CHAPTER II
LITERATURE REVIEW

Introduction

This literature review explores the three dominant themes of the research questions: symbolic representation of concepts, impact on academic achievement, and student attitudes, behaviors, and interactions. While geometry is the academic subject area of this particular research project, the scope of this literature review is expanded to include research that examines the dominant themes of the research questions, regardless of the specific academic subject area.

In 1996, the National Association for the Education of Young Children adopted its current position statement on the use of technology with children aged three to eight, based to a degree on several of the studies covered in this literature review (NAEYC, 1996). Some of the research studies in this review also refer to this current NAEYC position statement and previous position statements of the NAEYC and address their guidelines and concerns. This demonstrates a commitment by both the research community and early childhood leaders to work together towards finding appropriate and effective ways to integrate technology, and not just allow opinions to guide their work with children.

Symbolic Representation of Concepts

One argument critics often raise against young children using computers is that computer environments are not concrete, asserting the Piagetian belief that children construct knowledge through interaction with materials and people, and that children
cannot handle the symbolic representations present in a computer environment (Barnes & Hill, 1983; Wood, Willoughby, & Specht, 1998). However, what is “concrete” to a child may have more to do with what is meaningful and manipulable than with physical characteristics.

The well-known Logo programming language is a prime example of an effective method for working with symbolic concepts by utilizing an interactive computer environment. The programming involved in Logo promotes abstract thinking and returns a concrete visual picture (Allocco et al., 1992). Comparisons between Logo and non-Logo students have shown that Logo students are more effective in solving problems involving concepts and applications. They also score higher on figure classification, quantitative reasoning, and have shown a significant improvement in the achievement of geometry skills (Robinson, Feldman, & Ulhig, 1987). Computers not only enhance children’s learning experiences by allowing them to visualize connections among various topics (Enderson, 1997), but can indeed facilitate their cognitive development, leading to students investigating ideas beyond grade-level expectations (Duarte, Young, & DeFranco, 2000).

In a study comparing the symbolic computer environment to the “concrete” environment, a researcher (Ainsa, 1999) used M&M’s as math manipulatives to measure children’s ability to accomplish a mathematical task and the use of a computer to do a similar task. The study found that 101 subjects, aged four to six, showed no significant differences in their abilities to match colors and numbers, identify shapes, count items, or perform addition and subtraction. The researcher indicated that a combination of approaches yielded in enthusiastic learning, although the students
tended to request M&M’s anytime a math concept was discussed. A similar study showed that third grade children who used both manipulatives and computers demonstrated sophistication in classification and logical thinking and showed more foresight and deliberation in classification than did children who used only manipulatives (Clements, Nastasi, & Swaminathan, 1993).

Shade and Watson (1990) conducted a study in which young children learned to classify a unique array of objects, such as tables, cars, lamps, etc., based on the simple concept of inside or outside. Children aged 18 to 42 months spent one hour manipulating computer graphic objects in and around the background scene of a house and yard. These students were then asked to classify the matching “real” objects. The study found that around the age of 36 months, the computer manipulation of the objects enabled the children to be able to correctly classify the series of actual objects.

Another study (Clements et al., 1993) involved asking young children to create “bean stick pictures” in either a felt board or computer environment. Students could freely select and arrange beans, sticks, and number symbols on a computer, just like the real bean stick environment. The results of the study showed that the computer environment actually offered equal, and sometimes greater, control and flexibility to young children.

These studies indicate that children are able to transfer symbolic learning from the computer environment to the actual environment. This suggests that teachers could use computer software and web resources with their students and have the confidence that they are providing appropriate materials and experiences that are conducive to student learning.
Impact on Student Achievement

Not all technology is created equal, and research by Haugland (1992) suggests that the types of computer activities and software young children are exposed to makes a difference in their cognitive development and academic achievement. Haugland identified nine software programs as “developmental,” meaning they incorporated characteristics such as age appropriate, child control, expanding complexity, independence, process oriented, real-world modeling, trial and error, and transformations. Nine other programs were identified as “non-developmental.”

