INTEGRATING HYPERMEDIA INTO ELEMENTARY TEACHERS' SCIENCE PROFESSIONAL DEVELOPMENT OPPORTUNITIES: THE EFFECTS ON CONTENT KNOWLEDGE AND ATTITUDES TOWARD SCIENCE

By

CHARLES RICHARD HARTSHORNE

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Charles Richard Hartshorne

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Chair: Colleen R. Swain
Cochair: Richard E. Ferdig
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Recent calls for improvements in the teaching of science gave rise to the implementation of numerous reform strategies in the elementary classroom. Reviews of the different reform strategies showed varying levels of effectiveness in the overall quality of teaching and student learning. One method shown to be effective in producing changes in teachers, the teaching process, and ultimately student learning is the professional development workshop. Due to the success of professional development workshops in other subject areas, researchers have suggested this could be an effective strategy in addressing major concerns related to the teaching of science in elementary classrooms. However, past elementary science professional development workshops have not met with the same levels of success as other content areas.

The integration of hypermedia into professional development settings is one method of improving the effectiveness of elementary science professional development workshops. Integrating hypermedia into structured professional development settings can be helpful in addressing two major concerns with the teaching of science in the elementary classroom: lack of teacher content knowledge and poor teacher attitudes toward science.

In this study, the extent to which the integration of hypermedia into professional development workshops influenced elementary teachers' science content knowledge and attitudes toward science was examined. Results indicated that while the integration of hypermedia into the professional development environment could have contributed to elementary teachers' science content knowledge, the increases in content knowledge were not dependent on the presence of hypermedia in the professional development setting. Study findings did indicated the integration of hypermedia into professional development workshops had a positive influence on elementary teachers' attitudes toward science and was an integral component to the increase in elementary teachers' attitudes toward science. The results of this study provide a foundation for future research related to integrating hypermedia into professional development settings.

CHAPTER 1
INTRODUCTION

> Science is the tool of the Western mind and with it more doors can be opened than with bare hands. It is part and parcel of our knowledge and obscures our insight only when it holds that the understanding given by it is the only kind there is.
>
> -C. G. Jung, 1978

Within the past decade, numerous calls for reforming the teaching of elementary science in American public schools have been made (Bybee, 1993; Loucks-Horsley, 1996; National Research Council, 1996; Raizen, 1998; Yager, 1993). Two major premises form part of the foundation for these calls. First, research has shown that exposure to science processes at young ages enhances future science performance and the skills associated with 'doing' science (Keeves, 1995; Rowe, 1992). This is due, in part, to the idea that the study of science promotes the development of evaluative and analytical skills, as well as a logical approach to problem-solving, skills which promote scientific literacy (American Association for the Advancement of Science, 1989, 1993; Plourde, 2002; Tilgner, 1990). The second premise for the call for elementary science reform originates from research indicating a lack of student enrollment in more advanced science courses (Fraser & Walberg, 1995). Consequently, when compared to other technological nations, American students perform poorly on international science assessments (International Association for the Evaluation of Achievement, 1988; Knuth, Jones, & Baxendale, 1991; Plourde, 2002). These two premises, along with other factors, have influenced the introduction of science topics and skills on statewide standardized examinations and the formation of national science mandates and standards focusing on the inclusion of the development of science skills in the elementary classroom (American Association for the Advancement of Science, 1989, 1993; National Academy on Science, 1995).

Energies must be expended to improve the teaching of science in elementary classrooms. In an effort to improve the teaching of science at the elementary level, and ultimately student learning, different instructional strategies have been utilized and studied. These teaching methods include group learning, management by objectives, and smaller class sizes (Linn & Hsi, 2000). While the levels for success of these methods have differed, findings indicate that merely focusing on the instructional strategies used in the classroom are not enough. Elementary teachers of science are a critical component of students' academic achievement in science; hence, elementary teachers must be part of the solutions to improve science learning in elementary classrooms (Darling-Hammond, 2000; Sanders & Rivers, 1996). Tilgner (1990) suggested that one method of improving science teaching in elementary classrooms would be professional development workshops. This notion of focusing on professional development workshops is also supported by Smith, Banilower, McMahon, and Weiss (2002) who found that participation in professional development resulted in increased teacher preparedness. Other positive results of professional development have been reported. These benefits include increased student achievement (Anderson & Smith, 1986; Monk, 1994), improved content knowledge (Kahle, 2000), increased attitudes toward specific content areas (Henson, 1987; Tilgner, 1990), and increased confidence in teaching (Shrigley, 1977). However, the results of professional development efforts in elementary science have not reported the levels of success in other subject areas (Hilliard, 1997; Loucks-

Horsley et al., 1990; Newman & King, 2000; Tilgner, 1990). Therefore, the effectiveness of different strategies used in elementary science professional development needs to be examined.

One method of improving the effectiveness of professional development opportunities for elementary teachers is with the integration of hypermedia into the professional development environment. Hypermedia has a number of characteristics that can make it an effective tool for improving inservice opportunities for elementary science teachers. It allows for the contextualization and interaction with topics (Kumar & Sherwood, 1997), and potentially reduces the amount of time required to access materials on complex issues in various contexts (Collier, 1987; Halasz, 1988). Hypermedia also provides for more efficient searches of material (Ayersman & Reed, 1998; Burton, Moore, & Holmes, 1995), and allows for the exploration of topics from multiple perspectives (Astleitner & Leutner, 1995; Ayersman & Reed, 1995; Park, 1991).

Many of the characteristics inherent in hypermedia offer benefits that address the issues in inservice professional development opportunities for elementary teachers. Professional development workshops offer structured environments for the integration of hypermedia into the professional development of elementary teachers and address some of the current problems of elementary science professional development. This study will examine the influences of professional development opportunities that utilize hypermedia on inservice elementary teachers' content knowledge and attitudes toward science.

Statement of the Problem

Currently, the manner in which science is taught in many elementary classrooms does not afford students sufficient opportunities to understand science concepts and does not develop the skills commonly associated with science (Ginns & Watters, 1998;

Plourde, 2002; Tilgner, 1990). One reason for this is that elementary teachers often lack confidence in teaching science (Weiss, 1997). This lack of confidence can originate from a number of sources but is most commonly rooted in feelings of being unqualified to teach science (Abell & Roth, 1991; Czerniak & Schriver, 1994; Plourde, 2002). A second, yet related, barrier is elementary teachers' lack of science content knowledge (Abell & Roth, 1992; Jesky-Smith, 2002; Plourde, 2002), resulting from inservice teachers' inadequate backgrounds in science (Jesky-Smith, 2002; Tilgner, 1990). Because of limited science backgrounds, elementary teachers often have inadequate knowledge of stand-alone science topics and the interconnectedness between related topics. This leads to difficulties in the conceptualization of science topics (Jesky-Smith, 2002; Plourde, 2002). Third, lack of support for teachers inhibits quality science teaching (Mitchner & Anderson, 1989). Effective science teaching requires not only a variety of instructional strategies but also varied instructional settings and equipment. With elementary schools' current emphasis on the development of math and language arts skills, science has somewhat been ignored. Thus, teachers are frequently not provided with appropriate facilities and equipment necessary for effective science instruction (Helgeson, Blosser, & Howe, 1977; Plourde, 2002; Tilgner, 1990; Tosun, 2000). Fourth, teachers lack time to prepare science lessons and materials, which adversely influences science instruction (Tilgner, 1990; Weiss, Banilower, McMahon, & Smith, 2001). Science lessons frequently require more preparation time than lessons in other content areas; hence, teachers are often reluctant to integrate science into their classroom (Wolff, Tobin, & Ritchie, 2001). A final obstacle, which is closely related to many of the previous barriers, is that teachers have negative attitudes toward science in the elementary classroom (Koballa & Crawley, 1985; Mulholland & Wallace, 1996; Stepans & McCormack, 1986; Tilgner, 1990; Tosun, 2000; Westerback, 1982). These negative attitudes can have two major impacts on elementary science teaching (Bogut & McFarland, 1975; Cohen, 1964; Stollberg, 1969). First, these negative attitudes can result in teachers spending less time teaching science curriculum (Kennedy, 1973; Plourde, 2002), leading to decreased student achievement in science (Fraser & Walberg, 1995). Second, teachers can pass negative attitudes toward science to their students, which also decreases student achievement (Plourde, 2002; Shrigley & Johnson, 1974; Stollberg, 1969). The combination of these barriers to effective science teaching and the documented poor achievement of elementary science students indicate methods of professional development need to be developed to address these deficiencies. One such method involves the integration of hypermedia into professional development opportunities. This study investigated the influences of integrating hypermedia into professional development opportunities on two of the major barriers to effective science instruction in elementary classrooms: teachers' content knowledge and attitudes toward science.

Purpose of the Study

The purpose of this study was to examine the change in content knowledge and attitudes in elementary teachers of science when hypermedia is integrated into professional development opportunities. More specifically, this study examined the extent to which the use of a hypermedia environment during an inservice professional development setting positively influenced elementary teachers' content knowledge of scientific topics and processes and attitudes toward science.

Significance of the Study

A number of the issues with the teaching of science in elementary classrooms begin with the lack of preparation of current teachers to teach science (Abell & Roth, 1992; Helgeson et al., 1977; Plourde, 2002; Tilgner, 1990; Tosun, 2000; Weiss, 1997). Many of the problems with elementary science teaching originate with inadequate science backgrounds (Jesky-Smith, 2001; Tilgner, 1990); lack of confidence in the ability to teach science effectively (Abell & Roth, 1991; Czerniak & Schriver, 1994; Weiss, 1997); lack of science content knowledge (Abell & Roth, 1992; Jesky-Smith, 2002; Plourde, 2002); lack of equipment and resources (Helgeson et al., 1977; Tilgner, 1990; Tosun, 2000); and lack of time (Hone, 1970; Weiss et al., 2001; Wolff, Tobin, & Ritchie, 2001). In order to deal with these issues, it is important to focus on methods that afford inservice teachers opportunities to become better prepared to teach science. Using hypermedia during inservice teachers' professional development workshops addresses several of the barriers hindering effective elementary science instruction.

Due to the complexities associated with the creation and implementation of effective elementary science learning environments, it is important to look at teaching as an ill-structured domain (Shulman, 1992; Spiro, Feltovich, Jacobson, & Coulson, 1991). In order to understand complex, ill-structured domains, multiple representations are necessary (Spiro, Coulson, Feltovich, & Anderson, 1988). Kumar and Sherwood (1997) purport that using multiple knowledge representations are necessary to maximize transfer of learned information. Studies indicate effective science instructors possess multiple knowledge representations of a number of different types of scientific knowledge (Knuth, Jones, & Baxendale, 1991; Loucks-Horsley et al., 1990; National Research Council, 1996; Raizen, 1998). Among these different types of scientific knowledge are science content knowledge, science pedagogical knowledge, and pedagogical content knowledge (Shulman, 1986). Hypermedia environments can be used to address issues related to these various types of scientific knowledge and allow teachers to explore them in depth (Jonassen, 1988; Marchionini, 1988; Park, 1991).

