)  The base hits are determined by a chart of 'Base Hit Times for the (Addition, Subtraction, Multiplication, or Division) Facts' developed through a pilot implementation of the game in elementary schools.

2)  Point values are assigned according to the league (Lg) level in which the 'base hit' is accomplished as identified on the chart below:

Points Assigned per Hit

|           | Single | Double | Triple | Home Run |
|-----------|--------|--------|--------|----------|
| Little Lg | 1      | 2      | 3      | 4        |
| Minor Lg  | 2      | 3      | 4      | 5        |
| Major Lg  | 3      | 4      | 5      | 6        |
| Hall/Fame | 4      | 5      | 6      | 7        |

3)  <u>Batting Average</u> (BA) is calculated as follows:
    BA = points (table above) multiplied by .142857, then divided by times at bat and rounded to the nearest thousandths.  BA is calculated per mode (addition, subtraction, multiplication, etc.) only.  A student's BA in one mode does not affect the same student's BA in another mode.

4)  <u>Automatic Level assignment</u> is calculated as follows:
    If BA in identified mode is < .429, then assign to Little League.
    If BA in identified mode is ≤ .429 but ≥ .642, then assign to Minor League.
    If BA in identified mode is < .642 but ≥ .785, then assign to Major League.
    If BA in identified mode is > .785, then assign to Hall of Fame.

Appendix B

Base Hit Times for the Multiplication Facts

## Base Hit Times for the Multiplication Facts

The number of seconds to beat for each league level (little, minor, major and Hall of Fame) is identified below in the row with the achieved 'base hit' in the far right column. The left column identifies the 'fact set' being practiced.

| Mul# | Little | Minor | Major | Hall of Fame | Base |
|------|--------|-------|-------|--------------|------|
| 2 | 30 | 21 | 14 | 11 | First |
| 2 | 21 | 14 | 11 | 8 | Second |
| 2 | 14 | 11 | 8 | 4 | Third |
| 2 | 11 | 8 | 4 | 3 | Home |
| 3 | 35 | 24 | 16 | 12 | First |
| 3 | 24 | 16 | 12 | 8 | Second |
| 3 | 16 | 12 | 8 | 5 | Third |
| 3 | 12 | 8 | 5 | 3 | Home |
| 4 | 35 | 24 | 16 | 12 | First |
| 4 | 24 | 16 | 12 | 8 | Second |
| 4 | 16 | 12 | 8 | 5 | Third |
| 4 | 12 | 8 | 5 | 3 | Home |
| 5 | 33 | 23 | 15 | 11 | First |
| 5 | 23 | 15 | 11 | 8 | Second |
| 5 | 15 | 11 | 8 | 4 | Third |
| 5 | 11 | 8 | 4 | 3 | Home |
| 6 | 45 | 33 | 22 | 17 | First |
| 6 | 33 | 22 | 17 | 11 | Second |
| 6 | 22 | 17 | 11 | 5 | Third |
| 6 | 17 | 11 | 5 | 4 | Home |
| 7 | 45 | 33 | 22 | 17 | First |
| 7 | 33 | 22 | 17 | 11 | Second |
| 7 | 22 | 17 | 11 | 6 | Third |
| 7 | 17 | 11 | 6 | 4 | Home |
| 8 | 45 | 33 | 22 | 17 | First |
| 8 | 33 | 22 | 17 | 11 | Second |
| 8 | 22 | 17 | 11 | 6 | Third |
| 8 | 17 | 11 | 6 | 4 | Home |
| 9 | 50 | 24 | 24 | 14 | First |
| 9 | 36 | 14 | 14 | 11 | Second |
| 9 | 24 | 11 | 11 | 7 | Third |
| 9 | 14 | 7 | 7 | 4 | Home |

(table continues)

| Mul# | Little | Minor | Major | Hall of Fame | Base |
|------|--------|-------|-------|--------------|--------|
| 10 | 25 | 18 | 12 | 9 | First |
| 10 | 18 | 12 | 9 | 7 | Second |
| 10 | 12 | 9 | 7 | 4 | Third |
| 10 | 9 | 7 | 4 | 2 | Home |
|  |  |  |  |  |  |
| 11 | 60 | 38 | 24 | 19 | First |
| 11 | 38 | 25 | 19 | 12 | Second |
| 11 | 25 | 19 | 12 | 7 | Third |
| 11 | 19 | 12 | 7 | 4 | Home |
|  |  |  |  |  |  |
| 12 | 60 | 38 | 25 | 19 | First |
| 12 | 38 | 25 | 19 | 14 | Second |
| 12 | 25 | 19 | 14 | 7 | Third |
| 12 | 19 | 14 | 7 | 5 | Home |

*Note.* Mul# = multiplication times tables being practiced.

Appendix C

Correlation Between Playing Modes and Automaticity Improvement

Correlation Between Playing Modes and Automaticity Improvement

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| Variables | 1 | 2 | 3 | 4 |
|-----------|---|---|---|---|

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Students Playing Addition (n = 100)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Individual Play | -- | -- | -- | .03 |
| 2. Competitive Play | | -- | -- | .07 |
| 3. Cooperative Play | | | -- | -.15* |
| 4. Automaticity Improvement | | | | -- |

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Students Playing Subtraction (n = 72)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Individual Play | -- | -- | -- | .21** |
| 2. Competitive Play | | -- | -- | -.15 |
| 3. Cooperative Play | | | -- | -.10 |
| 4. Automaticity Improvement | | | | -- |

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Students Playing Multiplication (n = 59)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Individual Play | -- | -- | -- | .08 |
| 2. Competitive Play | | -- | -- | .01 |
| 3. Cooperative Play | | | -- | .01 |
| 4. Automaticity Improvement | | | | -- |

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Students Playing Division (n = 53)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Individual Play | -- | -- | -- | .13 |
| 2. Competitive Play | | -- | -- | -.03 |
| 3. Cooperative Play | | | -- | -.08 |
| 4. Automaticity Improvement | | | | --- |

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Students Collapsed Across All Playing Modes (n = 285)

| | | | | |
|---|---|---|---|---|
| 1. Individual Play | -- | -- | -- | .09* |
| 2. Competitive Play | | -- | -- | -.01 |
| 3. Cooperative Play | | | -- | -.08* |
| 4. Automaticity Improvement | | | | --- |

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*Note.* *marginally significant $(.05 < p < .10)$ ;   **significant $(p < .05)$.