Haugland studied four preschool classes that were exposed to four different treatments during one school year. These treatments were: developmental software plus corresponding off-computer activities; developmental software only; non-developmental software only; and no exposure to computer software. The two groups that included developmental software in the treatment demonstrated significant gains in intelligence, non-verbal skills, structural knowledge, long-term memory, and complex manual dexterity. The group that included corresponding off-computer activities showed significant improvement in verbal skills, problem solving, abstraction, and conceptual skills. The group with access to non-developmental software demonstrated significant gains in concentration and short-term memory but significant losses in creativity.

The use of word processing software is an area where a teacher’s instructional decisions will impact if the technology is used appropriately. When compared to the characteristics listed above, word processing software fits well as it provides tools such as easy text entry, spell checking, and editing that allow students to experiment and
creatively communicate with language. Students using a computer to write can cooperatively plan, write, and revise within the frameworks of the six-trait writing model that is used in Nebraska schools. However, if a teacher makes the specific features of word processing software the focus of instruction instead of the writing process, they would not likely see any improvement in the quality of student writing.

Clements et al. (1993) found that when children write on computers, their stories are more fluid, they write more, their stories are more complex, they make fewer mechanical errors, they worry less about making mistakes, and they are more willing to make revisions. These findings are similar to Russell and Haney (1997) who conducted a study with middle school students accustomed to writing on computers. When comparing computer and paper-and-pencil essays, students writing their essays on the computer performed "substantially better" than those who wrote using paper-and pencil. Thirty percent of paper-and-pencil essays were rated as satisfactory, compared to 67 percent of the computer essays. Students who performed the assessment on the computer tended to write almost twice as much and were more apt to organize their responses into more paragraphs. The researchers observed that computers allowed students to write and revise much more easily and quickly than with a pencil. Crippen (2000) notes that nearly all standardized writing tests are paper-and-pencil, and states, “There is an emerging gap between how students are taught and how they are assessed.” This is evidenced in Nebraska by the fact that the state writing assessment is paper-and-pencil based.

Related closely to word processing is the topic of keyboarding with young children. Several teachers utilize keyboarding as a way to support and reinforce the
language arts. The National Business Education Association (1992) supports the introduction of keyboarding instruction at grade three because students at that grade are generally more anatomically ready to learn keyboarding. Students younger than grade three may not have the dexterity or hand size to master the reaches. They also recommend that keyboarding instruction be introduced one year prior to word processing and emphasize that it if students are not going to use their keyboarding skills by using a word processor, then it is a waste of instructional time.

McClendon (1991) conducted a study with a first grade class to see if keyboarding instruction could improve spelling. The first half of the year was taught using the direct instruction method and the second half of the year with a combination of direct instruction and keyboarding practice. The first graders were randomly assigned to the class and the group consisted of two high achievers, eight average achievers, and eight low achievers. Results indicated that students’ attitudes toward spelling class improved with the keyboarding included, and achievement test spelling scores at the end of the year showed a significant difference when compared to gains made during the first half of the year. Students’ keyboarding rates were equal to or faster than their handwriting rates. Recommendations included introducing the keyboarding instruction at the beginning of the year, and completing the keyboarding lessons before integrating them with the spelling lessons. This study is important more for the fact that student attitudes improved than for the spelling achievement. The increased positive student attitudes regarding spelling, and the demonstration of first graders acquiring keyboarding skills equal to or better than their handwriting speeds seem to be two compelling reasons for integrating keyboarding into language arts classes.
Cowles (1983) studied 24 students from a summer-enrichment keyboarding program ranging in ages from five to eight. Results of the study indicated that even young children can learn to type correctly and they can do so without frustration. Some factors that may have influenced the success of this study were the small class sizes of six students per age group, and that this was an enrichment program which was not a random, typical sample of students in that age population. The most relevant finding in this study was that being able to read was important to acquiring keyboarding skills.