Hypermedia environments can also be effective for use with internalizing information, interacting with tools for organization, and creating meaningful contexts in teaching and learning (Jacobson & Spiro, 1995; Marchionini, 1988). The attributes of hypermedia provide a number of benefits. First, hypermedia prevents the overgeneralization of topics and the teaching and learning of topics in isolation (Landow, 1992). This is effective in improving science content knowledge and providing teachers with a more structured science background (Kumar & Sherwood, 1997). Second, hypermedia environments can promote the ability to apply knowledge to new situations with different characteristics other than those of the initial setting, leading to the ability to transfer knowledge to new contexts (Astleitner & Leutner, 1995; Jacobson & Spiro, 1995; Jacobson, Maouri, Mishra, & Kolar, 1996; Jonassen, 1996; Marchionini, 1988; Tao, 1998). Third, as an organizational tool (Bush, 1945), hypermedia can reduce the amount of time necessary to access, organize, and address complex issues involving a large number of cases (Collier, 1987; Halasz, 1988; Landow, 1992). Finally, material can be presented from multiple perspectives within hypermedia environments, allowing users to form multiple representations about the topic (Astleitner & Leutner, 1995; Ayersman & Reed, 1998; Burton et al., 1995; Park, 1991). The attributes of hypermedia allow for the construction of more comprehensive knowledge structures by inservice elementary teachers.

Theoretical Framework for the Study

The theoretical foundation of this study is rooted in the principles of constructivist learning theory, emphasizing learner-centered aspects of constructivism. Constructivists believe knowledge is not transmitted from one learner to another but instead is constructed by the learner (Bruner, 1961; von Glaserfeld, 1989). In constructivist learning environments, the role of the instructor is to encourage learners to discover principles on their own and to provide appropriate formats for learners to interact with various learning materials. According to many constructivist theorists, experience is another factor that plays a major role in the learning process (Bandura, 1976; Brown Collins, & Duguid, 1989; Dewey, 1938; von Glaserfeld, 1987). For example, Bruner (1961) states learning is an active process in which the learner constructs his own knowledge based on prior experiences. Bruner and many other constructivists also think that social interaction plays a major role in the formation of knowledge structures. These theorists state learners should not be isolated in the learning environment but actively engaged in dialogue and experience contextual, real-world learning situations (Jonassen, 1996; Piaget, 1970; Vygotsky, 1978). Both experiential and social processes have a major effect on learning and have been integrated into a number of professional development models, which are also anchored in other basic tenets of constructivist theory.

Yager (1996) states that recent attempts to improve science education are rooted in constructivist learning theory. Both the social and psychological contexts for professional development have been addressed within constructivist learning environments (Tobin, Kahle, & Fraser, 1990). From a psychological perspective, constructivism holds the belief that knowledge is constructed by the learner. In constructivist-based professional development environments, knowledge is constructed as participants examine inquiry and activity-based pedagogy (Hassard, 1992). From a social perspective, constructivists hold the belief that knowledge is constructed both within the mind as well as within social communities (Richardson, 1999). In professional development environments that address the social perspective of constructivism, participants are provided with opportunities to interact and discuss various situations with others in the professional development setting.

More specifically, the branch of constructivism that provides the basis for this study is cognitive constructivism. Within cognitive constructivist theory, there is a focus on the importance of the interactions with social or physical environments during the knowledge construction process. One example of this is the role of cognitive dissonance in the learning process. It is through social interaction that cognitive dissonance typically occurs (Festinger, 1957; Lyddon, 1995). Discussing ideas and information with others allows learners to develop an understanding of concepts that are inconsistent with current beliefs. Resolving these inconsistencies results in the construction of new knowledge structures (Bruner, 1986). This ongoing process of assimilating past experiences and knowledge with new experiences and knowledge contributes to an enhanced view of the external world (Piaget & Inhelder, 1973). Based on the assumption that learning occurs as a result of resolving inconsistencies encountered by learners, it is critical that inservice teachers experience opportunities to encounter, discuss, and resolve these inconsistencies. This is also important because professional development opportunities provide for experiences that act as catalysts for change in teachers' conceptions (Radford, 1998; Tobin, 1993).

As with the professional development environments implemented in this study, the theoretical foundation for the design of most hypermedia environments is based on the constructivist paradigm. Among the many features of hypermedia that make it compatible to constructivist learning environments are learner control, non-linearity and non-sequential presentation of information, hyperlink functionality, open access to information, and associative properties of information (Ayersman, 1995; Vrasidas, 2002). These functions promote the individual development of complex and unique knowledge representations (McGuire, 1996).

Cognitive constructivism is also closely related to the construction of many hypermedia environments (Burton et al., 1995; Duffy & Jonassen, 1991). According to cognitive constructivist theory, teachers act as guides in the learning process (Piaget, 1970; Vygotsky, 1978). Consistent with this idea, the computer can act as a partner and help facilitate the learning process. As a branch of constructivism, cognitive constructivists also hold many of the same views as other constructivists (Phillips, 1995, 1997). These include the importance of an active learner role in the learning process, learner involvement with authentic tasks, and the social nature of learning (Jonassen, 1999).

Another theoretical viewpoint addressed with the design and implementation of hypermedia environments is cognitive flexibility theory. Cognitive flexibility theory is a branch of constructivism focusing on the idea that knowledge of a concept will be more thorough if information is revisited from multiple perspectives at various times and in different contexts. The goal of addressing concepts in this manner is advanced knowledge acquisition suitable for understanding and transfer (Collins, Brown, &

Newman, 1989; Spiro et al., 1991). According to Jacobson, Maouri, Mishra, and Kolar (1996), hypermedia

> proposes complex knowledge may be better learned for flexible applications in new contexts by employing case-based learning environments that include features such as: (a) use of multiple knowledge representations, (b) link abstract concepts in cases to depict knowledge in-use, (c) demonstrate the conceptual interconnectedness or web-like nature of complex knowledge, (d) emphasize knowledge assembly rather than reproductive memory, (e) introduce both conceptual complexity and domain complexity early, and (f) promote active student learning. (p. 241)

As with other constructivist theories, social interaction plays an important role in cognitive flexibility theory (Jonassen, 1999; Spiro et al., 1991). As a result of integrating social interaction into the learning environment, learners can discuss ambiguities and inconsistencies present in various situations creating improved knowledge structures. Hypermedia environments are extremely well suited to address social interaction issues. Hypermedia also addresses other tenets of cognitive flexibility theory in that it allows multiple alternative representations of the same concepts. Learners, through interconnected hyperlinks, can explore these representations and develop their own knowledge structures (Jonassen & Wang, 1993). These multiple representations promote the re-assembling of structures in new domains resulting in improved knowledge structures. This intertwining of constructivism, cognitive constructivism, and cognitive flexibility theory with professional development models and hypermedia provide the theoretical underpinnings for this study.

Research Questions

The following two research questions will be addressed in this study:

1. To what extent does the use of hypermedia during inservice professional development increase elementary teachers' understanding of elementary science concepts?

2. To what extent does the use of hypermedia during inservice professional development influence elementary teachers' attitudes toward science?

Variables

Independent Variables

In this study, there was a single independent variable with two factors. The independent variable was the professional development workshops for elementary science teachers. The first factor was the absence of hypermedia in the professional development workshops, and the second factor was the integration of hypermedia into the professional development workshops.

Dependent Variables

In this study, there were two dependent variables. The first dependent variable was teacher science content knowledge, as measured by the Project to Improve Elementary Science (PIES) Science Knowledge Test (Zielinski & Smith, 1990). The second dependent variable was teacher attitudes toward science, as measured by the Science Attitude Scale (Shrigley & Johnson, 1974).

Limitations and Delimitations of the Study

Limitations

1. This study does not address technological issues. Some of these issues may include the participants' comfort level with computers (computer anxiety) or the amount of computer usage in the classroom. The gains in content knowledge and attitudes

toward science for participants with higher levels of computer anxiety may be smaller than those participants who feel more comfortable with computers. Also, the gains in science content knowledge and attitudes toward science for participants who already use computers in the class more frequently may be greater than for participants who rarely use computers in the classroom.

2. The sample size for the study is small. Due to the availability of participants, lab space, and equipment, the size of each experimental group was limited. As a result, the statistical power for the study was diminished. Increasing the sample size would result in a more statistically powerful study.

3. It is not clear whether or not the research generalizes to other levels of science education. This is because the problems in secondary and postsecondary science education differ significantly from those of elementary science. For example, secondary and postsecondary science educators are typically much more confident with the content, have more content knowledge, and have more positive attitudes toward science. Therefore, hypermedia may not be an appropriate tool to address many of the problems associated with science education at other levels. Further research would be necessary to determine the effectiveness of hypermedia in addressing problems associated with science education at other levels.

Delimitations

1. There are no examinations of the effects of the treatments over time. While pretest and posttest measures are investigated, no future measures to examine the sustained

effectiveness of the treatments will be taken. Further research is necessary to examine the sustained effects of the treatments.

2. There are no measures of the effects of the professional development on student achievement. While a link between teacher attitudes toward science and science content knowledge is referenced in the review of literature, no direct measures of the degree to which the professional development workshops influenced student achievement were collected during the study. It is expected that there will be a positive effect on student achievement, but further research would be necessary to determine the effects of hypermedia on student achievement.
3. The length of the professional development workshops was short. Participants experienced three two-hour elementary science professional development workshops totaling six hours. This was due to participant availability, time of the school year, district funding, and lab space availability. Further research would be necessary to examine the effectiveness of hypermedia at improving science content knowledge and attitudes toward science in a longer series of professional development workshops.

Definition of Terms

In research regarding topics related to the teaching of science in the elementary classrooms and the integration of technology into professional development activities, many of the terms used in this study have a wide array of definitions. This is due to the fact that frequently researchers come from different fields and attempt to fuse information from their fields into this area. For this study, the following terms and definitions are provided to clarify meaning and promote a clearer understanding.

Attitudes. Attitudes are learned predispositions that result in consistent responses, either favorable or unfavorable, toward a specific entity (McGuire, 1969).

Constructivism. Constructivism refers to a learning theory based on the principle that learners construct their own knowledge structures based on prior knowledge and experience (Bruner, 1966).

Hypermedia. Hypermedia are a nonlinear and nonsequential method for displaying and organizing multiple forms of media, such as sound, graphics, videos, or text (Jonassen, 1989, 2000).

Hypermedia environment. A hypermedia environment refers to the inclusion of hypermedia into the professional development workshops.

Professional development. Professional development encompasses a variety of opportunities afforded to educators with the purpose of developing teaching approaches, dispositions, and knowledge skills in an effort to improve the effectiveness of classroom teaching (Loucks-Horsley, 1996).

Workshops. Workshops refer to a series of three two-hour on-site teacher preparation sessions in which the researcher guided the participants through basic processes related to a variety of scientific concepts and processes.

Summary

Recent calls for science education reform have arisen from American students' poor performance on international science assessments (International Association for the Evaluation of Achievement, 1988; Knuth, Jones, & Baxendale, 1991; Plourde, 2002), research that supports the development of science skills at the elementary level (Keeves, 1995; Rowe, 1992), and a lack of student enrollment in advanced science courses (Fraser & Walberg, 1995). As a result of these calls, a number of methods of science education reform have been implemented with varying levels of success (Linn & Hsi, 2002). Due to successes in other subject areas and parallels with the issues related to elementary science instruction, researchers (Tilgner, 1990; Smith et al., 2002) suggested that professional development workshops could be a successful method to address problems in the teaching of science in elementary classrooms. In other content areas, professional development workshops have reported significant positive results, such as improved positive attitudes toward subject areas (Henson, 1987; Tilgner, 1990), increased student achievement (Anderson & Smith, 1986; Monk, 1984), and increased confidence in teaching (Shrigley, 1977). While these results positively correlate with the problems in professional development opportunities for inservice elementary teachers (Abell & Roth, 1991; Czerniak & Schriver, 1994; Helgeson et al., 1977; Jesky-Smith, 2002; Koballa & Crawley, 1985; Mulholland & Wallace, 1996; Plourde, 2002; Stepans & McCormack, 1986; Tilgner, 1990; Tosun, 2000; Weiss, 1997; Weiss et al., 2001; Westerback, 1982), professional development environments have been significantly less effective in addressing the barriers to effective elementary science instruction.

One method of improving inservice elementary science professional development is with the integration of hypermedia into the professional development environment. A number of traits inherent in hypermedia make it effective in addressing many of the barriers to effective science instruction in elementary classrooms. Professional development workshops also provide a structured environment to address these barriers. In this study, changes in elementary teachers’ science content knowledge and attitudes toward science, which resulted from the integration of a hypermedia environment into a series of professional development workshops, were examined. More specifically, this study examined the extent to which the integration of hypermedia into a series of professional development workshops positively influenced teachers’ content knowledge and attitudes toward elementary science.

CHAPTER 2
REVIEW OF THE LITERATURE

Introduction

In many elementary classrooms, science is currently being taught in a manner that does not provide students with adequate opportunities to comprehend various science concepts or construct the skills associated with “doing” science (Ginns & Watters, 1998; Plourde, 2002; Tilgner, 1990). While numerous efforts have been implemented to improve the state of science instruction in the elementary classroom, many efforts have been largely unsuccessful. This review of literature will be divided into three sections. The first section is an examination of how science fits into the elementary curriculum, the barriers associated with effective science teaching in the elementary classroom, and methods for addressing these barriers. The second section will discuss hypermedia and database-driven hypermedia environments. Various benefits and constraints of hypermedia and database-driven hypermedia environments will be explored. The third section will examine the theories that provide the underpinnings for this study. Specifically, constructivism, cognitive constructivism, and cognitive flexibility theory will be discussed.

Calls for Science in the Elementary Curriculum

The importance of science in education can be seen in the multitude of documents that specifically address science (International Assessment of Educational Progress, 1992; International Association for the Evaluation of Achievement, 1988; National Academy on Science, 1995; National Assessment of Educational Progress, 1983;

National Commission on Excellence in Education, 1983; National Education Goals Panel, 1991; National Science Foundation, 1996). Goal Four of the National Education Goals stated, “By the year 2000, U.S. students will be first in the world in mathematics and science achievement” (National Education Goals Panel, 1991, p. 16). Initiatives, such as Project 2061, various state systemic initiatives, the National Science Education Standards, and state science standards have begun focusing on the integration of science into elementary education and the improvement of science instruction at the elementary level (Knuth, Jones, & Baxendale, 1991). A number of reasons exist for the integration of science into these initiatives and standards. First, research has indicated the inclusion of science at the elementary level results in enhanced scientific performance at higher levels, such as secondary and postsecondary levels (Keeves, 1995; Rowe, 1992). Second, American students lag behind students from most other industrialized nations in both science and mathematics achievement (International Assessment of Educational Progress, 1992). This can be illustrated by American students’ poor performance on various international science assessments, such as the Third International Mathematics and Science Study and the Second International Science Study (International Association for the Evaluation of Achievement, 1988; Knuth, Jones, & Baxendale, 1991; Plourde, 2002). This poor performance, coupled with other issues in science education, has resulted in the introduction of science topics on standardized examinations (American Association for the Advancement of Science, 1989, 1993; National Academy on Science, 1995). Third, a recent trend in science shows a decline in student enrollment in both upper level and advanced science courses (Fraser & Walberg, 1995). One reason for this lack of enrollment is students are not provided with adequate opportunities to address science concepts and skills effectively (Plourde, 2002; Tilgner, 1990; Tosun, 2000). Also, negative attitudes toward science are often fostered by elementary teachers of science and can negatively influence student achievement and attitudes toward science (Ashton, 1984; Bogut & McFarland, 1975; Ginns & Watters, 1998; Plourde, 2002; Tilgner, 1990).

Barriers to Effective Science Teaching in the Elementary Classrooms

As with all academic areas, barriers specifically associated with effective teaching of science must be addressed. These obstacles include: lack of content knowledge (Harlen & Holroyd, 1997; Stevens & Wenner, 1996; Weiss, 1994); negative teacher attitudes toward science (Koballa & Crawley, 1985; Mechling, Stedman, and Donnellson, 1982); lack of teacher preparedness (Tilgner, 1990; Weiss, 1987); lack of confidence (Hurd, 1982; Mechling, Stedman, & Donnellson, 1982; Weiss et al., 2001); and lack of educational resources for teachers (Anderson, 1984; Helgeson et al., 1977). One problem resulting from these barriers is the fact that elementary science does not receive the same amount of instructional time as other academic areas, such as language arts and mathematics. Tressel (1988) stated, “For all practical purposes, we do not teach science in elementary schools. One hour a week of so-called science does not count” (p. 2). Another related problem with elementary science education is the method in which most elementary science is taught. Muttlefehldt (1985) found that many instructional strategies being implemented in elementary science classrooms are not effective at promoting cognitive or affective learning. In order to address these problems, it is important to first examine the barriers that led to these problems.

Elementary Teachers’ Lack of Science Content Knowledge

Lack of science content knowledge is a serious issue for elementary teachers. Interactions with other barriers compound the problems of effective science teaching in elementary classrooms (Abell & Roth, 1992; Franz & Enochs, 1982; Hurd, 1982; Jesky-Smith, 2002; Plourde, 2002; Tilgner, 1990; Weiss, 1997). Vaidya (1993) stated, "teachers' science content knowledge, as well as their pedagogical content knowledge, are both issues of concerns" (p. 63). Studies such as those conducted by Harlen and Holroyd (1997) and Stevens and Wenner (1996) focused on the lack of inservice elementary teachers' science content knowledge. Theses studies documented their lack of sufficient scientific content knowledge to address many of the topics in elementary science effectively and appropriately. A lack of content knowledge has a major influence on classroom practice and student achievement. Weiss (1994) found that most elementary teachers self-report inadequate understanding of science content knowledge and, as a result, lack confidence in teaching elementary science concepts. This lack of science content knowledge can impact other issues related to the effective instruction of science, such as attitudes toward science, feelings of preparedness to teach science, and teacher confidence.

Elementary Teachers' Attitudes Toward Science

Another problem in the teaching of science in the elementary classroom is that negative attitudes toward science are particularly prevalent among teachers. Mechling, Stedman, and Donnellson (1982) found that more than half of the elementary teachers they surveyed rank science fourth among the five major subject areas. Attitudes toward science are significant to examine because of their importance in every aspect of the learning environment and their role as foundations of behavior (Ashton, 1984; Cohen, 1964). Ramsey-Gassert, Shroyer, and Staver (1996) found that attitudes played a significant role in the development of a teacher's belief in his or ability to teach science effectively. Beliefs and attitudes toward science also play a major role in shaping teachers' instructional beliefs (Thompson, 1992; Tobin, Tippins, & Gallard, 1994). For example, consequences of having negative attitudes toward science may include either reluctance in teaching or complete avoidance of teaching scientific content (Kennedy, 1973). Conversely, more positive attitudes result in an increase in the teaching of science, positively influencing student achievement (Ashton, 1984; Plourde, 2002). Another important aspect of attitudes is that teacher attitudes are often transferred to students and influence the learning process. Negative teacher attitudes can be passed to students and, as a result, negatively influence the learning process (Bogut & McFarland, 1975).

Elementary Teachers' Lack of Preparedness to Teach Science

Numerous studies have focused on the lack of inservice elementary teachers' experience and enrollment in postsecondary science courses. Tilgner (1990) stated, "Not only do many elementary teachers not like science; many feel totally unprepared to do an adequate job teaching science" (p. 423). This lack of teacher preparedness is often rooted in a poor scientific background. Manning, Elser, and Baird (1982) surveyed inservice elementary teachers and found that 12 percent had never participated in a postsecondary science content or methods course and 65 percent had never participated in any inservice science programs. Weiss (1987) found similar results when he surveyed kindergarten through third grade teachers and noted only 31 percent had participated in a postsecondary science course. This percentage was slightly higher, at 42 percent, for fourth through sixth grade teachers (Weiss, 1987). Loucks-Horsley et al. (1990) noted there is a lack of science preparation for elementary teachers. One reason for this is the increased emphasis on the development of teaching skills related to language arts and mathematics. They also documented a lack of elementary science professional development opportunities. Once preservice teachers enter the classroom, science professional development opportunities are oftentimes not provided. The lack of preparation of elementary science is very important in that it contributes to other obstacles that hinder effective elementary science instruction, such as elementary teachers' confidence in teaching science.