Connected to the ability to read, researchers (Foster, Erickson, Foster, Brinkman, & Torgesen, 1994) conducted two experiments on the instructional effectiveness of a computer program, DaisyQuest, designed to increase phonological awareness in young children. In experiment one, twelve kindergarten-aged children worked on the program for 20 sessions of about 20-25 minutes each. Children in this group showed significantly (p < 0.02) greater gains in phonological awareness, as measured by two different tests, than the control group of 15 children who did not receive training. In experiment two, 34 kindergarten-aged students completed an average of 4.9 hours of training with DaisyQuest and they significantly (p < 0.01) outperformed a control group of 35 children on three different phonological tests. The DaisyQuest training produced an average effect size of 1.05 standard deviations. The researchers cited studies of similar experiments concerning teacher-led phonological training. While the teacher-led sessions produced an average effect size of 1.23 standard deviations, slightly higher than DaisyQuest, those sessions involved double the training time with students. This would suggest that DaisyQuest may have advantages in terms of accelerating the acquisition of reading, and the researchers stated they also intended
to examine the effectiveness of the program in a future study on children who are at risk for serious difficulties in learning to read.

Clariana (1994) investigated the effects of a computer Integrated Learning System (ILS) on the mathematics and reading standardized exam scores of four separate third grade classes. According to the Office of Technology Assessment (1988), ILS generally refers to a system that includes extensive courseware plus management software running on a networked system. The four classes in the study were taught by the same teacher over a period of four years, and had a total of 85 students. The first and second groups received traditional classroom instruction while the third and fourth groups received traditional classroom instruction plus ILS instruction. The ILS groups showed a larger gain for mathematics with an effect size of 0.49 than for the reading groups that had an effect size of 0.06.

Two years later, Clariana (1996) reported on the effects of an ILS on the standardized test scores of elementary students. He selected three consecutive fifth grade cohorts from five elementary schools, for a total of 873 students. The first and second cohorts received traditional classroom instruction while the third received traditional classroom instruction plus ILS mathematics instruction. The median effect size gains for the ILS group compared to the non-ILS groups were 0.13 for computation, 0.63 for concepts, and 0.33 for applications. Clariana points out that while most computer math software tends to focus on computation skills, the greatest effect size in this study was in the area of mathematical concepts.

In another ILS study (Underwood, Cavendish, Dowling, Fogelman, & Lawson, 1996), researchers followed a six month ILS trial in nine schools. The student
population ranged from 8 to 13 years of age. The researchers compared the academic performance of treatment and control groups and also monitored student behavior. An effect size of 0.4 was reported in the ILS math groups. General observations on behavior were that students in the ILS groups had a higher time on task than students in the control groups. There were no differences in recorded attendance rates between the groups.

Computer assisted instruction (CAI) was compared to traditional instruction in a sample of 48 hearing impaired children (Braden, Shaw, & Grecko, 1991). The treatment and control groups were compared on measures of written language, in-class quizzes, and standardized achievement scores. The CAI math group had significantly higher scores ($p < 0.01$) on in-class math quizzes than the control group. No other statistically significant differences were found on the other measures of achievement. The researchers reported informally that the CAI students enjoyed using the computer, stayed on-task when using the computer, and that parents, teachers, and administrators all rated CAI favorably.

In a meta-analysis (Christmann, Badgett, & Lucking, 1997) comparing the academic achievement of students in eight curricular areas who received either traditional instruction or traditional instruction supplemented with computer assisted instruction, researchers reported an overall mean effect size of 0.209 for students who received CAI. The specific subject areas had the following effect sizes: science, 0.639; reading, 0.262; music, 0.230; special education, 0.214; social studies, 0.205; math, 0.179; vocational education, -0.80; and English, -0.420.
Kulik’s (1994) meta-analysis on computer-based instruction found that on average, computer-using students at the elementary level scored at the 64th percentile on achievement tests compared to students without computers who scored at the 50th percentile. Kulik also noted that students learn more in less time when they receive computer-based instruction and that students like their classes more and develop more positive attitudes.

A report on Missouri’s eMINTS program showed that students who participated in eMINTS classrooms scored consistently higher on the Missouri Assessment Program (MAP) tests than non-participants (MOREnet, 2002). The eMINTS program combined multimedia and computer technology, inquiry-based teaching, and professional development. Researchers analyzed test scores from 85 eMINTS classrooms and 203 non-eMINTS classrooms. Results of the MAP tests show that a higher percentage of eMINTS students scored in the top two achievement levels. The eMINTS students in special programs, such as special education, Title 1, and free and reduced lunch programs, also showed substantial increases in their MAP scores.