Elementary Teachers' Lack of Confidence Teaching Science

One prevalent theme in research related to science teaching in elementary classrooms is inservice elementary teachers' lack of confidence in teaching science (DeTure, Gregory, & Ramsey, 1990; Manning, Elser, & Baird 1982; Mechling, Stedman, & Donnellson, 1982; Weiss et al., 2001). Jesky-Smith (2002) found that although teachers view science as an important topic at the elementary level, many of them did not feel confident in their ability to teach science in their classroom. Lack of confidence seems to be prevalent in teaching all areas of science. Weiss (1987) found that slightly more than a quarter of inservice elementary teachers felt competent to teach content related to the life sciences. This overall lack of confidence in teaching science was not only evident with the life sciences but also with the physical sciences (Harlen & Holroyd, 1997). Weiss (1987) also found that only 15 percent of elementary teachers felt confident in teaching the physical or earth/space sciences. A decade later, Weiss (1997) confirmed his previous findings when he surveyed elementary teachers and noted that less than a third of the teachers were confident in their abilities to teach elementary science content, indicating an ongoing trend in elementary science. In addition, Abell and Roth (1991) found that elementary teachers not only lack confidence in teaching science, but also do not feel as comfortable teaching science as they do in teaching other content areas. Ginns and Watters' (1998) findings supported the premise that beginning elementary teachers often lack confidence in teaching science. This lack of confidence has serious implications for students. Ashton (1984) found that lack of confidence in teaching a subject area has major negative impacts on student achievement, as well as other negative implications for the teacher, such as the lack of participation in ongoing science professional development, avoidance of science instruction, and the development of negative attitudes toward science.

Lack of Educational Resources for Elementary Teachers

Another factor inhibiting the effective instruction of science at the elementary level is the lack of educational resources available to elementary teachers (Helgeson et al., 1977; Loucks-Horsley, 1990; Tilgner, 1990; Weiss, 1978). Educational resources are materials that either help students prepare to learn or facilitate the process of teaching (Danielson, 1996). Examples of educational resources include teacher lesson plans and student activities, lesson materials and equipment, videos or laserdiscs, and communication tools, such as online bulletin boards and e-mail. The lack of readily available educational resources inhibits teachers from creating certain science lessons, as well as discourages the implementation of hands-on lessons in elementary science (Helgeson et al., 1977). Anderson (1984) purported that resources play a major role in increasing student achievement. He reinforced this idea by stating the improvement of student achievement is not about the development of standards, but it is about making resources available to children and their teachers so effective instruction can occur. This can be problematic because in elementary science a shortage of adequate resources and support materials for primary teachers exists (Loucks-Horsley et al., 1990). Addressing the lack of teacher resources necessary for effective elementary science instruction can promote the integration of hands-on lessons into the science classroom and have a positive impact on student achievement and teacher effectiveness.

Science Instruction and Student Achievement

One major implication of effective science instruction at the elementary level is that student achievement at earlier levels of education influences achievement at higher levels of education. Rowe (1992) stated, “Increasing early exposure to the kinds of science experiences and discursions that develop analytic and proportional reasoning could reasonably be expected to enhance science performance of all students” (p. 1174). Research also indicates a positive correlation between the amount of time spent on science instruction and science understanding (Schwerian, 1969). Keeves (1992) found the amount of time spent addressing a subject area plays a major role in influencing student achievement in the particular subject area. This is also supported by recent research on learning and understanding (Bransford, 2002). Rowe (1992) reported that providing students with appropriate experiences with science in the elementary grades increases the amount of quality time spent interacting with science content. This can have a positive impact on science achievement in secondary and postsecondary science grades.

A number of additional factors influence student achievement in science at the elementary level. These include teacher attitudes, beliefs, and confidence with science content. Plourde (2002) documented that more positive attitudes toward science result in more teaching of science, which, in turn, results in greater levels of student achievement. Other research has demonstrated that beliefs about science play a major role in developing instructional strategies with science (Thompson, 1992; Tobin, Tippins, & Gallard, 1994). The development and use of appropriate instructional strategies at the elementary level has major implications on student achievement. Finally, Ashton (1984) found that confidence in the ability to teach a subject area has major implications on student achievement. Teachers with greater confidence and more positive beliefs about their ability to influence student achievement see higher levels of student achievement than teachers with less confidence and less positive beliefs (Ashton, 1984; Berman, McLaughlin, Bass, Pauly, & Zellman, 1977). Addressing these issues by providing early exposure to science, improving teacher attitudes, beliefs, and confidence toward science, and increasing the amount of time of science instruction can have major positive implications for science in the elementary classroom.

Inservice Elementary Science Professional Development

Smith et al. (2002) demonstrated the preparation of teachers is a major issue in science education. Areas of particular concern include inservice teachers' lack of content knowledge and lack of the ability to choose and implement appropriate and effective instructional strategies to address science standards. Yet Smith et al. (2002) found that when inservice professional development opportunities addressed science education standards, teachers' content knowledge increased. Their ability to choose and implement appropriate instructional strategies for teaching science in the elementary classroom also improve (Smith et al., 2002). Shrigley (1977) reinforced these ideas in her findings that an improved self-concept and an increase in confidence resulted when teachers were provided with opportunities to improve their science teaching skills and science content knowledge.

Kahle (2000) provided a strong argument for the professional development of teachers by stating the development of teacher content knowledge and improved teaching practices are two results of good inservice professional development. Increased content knowledge influences classroom practice in a number of ways. First, class discussions are encouraged because discussion provides opportunities for students to become engaged with the material. Second, more time is spent focusing on the concepts being discussed, providing students with opportunities to examine the content in more depth and spend less time on extraneous events in the classroom. Finally, Kahle (2000) noted professional development that results in increased attitudes and content knowledge toward a particular subject area, also leads to increased student achievement. These ideas are supported by other studies that indicate a positive relationship between improved student achievement and appropriate inservice teacher professional development (Anderson, 1984; Klein, Hamilton, McCaffrey, Stecher, Robyn, & Burroughs, 1999; Monk, 1994).

Professional Development and Teacher Attitudes

Research suggests the teacher should be an important and critical factor in all reform. Bybee (1993) stated, “The decisive component in reforming science education is the classroom teacher” (p. 144). Recent research suggests that teacher quality has a major influence on student achievement (Darling-Hammond, 2000; Darling-Hammond & Ball, 1998; Monk, 1994; National Center for Education Statistics, 2000; Olson, 1997; Wayne & Youngs, 2003). Hanushek (1992) found that differences of more than one grade-level of achievement are evident in students who have a good teacher versus a bad teacher. An issue related to the improvement of science instruction at the elementary level is the development of positive teacher attitudes toward science. Because negative teacher attitudes toward science are commonplace among elementary teachers, the improvement of teacher attitudes toward science has been the subject of numerous studies (Bogut & McFarland, 1975; Kennedy, 1973; Stollberg, 1969;). Tilgner (1990) suggested one effective method of changing teachers' attitudes would be professional development workshops. One reason for this is that professional development workshops provide teachers with opportunities to gain additional content knowledge and teaching skills, thus improving confidence in their ability to effectively teach science (Shrigley, 1977). While many studies have touted the effectiveness of professional development workshops in subject areas such as math and language arts (Anderson, 1984; Kahle, 2000; Monk, 1994), science professional development workshops have not been as successful. Other studies, however, have suggested that the integration of hypermedia into learning environments can result in more positive learning outcomes (Baker, Niemi, & Herl, 1994; Jacobson & Spiro, 1995; Jonassen & Wang, 1993).

Hypermedia

This second section of the review of literature will begin by defining hypermedia and discussing various characteristics of hypermedia environments. This section will continue with a discussion of the benefits and constraints of hypermedia and conclude with a presentation of research related to the integration of hypermedia into the learning environment.

Hypermedia are defined as a non-linear and non-sequential method for displaying and organizing multiple forms of media, such as sound, graphics, videos, or text (Jonassen, 1989, 2000). Hypermedia are typically seen as possessing the three primary applications of information representation, information presentation, and information construction (Ayersman & Reed, 1995; Nelson, 1994). Hypermedia provide a way to organize, manage, and represent information in a variety of methods utilizing different media (Kumar & Sherwood, 1997). As a result of its many strengths, there has recently been an increase in the integration of hypermedia applications into the teaching and learning environment (Grabowski & Small, 1997). In professional development settings, hypermedia has a number of benefits, such as allowing teachers to examine classroom settings, viewing various models of instruction, searching for teacher resources, and communicating with other teachers and experts (Koehler, 2002; Kumar & Sherwood, 1997). As a result of increases in the incorporation of hypermedia into the learning environment, it is essential to address both the beneficial and constraining factors associated with this relatively new educational tool (Grabowski & Small, 1997).

Benefits of Hypermedia

Numerous studies have found positive influences on learning outcomes with the integration of hypermedia into the learning environment (Baker, Niemi, & Herl, 1994; Beeman, Anderson, Bader, Larkin, McClard, McQuillan, & Shields, 1988; Jacobson & Spiro, 1995; Jonassen & Wang, 1993; Lehrer, 1993). First, research has provided evidence that the structure and navigational freedom associated with hypertext environments possess various benefits to the learning process (Ayersman, 1996; Dillon & Gabbard, 1998; Hede, 2002; Jonassen, 1996; Landow, 1992). Hypermedia environments provide non-linear access to information, allowing users more freedom in the learning process (Nielsen, 1995; Reed & Oughton, 1997). Barab, Bowdish, and Lawless (1997) stated:

> Hypermedia allows for learners with unique intentions and purposes to determine which, and in what order, information will be displayed; potentially configuring what, when, and how learning will transpire. As a result, learners can tailor the educational experience to meet their own unique needs, interests, and goals, many of which emerge while interacting with the hypermedia. (p. 37)

Hypermedia environments allow students to access information in depth (Collier, 1987), affording complex representations of fundamental concepts and comprehensive illustrations of more abstract concepts. This deeper examination of material results in increases in students' conceptual connections between related topics (Landow, 1992). By participating in multi-case analyses, students create more personal interpretations of the content (Landow, 1992; Marchionini & Crane, 1994). A second benefit of hypermedia applications is they address many of the attributes that foster meaningful learning (Jonassen, 2000). Hypermedia applications provide environments for interacting with and developing meaningful contexts for teaching and learning (Kumar & Sherwood, 1997). They are engaging to the learner (Jonassen, 1989), allow for active learner participation (Landow, 1992; Shyu & Brown, 1995), involve complex, contextual situations (Jonassen, 1989), and promote reflection (Hede, 2002).

In addition, hypermedia applications offer a number of other benefits directly related to the critical issues of teaching science in the elementary classroom. As mentioned previously, teacher attitudes toward science are a major barrier to effective science instruction in the elementary classroom. Janda (1992) found the integration of hypermedia into learning environments resulted in more positive attitudes toward hypermedia applications. Ayersman (1996) stated, "Generally speaking, positive attitudes are reported following hypermedia based learning situations. Perceptions and attitudes toward hypermedia are fundamentally important because they often accompany effective learning" (p. 505). Results from studies of hypermedia and attitudinal changes have indicated that individuals with more hypermedia experience tend to have more positive attitudes toward hypermedia (Ayersman, 1996). Another issue in science education, and a catalyst for science education reform, is poor student performance in science. Abrams and Streit (1986) found that the integration of hypermedia applications into the learning environment resulted in an increase in student achievement. The amount of instructional time allocated for science is also a critical issue in the teaching of science at the elementary level. Teachers tend to spend less time teaching science in the elementary classroom. Higgins and Boone (1990) reported that the integration of hypermedia into the teaching and learning environment resulted in a decreased demand on teaching time. Hence, the use of hypermedia in the teaching of elementary science could prove to be beneficial. Smith (1987) concluded in a review of literature that hypermedia is both an effective and efficient medium for instruction.

Constraints of Hypermedia

Although hypermedia has many benefits, it may not be beneficial for all learning scenarios. Certain issues related to learner type, ability level, and the type of learner activity in the hypermedia environment can have major influences on the effectiveness of the hypermedia application. Conklin (1987) reported that learner control of the hypermedia environment is the most prevalent concern and advantage of hypermedia applications. Dillon and Gabbard (1998) stated that while hypermedia "can offer techniques that can help the less able student perform better" (p. 345), lower ability learners typically have more difficulty effectively utilizing hypermedia. Jonassen and Wang (1993) found that field independent learners "are better hypermedia processors, especially as the form of the hypermedia becomes more inferential and less overtly structured" (p. 7). Lee and Lehman (1993) suggested the level of activity the learner engages in affects the learner's achievement in the hypermedia environment. Reed and Oughton (1997) found that more experienced hypermedia users take more non-linear steps through the hypermedia environment, thus increasing the effectiveness of the hypermedia application as a learning tool. They also noted that the structure and freedom associated with hypermedia environments, while providing some benefits, can also act as constraining factors (Reed & Oughton, 1997).

Other limitations involve navigational and experiential issues (Gardarin & Yoon, 1995). Users who are unfamiliar with the content and hypermedia environment face various problems including: 1) goal attainment, in which inexperienced users can often overlook important information; 2) spatial disorientation, in which users can be overwhelmed and have a sense of being lost in the information; and 3) knowledge acquisition, in which students feel cognitively overloaded due to having to perform multiple tasks of information storage, restructuring, transfer, and evaluation (Astleitner & Leutner, 1995). Finally, if the environment or content is too new, hypermedia structures can initially be too advanced for many inexperienced learners. Hence, it is critical that hypermedia environments be explored before being implemented in teaching and learning environments.

Databases as Intermediaries

While hypermedia can be an extremely powerful tool for learning, it is essential to be cautious with the manner in which it is implemented. In order to ensure growth in the ability to teach or learn when integrating hypermedia into the learning scenario, the constraints associated with hypermedia must be addressed. One solution that addresses the constraints of hypermedia is the use of hypermedia-integrated databases (Beaufils, 2000; Bhaumik, Dixit, Glanares, Krishna, Tzagarakis, Vaitis, et al., 2001). In general, hypermedia-integrated databases address many of the constraints of hypermedia. For example, databases can be used to address complexity issues related to navigation, flexibility, and organization of information, by reducing the users' sense of being overwhelmed (Reed & Oughton, 1997). Database structures can also help low ability learners and those not experienced with hypermedia applications or the specific content area in manipulating the learning environment (Jonassen, 2000). There are three main ways this may occur. First, database applications allow the developers to sort information to control for cognitive overload issues. As a result, the user has less control over the environment and experiences less cognitive overload. More experienced and proficient users can be provided with more control of the environment to enhance the learning experience. One method of doing this is by providing advanced search procedures. Second, databases are effective as pre-structuring tools (Beaufils, 2000) because databases and hypermedia applications have different, yet related, strengths and functionality. The strengths of databases lie in the storage, organization, and retrieval of information; the strengths of hypermedia lie in the structuring and navigation of information and the ability to track various user actions and address access issues (Bhaumik et al., 2001). Hence, database applications can be structured to involve similar tasks as hypermedia (information storage, restructuring, transfer, and evaluation), but in a manner that is less overwhelming to the learner and focuses on the strengths of each tool. Third, Jonassen (2000) argued the "greatest problem related to using hypermedia to facilitate learning is how learners will integrate the information they acquire in the hypertext into their own knowledge structures" (p. 210). Database applications address this issue by helping students make their own content relationships and then relate those relationships to their existing knowledge structures (Jonassen, 2000; Rieber, 1994). This freedom to browse through the content is consistent with the constructivist principle that learners should be given the opportunity to discover knowledge through their own active exploration. In sum, using database structures in hypermedia applications assists teaching and learning processes. In doing so, database structures act as intermediaries between the learner and the hypermedia environment, and they are effective in addressing the constraints of hypermedia applications while highlighting the strengths of these tools.

Theoretical Framework

The third section of the review of literature will discuss the theoretical underpinnings of this study. This section will begin with a discussion of the basic tenets of constructivism and how these ideas relate to the study. This section will be followed by a discussion of cognitive constructivism and cognitive flexibility theory and the role of these theories in the development of this study and the connections to hypermedia.

Constructivism

The theoretical basis for this study is rooted in the ideas of constructivist theory, with a major focus on learner-centered facets of constructivism. One of the basic tenets of constructivism is that knowledge is constructed by the individual learner, as opposed to being passed from one learner to another (Bruner, 1961, 1966). In constructivist learning environments, the focus of the instructor is to create learning environments in which the learner is not a passive receiver of information. The learner instead is actively involved in the learning process and develops his own knowledge structures based on interactions in the learning environment. Instructors develop learning environments that provide appropriate opportunities for learners to make discoveries and become engaged with various learning materials. One major factor of constructivist theories is the role of prior experience in the learning process (Bandura, 1976; Carroll, 1990). Bruner (1961) stated that learning is an active process in which the learner, based on his previous experiences, constructs knowledge. Additionally, according to many constructivists, the role in which social interaction plays in the formation of new knowledge structures is vital to the learning process (Jonassen, 1996; Piaget, 1970; Vygotsky, 1978). These theorists believe learners should be immersed in real-world, contextual learning environments that promote dialogue and avoid learning in isolation. Issues related to both social processes and experience have major influences on the learning process.

A number of models have integrated the major tenets of constructivism in both the psychological and social aspects of professional development (Tobin, Kahle, & Fraser, 1990; Yager, 1996). Models addressing the social aspects of constructivist theory focus on promoting social communities within professional development settings (Richardson, 1999). Models addressing psychological aspects of constructivism have focused on the development of learner-centered settings that promote the construction of knowledge by the learner. This would result in constructivist-based professional development settings that foster knowledge construction as participants investigate inquiry and activity-based pedagogy (Hassard, 1992).

As with the professional development environments implemented in this study, the theoretical foundation for the design of most hypermedia environments is derived from constructivist theory. Features such as learner control, non-linearity, open access to information, hyperlink functionality, and the non-sequential presentation of information associate hypermedia applications with constructivist theory (Ayersman, 1995; Vrasidas, 2002). The major reason for this is these features foster the development of complex and unique knowledge representations (McGuire, 1996). While constructivism provides many of the basic principles of this study, it is important to note that the study is further rooted in cognitive constructivism.

Cognitive Constructivism

One of the areas of focus within cognitive constructivism is the role of interacting with both physical and social settings during the process of knowledge construction. Also important to the theory of cognitive constructivism is the role of cognitive dissonance. Cognitive dissonance occurs through inconsistencies in our current knowledge structure that arise through social interaction in the learning process (Festinger, 1957; Lyddon, 1995). New knowledge structures are constructed through the resolutions of inconsistencies (Bruner, 1986). The continuing process of incorporating past experiences and knowledge with new ones is extremely important in the learning process (Piaget & Inhelder, 1973).

Researchers have found that professional development opportunities can act as catalysts in changing teachers' conceptions by addressing many of the principles of cognitive constructivism (Radford, 1998; Tobin, 1993). Models of professional development, which are anchored in cognitive constructivist theory, provide teachers with a variety of opportunities to resolve inconsistencies through encounters with material and through social interactions with other individuals involved in the learning process.

Cognitive constructivist ideas also play a key role in the design of hypermedia applications (Moreno & Mayer, 1999). Being closely aligned with constructivist theory, cognitive constructivists hold many of the same beliefs as constructivist theorists (Phillips, 1995, 1997). These ideas include the role of authentic tasks in the learning environment, active learner role in the learning process, the social nature of learning, and the focus on learner-centered learning environments (Jonassen, 1999). In addition to addressing these roles, other aspects of cognitive constructivism are also addressed in hypermedia applications. For instance, while the teacher acts as a guide in the human-centered learning environments, the computer acts as the guide in hypermedia-based learning environments. Further, professional development models and hypermedia environments implemented in this study are using principles of cognitive flexibility theory.

Cognitive Flexibility Theory

One theoretical viewpoint that plays a major role in the design, development, and implementation of hypermedia applications to teaching and learning environments is cognitive flexibility theory (Spiro et al., 1988). Cognitive flexibility theory is rooted in Wittgenstein's (1953) idea of "criss-crossed landscapes," which acts as the driving metaphor for learning through hypermedia applications. According to Spiro and Jehng (1990),

> …one learns by criss-crossing conceptual landscapes; instruction involves the provision of learning materials that channel multidimensional landscape explorations under the active initiative of the learner (as well as providing expert guidance and commentary to help the learner to derive maximum benefit from his or her explorations); and knowledge representations reflect the criss-crossing that occurred during learning. (p. 170)

Cognitive flexibility theory also focuses on the idea that the construction of knowledge is more effective if information is revisited from a variety of perspectives, both in various contexts and at different times. According to Collins, Brown, and Newman (1989), the goal of addressing concepts from multiple perspectives in various contexts and at different times is advanced acquisition of knowledge suitable for in-depth understanding and transfer. According to Jacobson, Maouri, Mishra, and Kolar (1996), the integration of hypermedia into learning environments allows for the development of more complex knowledge structures which can be applied in new contexts.

Social interaction also plays a major role in cognitive flexibility theory (Jonassen, 1999; Spiro et al., 1991). The integration of social interactions into learning environments allows learners to discuss various inconsistencies and ambiguities in the learner's existing knowledge structures. Addressing these inconsistencies and ambiguities results in improved knowledge structures.