A large scale, longitudinal study of West Virginia’s Basic Skills/Computer Education (BS/CE) program analyzed 950 fifth-grade students from 18 elementary schools (Mann, Shakeshaft, Becker, & Kottkamp, 1999). The study began with a cohort of kindergarten students in the 1990-91 school year. Each year the state of West Virginia provided participating schools with enough technology equipment to serve the cohort and technology training, software, and support for the teachers. The analysis of the cohort showed that when the cohort reached grade three, the statewide test scores went up five points in one year, compared to a total six point rise in the previous four
years. As fourth graders, the cohort had the second highest reading scores among southern states. In fifth grade, the cohort showed gains in the Stanford-9 achievement test, with higher gains than non-cohort students. Girls and boys in the cohort did not differ in achievement, access, or use of computers in the study.

**Student Attitudes, Behaviors, and Interactions**

Some critics maintain that the use of computers with young children may detract from the social environment present in early learning settings, yet many researchers have found that computers can be effectively used at this age with positive influences on student attitudes, behaviors, and interactions (Rockman, 1993; Wood et al., 1998).

Goldmacher and Lawrence (1992) studied two groups of preschool children enrolled in a Head Start program. One group followed the standard Head Start program while the other group participated in computer enrichment activities in addition to their standard Head Start activities. The computer activities were theme-based and built around a variety of software. Students in the computer group exhibited significantly more behaviors indicative of positive self-concept than did students in the non-computer group.

In a full-inclusion kindergarten, researchers (Symington & Stanger, 2000) used inclusionary math software to investigate how classroom dynamics would change and how the software would help children with disabilities. The researchers reported that the accessible math software allowed students with various disabilities to become active participants in their classrooms. This led to the improvement of the children’s self-perception, and a stronger connection with classmates. One teacher involved in the
study stated, “It helped him develop his self-confidence because of the degree of feedback the software provided to him.”

A similar study (Stanger & Khalsa, 1998) reported that accessible math software forced some students with disabilities to work harder than they had before. One boy with cerebral palsy had poor handwriting and often used that as an excuse to not complete his math work. The software took away that obstacle and allowed the boy to focus on the math problems instead of the handwriting difficulty. His teachers reported that this helped him become a more integral part of the class, more independent in other areas, and they noticed a change in perception by classmates.

Haugland (1996) conducted a study where the self-esteem of four-year-old children in classrooms with computers was compared to the self-esteem of children in a classroom without computers. At the end of the nine-month study, the children in the classroom with computers had significantly higher increases in measures of self-esteem than the children in the classroom without computers. The researcher hypothesized that this occurred because children view computers as “adult machines” and when given the opportunity to explore and manipulate the computers, they feel important, capable, and competent.

In a comprehensive three-year study (Hutinger & Johanson, 2000), a portion focused on young children’s behaviors during various classroom activities. Eleven common activities, including free play, books, computer, art, and snack time were observed, described, and coded. Results showed that of the eleven observed activities, computer use was most often followed by desirable behavior and least likely to be followed by aggression. While at the computer, communication and turn taking
accounted for 63% of the observed text units (35% communication and 28% turn taking). These results are comparable with the level of communication during free play (43% communication) and superior to the level of turn taking during free play (4% turn taking). Children in this study with behavior problems exhibited fewer disruptive behaviors during computer time, interacted socially more often, and communicated more. Observations revealed that some students displayed unsuspected skills and abilities and became the “computer expert” of the class.

Wood et al., (1998) echo these findings as they report that children aged four and five engaged in more social interactions with their peers when using a computer than when solving jigsaw puzzles. They were more cooperative and engaged in more helping and sharing behaviors after a computer was introduced into their classroom than prior to its introduction.

As part of a review of 219 published and unpublished research projects, Sivin-Kachala & Bialo (1997) reported that students felt more successful in school, were more motivated to learn, and had increased self-confidence and self-esteem when using computer-based instruction. Evidence for these positive effects was the strongest in the areas of language arts, mathematics, and science.