Another characteristic of cognitive flexibility theory, which is evident in hypermedia applications, is the ability to address multiple, alternative representations of various concepts. Through interconnected hyperlinks, users can explore these multiple representations and assimilate these new representations with their current representations. This results in the development of new, improved knowledge structures (Jacobson, Maouri, Mishra, & Kolar, 1996; Jonassen & Wang, 1993). While other theoretical viewpoints are relevant to the design, development, and implementation of hypermedia applications, the basic tenets of cognitive flexibility theory play an instrumental role in the integration of hypermedia applications to teaching and learning environments.

Summary

A number of issues in the teaching of science at the elementary level currently exist. These include lack of instructional time in science and ineffective science instruction (Muttlefehldt, 1985; Tressel, 1988). These issues are driven by factors such as the lack of teacher preparation in elementary science, lack of science content knowledge, lack of confidence in teaching science, negative teacher attitudes toward science, and lack of elementary science resources (Harlen & Holroyd, 1997; Helgeson et al., 1977; Hurd, 1982; Koballa & Crawley, 1985; Tilgner, 1990; Vaidya, 1993; Weiss, 1994).

New methods of reform need to focus on the development of effective elementary science teachers and methods of instruction (Smith et al., 2002). By focusing on the teachers as a critical part of the reform, numerous benefits will be observed. Reform efforts that focus on the preparation of teachers--rather than the development of standards--have a number of benefits. These include increased confidence in teaching content, increased content knowledge, and improved teaching strategies (Hanushek, 1992; National Center for Education Statistics, 2000). One method of addressing the current issues in elementary science is through inservice professional development opportunities (Kahle, 2000; Shrigley, 1977; Smith et al., 2002). Appropriate professional development opportunities, while addressing the issues related to elementary science instruction, can also result in increased student achievement (Anderson, 1984; Klein et al., 1999; Monk, 1994).

Integrating hypermedia into elementary science professional development environments is one method of improving inservice elementary science professional development. Hypermedia has a number of characteristics that can make it an effective tool for addressing the barriers to effective instruction in elementary science, and professional development workshops provide a structured environment to address them.

In this study, the design of the professional development opportunities was founded in constructivist and cognitive-constructivist theory. The workshops were designed in an effort to promote knowledge construction through inquiry and activity-oriented events. The purpose of this was to promote active involvement of participants in the learning process and the development of new knowledge structures based on various interactions in the professional development setting. As with the professional development settings implemented in the study, the theoretical underpinnings for the hypermedia application utilized was rooted in the constructivist and cognitive constructivist theories. Characteristics implemented that relate to constructivist and cognitive constructivist ideas include learner control, non-sequential presentation of information, hyperlink functionality, and open access to information. These were implemented in the hypermedia environment to encourage the development of complex and unique knowledge representations.

The professional development workshops and the hypermedia application in this study were designed to address two major issues related to the effective instruction of science in the elementary classroom: improving content knowledge and attitudes toward science. Further, this study examined the effectiveness of integrating hypermedia into professional development workshops in changing elementary teachers' science content knowledge and attitudes toward science. More specifically, the extent to which the integration of hypermedia into a series of professional development workshops positively influenced teachers' content knowledge and attitudes toward elementary science was examined.

CHAPTER 3
METHODOLOGY

Introduction

The purpose of this study was to examine the change in elementary teachers' science content knowledge and attitudes toward science when hypermedia is integrated into professional development opportunities. To accomplish this, inservice elementary teachers who teach science experienced one of two different series of professional development workshops. The first series consisted of professional development workshops that used constructivist learning environments to present content with appropriate instructional strategies in the elementary science classroom. The second series contained similar content but also included the integration of hypermedia into the professional development setting. A control group was also used to measure the effects of confounding variables. The two series of professional development workshops were constructed specifically for this study and contained identical content with the exception of the hypermedia environment.

Study Procedures

In order to answer the research questions in this study, a non-equivalent control group quasi-experimental design was used (Affleck, Madge, Adams, & Lowenbraun, 1988; Campbell & Stanley, 1963). According to Campbell and Stanley (1963), it is appropriate to use a non-equivalent control group quasi-experimental design when group randomization is not possible and the groups are as similar as availability permits, but not similar enough to eliminate pretest measures. While true experimental designs are stronger than quasi-experimental, this non-equivalent control group design is widely used (Gall, Borg, & Gall, 1996).

Table 1 illustrates the design of the study. Three groups were examined in this study: a control group and two experimental groups. Group 1 was the control group, which received no treatment. Groups 2 and 3 were the experimental groups, which received different treatments. Group 2 members participated in a series of traditional inservice science workshops without hypermedia (X_1). Group 3 members participated in similar inservice science workshops with the addition of hypermedia to the professional development environment (X_2). The professional development workshops were conducted during a three-week period. During this three-week period, two measures, the Project to Improve Elementary Science (PIES) Science Knowledge Test (Zielinski & Smith, 1990) and the Science Attitude Scale for Inservice Elementary Teachers II (Shrigley & Johnson, 1974), were administered to the control group and each experimental group. These measures were given to participants prior to the administration of the elementary science workshops and at the conclusion of the workshops.

Table 1. Quasi-experimental Design

Group	Pretest	Treatment	Posttest
1	O_1		O_2
2	O_1	X_1	O_2
3	O_1	X_2	O_2

Research Population

Participants. A total of 57 inservice teachers participated in this study with 19 participants in each group. The professional development workshops consisted of inservice teachers from 21 schools in Duval County, a northeast Florida public school district. Tables 2 through 14 provide demographic information about the participants: gender, ethnicity, level of education, grade level taught, number of years teaching, science professional development experience, comfort level/experience with computers and hypermedia, hours of computer usage for instructional and productivity purposes, science content knowledge, confidence in teaching science, and attitudes toward elementary science.

Demographic information. As is consistent with the field of elementary education, a majority of the participants in the study were female. Table 2 provides the number and percentages for each gender by group.

Table 2. Gender of Participants

	Male		Female	
Group	N	Percentage	N	Percentage
Traditional	0	0	19	100
Hypermedia	2	10.5	17	89.5
Control	1	5.3	18	94.7

All participants in the study were either African-American or non-Hispanic white. Table 3 describes the ethnicity of each group in the study.

Table 3. Ethnicity of Participants

	Black or African American		Non-Hispanic White	
Group	N	Percentage	N	Percentage
Traditional	7	36.8	12	63.2
Hypermedia	1	5.3	18	95.7
Control	5	26.3	14	73.7

All participants in the study hold a bachelor’s degree. More than 20% of participants also have a master’s degree in various fields. Table 4 provides a breakdown of the highest degree obtained by participants in each group.

Table 4. Highest Degree Obtained by Participants

Group	Bachelor's		Master's	
	N	Percentage	N	Percentage
Traditional	13	68.4	6	31.6
Hypermedia	15	78.9	4	21.1
Control	15	78.9	4	21.1

A majority of the participants in the study taught the upper elementary grade levels. Table 5 provides a description of the grade levels taught by participants in each group.

Table 5. Grade Level Taught

Group	Kindergarten	1st	2nd	3rd	4th	5th
Traditional	1 (5.3%)	3 (15.8%)	1 (5.3%)	3 (15.8%)	5 (26.3%)	6 (31.6%)
Hypermedia	3 (15.8%)	3 (15.8%)	3 (15.8%)	6 (31.6%)	1 (5.3%)	3 (15.8%)
Control	0 (0%)	1 (5.3%)	2 (10.6%)	4 (21.1%)	7 (36.8%)	5 (26.3%)

The classroom teaching experience of study participants varied greatly with a range of 0 years to more than 20 years. While the majority of participants have been teaching for less than 5 years, there were also a number of participants who have been teaching for more than 20 years. Table 6 provides information on the teaching experience of participants in each group.

Table 6. Years Teaching

Group	0-5 years	6-10 years	11-15 years	16-20 years	More than 20 years
Traditional	9	3	1	1	5
Hypermedia	6	4	2	3	4
Control	8	3	1	3	4

Science professional development plays a significant role in the continuing education of teachers. Many opportunities in a variety of formats are provided during the school year and in the summer. However, the majority of teachers participating in this study had not participated in science professional development activities within the past year (61.4%), and more than a third of participants had not participated in science professional development for more than three years (36.8%). Table 7 provides information on participant involvement in elementary science professional development activities by group.

Table 7. Amount of Time Since Last Participation in Science Professional Development Activity

Group	Past 6 months	Past year	Past 2 years	Past 3 years	More than 3 years
Traditional	1	8	2	3	5
Hypermedia	2	4	0	3	10
Control	2	5	3	3	6

Because the activities in this study integrated the use of computers and hypermedia into the elementary science professional development workshops, it was important to have participants self-report their comfort level and feelings toward computers and hypermedia. Tables 8 through 11 provide a variety of information addressing participants' comfort level and feelings toward computers, hypermedia, and the amount of time spent using computers for instructional and productivity purposes.

Participants' comfort level and experience with computers in this study were varied. As illustrated in Table 8, almost 90% of the participants considered themselves to have at least an "average" comfort level with computers, while slightly more than 10% considered themselves "beginners."

Table 8. Comfort Level and Experience with Computers

Group	Beginner	Average	Experienced	Advanced
Traditional	4	7	8	0
Hypermedia	2	10	7	0
Control	0	14	4	1

While most participants felt comfortable with computers, this was not the case with hypermedia. A large percentage of participants (61.4%) were not familiar with hypermedia and 12.3% were "beginners" with hypermedia. Just over a quarter of the participants (26.3%) felt they had either “average,” “experienced,” or “advanced” experience with hypermedia.

Table 9. Comfort Level and Experience with Hypermedia

Group	What Is Hypermedia?	Beginner	Average	Experienced	Advanced
Traditional	9	2	6	2	0
Hypermedia	15	2	1	1	0
Control	11	3	2	2	1

Computer usage for participants also varied. As illustrated in Table 10, almost 80% of participants used computers for instructional purposes on a weekly basis. Almost 45% of participants used computers for instructional purposes from one to two hours per week and slightly more than a third (35%) used computers for instructional purposes more than three hours weekly.

Table 10. How Many Hours per Week Do You Use the Computer for Instructional Purposes?

Group	0 hours	1-2 hours	3-4 hours	5-6 hours	more than 6 hours
Traditional	4	8	5	1	1
Hypermedia	6	5	4	2	2
Control	1	12	2	3	1

Participants in this study used computers for teacher productivity purposes more often than for instructional purposes. As shown in Table 11, more than 90% of participants used a computer each week for teacher productivity purposes. More than a third of the participants (35.1%) use computers for productivity purposes between one and two hours a week and over half (55%) use computers for three or more hours a week for productivity purposes.

Table 11. How Many Hours per Week Do You Use the Computer for Productivity Purposes?

Group	0 hours	1-2 hours	3-4 hours	5-6 hours	More than 6 hours
Traditional	2	4	7	2	4
Hypermedia	2	7	6	2	2
Control	0	9	5	2	3

Because the activities in this study addressed topics related to science in the elementary classroom, it was important to examine the participants' science comfort level, content knowledge, and attitudes toward science. While most participants liked science and felt comfortable teaching science, more than 40% felt they did not possess enough content knowledge to effectively teach science. Tables 12 through 14 provide information addressing participants' comfort level with science, content knowledge, and attitude toward science.

Table 12. Do You Feel Comfortable Teaching Science?

Group	Yes		No	
	N	Percentage	N	Percentage
Traditional	17	89.5	2	10.5
Hypermedia	16	84.2	3	15.8
Control	17	89.5	2	10.5

Table 13. Do You Feel You Have Enough Science Content Knowledge?

Group	Yes		No	
	N	Percentage	N	Percentage
Traditional	10	52.6	9	47.4
Hypermedia	11	57.9	8	42.1
Control	11	57.9	8	42.1

Table 14. Do You Like Science?

Group	Yes		No	
	N	Percentage	N	Percentage
Traditional	19	100	0	0
Hypermedia	18	94.7	1	5.3
Control	17	89.5	2	10.5

School district.

Inservice elementary teachers from Duval County, a school district in northeast Florida that encompasses all of Jacksonville, participated in this study. The school district is situated within a county of more than 1 million residents; the district services 129,000 students. Student ethnicity for the district is as follows: White: 46%, Black: 42.6%, Hispanic: 4.7%, Asian: 3.1%, and Other: 2.9%.

The school district encompasses 109 elementary schools. On a scale of 1 to 500, the mean scale score on the FCAT Elementary Science Exam for the district was 285, equivalent to the state mean scale score. However, the district's average scores were slightly lower than the state average on three out of four categories of the FCAT Elementary Science Exam (Physical Science, Life and Environmental Science, and Scientific Thinking), but higher than the state average on the Earth and Space Science section. Table 15 contains detailed information of the district average on each section of the Florida Comprehensive Assessment Test (FCAT) for Elementary Science, as compared with the state of Florida average.

Table 15. District and State Averages on 2003 FCAT Science Exam

FCAT Science Section	District Average	Florida Average	Schools above State Average	Schools at State Average	Schools below State Average
			N	N	N
Physical and Chemical Sciences	6.8 (out of 12)	7.0 (out of 12)	30	33	44
Life and Environmental Sciences	7.46 (out of 13)	8.0 (out of 13)	17	38	52
Scientific Thinking	6.0 (out of 12)	7.0 (out of 12)	6	46	55
Earth and Space Sciences	6.24 (out of 12)	6.0 (out of 12)	45	35	27

Note: The data in this table were taken from the Research and Evaluation section of the Duval County Public Schools Website (2004a).

Individual schools.

Study participants taught at 21 schools in the district. The number of participants from individual schools ranged between 1 and 10 with an average of 2.7 participants per school. School populations for participants ranged between 138 and 744 students with the average school population being 458 students. Also, 50.9% of participants taught at schools that performed below the state and district averages on the 2003 FCAT Science Exam. The remaining 49.1% of participants taught at schools performing above the state and district averages on the 2003 FCAT Science Exam. Table 16 provides the school demographic information including school enrollment, student ethnicity percentages, 2003 FCAT Science mean scores, and the number of teachers who participated in the study.

Treatments

For each experimental group, there were a total of six hours of elementary science professional development workshops divided into two-hour segments. The workshops addressed seven elementary science topics as well as the development of constructivist learning environments in the elementary classroom. Because the school district's scores on the Physical and Chemical Sciences and the Scientific Thinking sections of the FCAT Elementary Science Exam were below the state average, the content of the professional development workshops was designed to address topics in these areas. Areas of focus included Newton's laws of motion, energy, and electricity from the Physical and Chemical Sciences, and the scientific method, observation, experimentation, and measurement from the area of Scientific Thinking. The schedule of workshops can be found in Appendix D and the activities of each workshop session are detailed in Appendix E.

Table 16. School Demographic Information

School	Number of Participants	School Size (Enrollment)	Ethnicity (%)	2003 FCAT Science (Mean Score)
Biltmore	1	324	Black: 85%, Mixed: 1%, White: 14%	251
Cedar Hills	1	318	White: 50%, Black: 38%, Hispanic: 6%, Mixed: 4%, Indian: 1%, Asian: 1%	295
Central Riverside	2	434	Black: 69%, White: 20%, Mixed: 6%, Hispanic: 4%, Asian: 2%	300
Crystal Springs	10	204	White: 64%, Black: 27%, Mixed: 4%, Hispanic: 3%, Asian: 2%	295
Gregory Drive	3	652	White: 48%, Black: 38%, Hispanic: 6%, Mixed: 4%, Asian: 3%	298
Hendricks Avenue	4	620	White: 73%, Black: 19%, Mixed: 3%, Hispanic: 2%, Asian: 2%	307
Holiday Hill	2	557	White: 67%, Black: 26%, Mixed: 4%, Hispanic: 2%, Asian: 1%	289
Hyde Grove	6	590	Black: 70%, White: 21%, Mixed: 4%, Hispanic: 3%, Asian: 1%	276
Hyde Park	1	516	White: 48%, Black: 45%, Mixed: 4%, Hispanic: 2%, Asian: 1%	277
Stonewall Jackson	3	322	Black: 46%, White: 43%, Mixed: 5%, Hispanic: 4%, Asian: 2%	276
Thomas Jefferson	3	510	White: 83%, Black: 14%, Hispanic: 2%, Indian: 1%	283
Normandy	1	138	White: 59%, Black: 29%, Hispanic: 7%, Mixed: 3%, Asian: 2%	266
Oak Hill	1	530	Black: 54%, White: 30%, Hispanic: 7%, Mixed: 5%, Asian: 4%	284

Table 16 Contd.

School	Number of Participants	School Size (Enrollment)	Ethnicity (%)	2003 FCAT Science (Mean Score)
Pinedale	5	537	Black: 72%, White: 22%, Hispanic: 2%, Mixed: 2%, Asian: 2%	256
Ramona	2	461	Black: 52%, White: 39%, Hispanic: 4%, Mixed: 3%, Asian: 2%	273
Reynolds Lane	1	310	Black: 49%, White: 29%, Hispanic: 15%, Asian: 5%, Mixed: 2%	292
Sadie Tillis	1	391	Black: 50%, White: 35%, Hispanic: 9%, Mixed: 4%, Asian: 2%	277
Louis Sheffield	2	744	White: 93%, Black: 4%, Hispanic: 1%, Mixed: 1%	306
Spring Park	3	373	Black: 51%, White: 34%, Hispanic: 6%, Mixed: 6%, Asian: 4%	259
Timucuan	2	658	White: 59%, Black: 29%, Hispanic: 7%, Mixed: 3%, Asian: 2%	275
Venetia	5	420	White: 45%, Black: 35%, Hispanic: 9%, Mixed: 8%, Asian: 2%	303

Note: The data in this table were taken from the Individual School Profiles section of the Duval County Public Schools Website (2004b).

After gaining approval to conduct research from the University of Florida's Institutional Review Board (UF IRB Protocol Number: 2004-U-298), approval to conduct research was attained from the Research and Evaluation Department of the Duval County School Board. After approval was granted by the Research and Evaluation Department, approval to carry out two series of professional development workshops had to be granted by the Professional Development Department and Science Department of the Duval County School Board. Permission to conduct the workshops was granted and the workshops were recognized as part of the teachers' continuing professional development. As a result, participants in the experimental groups that completed the workshops received six inservice points that could be applied to teacher re-certification and an hourly stipend from Duval County.

Both series of workshops addressed identical content (see Appendix F). In the workshops, a variety of issues were addressed through an assortment of different activities. For example, after the pretest data collection on the first day, an introductory discussion was held regarding current issues in elementary science. This allowed participants to voice their feelings on the state of science teaching in the elementary classroom and provide the rationale for their feelings. Following this discussion, pre-structuring for the first activity began. The presentation was conducted as an instructor-led whole-group discussion. Ideas and concepts were introduced to participants and follow-up questions were asked in an effort to determine the level of science content knowledge regarding kinematics, the topic for the particular activity. Following this, the first activity was performed in small groups. After the activity was completed, a whole-group discussion of the findings was held. A similar format was followed for the second activity of the day by modeling a different instructional strategy. After the two daily activities, a closing discussion was conducted. The workshop concluded with participants writing reviews of the lessons. Differences in the workshops consisted of the manner in which activities were accessed and presented, the manner in which presentations were accessed and presented, and the method used to read and write lesson reviews (See Appendix F). First, for the hypermedia group, activities and pre-structuring presentations were accessed via the hypermedia environment Elementary Level Lessons in Physical Science (ELLIPS). To do this, participants were first introduced to the hypermedia environment. Following this, they were provided an opportunity to search for content resources related to the first topic: kinematics. Following this, a discussion on kinematics ensued. After this, participants were prompted to use the hypermedia environment to access various lessons related to kinematics. When lessons were accessed, a single lesson was selected and then conducted in small groups. This procedure was then conducted for each activity presented throughout the series of workshops. Lesson reviews were completed online with the lesson review feature of ELLIPS. After each workshop session had concluded, participants were prompted to add lesson reviews utilizing the hypermedia environment. To do this, participants selected the specific activity that was performed (See Appendix D). When the activity was selected, an 'Add A Review' link was selected. Participants were then provided an opportunity to write reviews for each lesson. For the traditional group, activities and pre-structuring presentations were found in the workshop book provided to participants. Participants accessed lessons and content resources related to similar topics in the workshop book. After accessing content resources, a group discussion ensued. Following the discussion, individual activities were conducted in small groups. At the conclusion of each workshop session, participants were prompted to complete lesson review forms located in the individual workshop books.

A similar format took place for each workshop. The content in the three workshops was (1) kinematics and acceleration, (2) mass, weight, gravity, and simple electricity, and (3) waves and simple machines.

Instrumentation

The two instruments used in this study were the Program to Improve Elementary Science (PIES) Science Knowledge Test (Zielinski & Smith, 1990) and the Science Attitude Scale for Inservice Elementary Teachers II (Shrigley & Johnson, 1974).

The PIES Science Knowledge Test.

The PIES Science Knowledge Test is a 25-item multiple-choice instrument designed by Zielinski and Smith (1990) to evaluate the effectiveness of the PIES Project. The instrument was derived from an original PIES test that included 50 multiple-choice items and had a test-retest reliability of r=.67 using 24 participants over a two-week period. The instrument was designed to measure participants' comprehension of basic science principles and processes. Areas of science content addressed by this instrument include life sciences, earth sciences, and physical sciences. Science processes addressed by this instrument include data analysis, data clarification, and identification of variables. An internal consistency of r = .89 was determined using Kuder-Richardson-20 procedures (Zielinski & Smith, 1990). The instrument can be found in Appendix B.

The Science Attitude Scale for Inservice Elementary Teachers II.

The Science Attitude Scale for Inservice Elementary Teachers II is a 26-item Likert-type instrument designed by Shrigley and Johnson (1974) to assess inservice teachers' attitudes toward science. The scale consists of 16 positive statements and 10 negative statements on a Likert-scale. Topics of the Science Attitude Scale for Inservice Elementary Teachers II include enjoyment of science, interest in science, and confidence in teaching science and conducting scientific experiments. The items on the scale were submitted to Likert Analysis. In conducting the Likert Analysis, items were weighted as follows: "On positive statements, 'strongly agree' was weighted as 5 points; 'agree,' 4 points; ‘undecided,’ 3 points; ‘disagree,’ 2 points; and ‘strongly disagree,’ 1 point. In scoring negative statements, the weights were reversed” (Shrigley & Johnson, 1974, p. 439). In order to establish reliability of the instrument, the scale was administered to 114 inservice elementary teachers. A reliability coefficient alpha of .92 was calculated for the instrument. When the scale was submitted to test-retest procedures a correlation coefficient of .94 was calculated. All items on the scale reported an item-total correlation greater than .30 (Shrigley & Johnson, 1974). The item-total correlation consists of “each respondent’s score on a particular item when correlated with that respondent’s score on the remaining items” (Shrigley & Johnson, 1974, p. 439). Table 17 illustrates each statement type (positive or negative) and the item-total correlation for each item. The instrument can be found in Appendix A.

Table 17. Item-Total Correlations for the Science Attitude Scale for Inservice Teachers II

Statement	**Statement Type**	**Item-total Correlation**
As a teacher, I am afraid that science demonstrations will not work.	Negative	.34
I enjoy discussing science topics with fellow teachers.	Positive	.76
If I had time, I would like to attend an elementary science workshop during the summer.	Positive	.55
If I were to enroll in a college science course, I would enjoy the laboratory periods of the course.	Positive	.55
I am afraid that I do not have enough background to teach science adequately.	Negative	.61
If I were to return to college for additional graduate work, I would enroll in at least one science course.	Positive	.59
I enjoy manipulating science equipment.	Positive	.69
I believe science is too difficult for me to learn.	Negative	.36
I would like to have a desk barometer that measures air pressure.	Positive	.72
I would like to work with the science consultant on my science program.	Positive	.55
Most science equipment confuses me.	Negative	.56
I enjoy constructing simple equipment.	Positive	.62
I would not enjoy working in a science laboratory for a summer.	Negative	.42
I enjoy science courses.	Positive	.53
I would enjoy participating in a science inservice program in my school district.	Positive	.57
I eagerly anticipate the teaching of science to elementary school children.	Positive	.71
Science is my favorite subject.	Positive	.70
If I were to enroll in any college science course, I would likely be bored.	Negative	.38
I prefer teaching science over any other subject of elementary school.	Positive	.68
I would not like to keep a hamster in my classroom.	Negative	.33
In a departmental situation or similar situation, I would like to be responsible for teaching all of the science.	Positive	.71
I am apprehensive about anything that is associated with science.	Negative	.54
I would read an issue of the professional journal, *Science and Children*, if it were in the teacher's room.	Positive	.59
I would be interested in working in an experimental science curriculum project.	Positive	.68
If given a choice in professional improvement, I would choose any area but science.	Negative	.73
I would prefer to be a team leader in any curriculum area but science.	Negative	.56

Note: Adapted from "The Attitude of Inservice Elementary Teachers Toward Science" by R. L. Shrigley and T.M. Johnson, 1974, *School Science and Mathematics*, 74(5), pp. 439-440.

The Hypermedia Environment

Due to the fact that inservice elementary teachers are often inexperienced with physical science content (Harlen & Holroyd, 1997; Hurd, 1982; Stevens & Wenner, 1996; Tilgner, 1990; Weiss, 1994), a hypermedia environment was designed to aid in the structuring and organization of the material. The Elementary Level Lessons in Physical Science (ELLIPS) is a web-based hypermedia environment developed for inservice teachers. There are a number of components and teacher resources embedded in ELLIPS. First, it contains a collection of searchable elementary school level physical science activities. Physical science activities are organized according to a number of criteria, including topic, type of activity, grade level, amount of equipment needed, and the Sunshine State Standards (statewide academic standards for all K-12 Florida students). Second, ELLIPS contains a collection of teacher content resources. These resources are organized utilizing identical topic areas present in the collection of physical science activities. Third, ELLIPS contains a discussion board. With this tool, teachers can post discussion topics as well as reply to topics posted by others. Finally, ELLIPS users have the ability to read and write reviews for the lessons embedded in the hypermedia structure.

Information that is both complex and often new to the learner was presented using ELLIPS. Due to the environment and content being new to the learners, a database structure was embedded in ELLIPS in an effort to diminish many of the constraints of the hypermedia environment. Another important note is that the strengths of each medium, databases and hypermedia, were a major focus during the development of the tool. The database structure was used for the storage, organization, and retrieval of information while the hypermedia structure was used to address navigation, structure, and presentation of the information. All of these factors were implemented to develop a more effective learning environment.

Data Collection

The professional development workshops (see Appendices C and D) were held from April 27 to May 13, 2004; each workshop series was six hours (see Table 18). The six hours of professional development were divided into two-hour segments scheduled one week apart. They were carried out at Edward H. White High School, a local high school near a majority of participants' home schools, from 4:00 to 6:00 p.m. Each of the instruments was administered prior to the beginning of the first professional development workshop and after the final activity of each group's third workshop. The instruments were administered to the control group prior to the beginning of any of the workshops and again after a three-week interval. The time interval of three weeks between the administration of the pretest and posttest measures was identical for all three groups. The Science Attitude Scale (Shrigley & Johnson, 1974) took between 10 and 15 minutes to complete and the PIES Science Knowledge Test (Zielinski & Smith, 1990) took between 15 and 25 minutes to complete.

Table 18. Schedule of Data Collection and Workshops

	Control	Hypermedia	Traditional
Pretest data collection	April 26 & 27, 2004	April 27, 2004	April 29, 2004
Workshop 1	None	April 27, 2004	April 29, 2004
Workshop 2	None	May 4, 2004	May 6, 2004
Workshop 3	None	May 11, 2004	May 13, 2004
Posttest data collection	May 11-14, 2004	May 11, 2004	May 13, 2004

Data Analysis

The scores of each survey were analyzed by examining the range and means of the pretest and posttest scores to assess changes in science content knowledge and attitudes towards science. The Statistical Package for the Social Sciences (SPSS) software was used to analyze all quantitative data. In order to increase statistical power and to control for the effects of the covariates, an analysis of covariance (ANCOVA) was conducted on the groups to determine if there were significant main effects and interaction effects (Borg & Gall, 1989). Significant differences in means were measured using a probability value of $p < 0.05$. The pretest served as the baseline measure for attitudes toward science and science content knowledge. In situations in which there were significant effects or effects approaching significance, Tukey HSD post-hoc pairwise comparisons were conducted to further examine differences between groups and to control for type I error across additional comparisons. Hays (1994) reported the Tukey HSD post-hoc test is a suitable follow-up procedure for an ANCOVA. Also, according to Hinkle, Wiersma, and Jurs (1994), the Tukey HSD post-hoc analysis is an appropriate procedure for equal group sizes that illustrate a significant F-ratio. The Tukey HSD analysis is also useful with less complex contrasts, such as those implemented in this study.

Hypotheses

The following research hypotheses were tested using an analysis of covariance statistical test. This was done to increase statistical power and to control for the effects of the covariates. The ANCOVA allows for an appropriate comparison of group mean scores on each posttest measure, accounting for group mean score adjustments based on the covariate variable (pretest measures). This provides for a more effective investigation of the effects of the independent variables (Hinkle et al., 1994).

Hypothesis 1. There is a significant difference in scores on the PIES Science Knowledge test between the control group and the traditional group after inservice professional development.

Hypothesis 2. There is a significant difference in scores on the PIES Science Knowledge test between the control group and the hypermedia group after inservice professional development.

Hypothesis 3. There is a significant difference in scores on the PIES Science Knowledge test between the traditional group and the hypermedia group after inservice professional development.

Hypothesis 4. There is a significant difference in scores on the Science Attitude Scale between the control group and the traditional group after inservice professional development.

Hypothesis 5. There is a significant difference in scores on the Science Attitude Scale between the control group and the hypermedia group after inservice professional development.

Hypothesis 6. There is no significant difference in scores on the Science Attitude Scale between the traditional group and the hypermedia group after inservice professional development.

Internal Validity Concerns

In addressing internal validity issues, it is important to control for various extraneous variables in such a manner that any observed differences in the experiment can be attributed to the treatment (Tuckman, 1978). In non-equivalent control group designs, Campbell and Stanley (1963) recorded eight variables that can potentially confound the effects of the treatment. These threats are history, maturation, instrumentation, testing, selection, mortality, selection-maturation interaction, and regression. In an effort to reduce the effect of these factors on the internal validity of the study, these threats to internal validity were addressed in the following ways.

History and Maturation

History and maturation are two internal validity concerns that did not play a large role in this study. To address history concerns, the content and structure of each of the treatment groups were identical. Maturation concerns were also negligible in this study because the length of the study was only three weeks. Therefore, maturation had little effect on participants and/or results of the study.

Instrumentation and Testing

To address instrumentation concerns, participants from all groups were subjected to identical testing material. Also, instrument items were in a multiple choice or Likert-scale format to reduce rater-bias. Because the same instruments were used for both the pretest and posttest measures, test-retest was a concern in this study. A control group was used to address potential increases in posttest scores that may have resulted from participants having taken an identical pretest. During the analysis of the data, appropriate statistical analyses were implemented to adjust for initial group differences.

Selection

Selection issues are often a problem in quasi-experimental designs. In this study, t-tests were conducted on both pretest measures for all groups and resulted in no statistically significant differences between the groups for either science content knowledge or attitudes toward science. However, this method, in itself, is not sufficient to address selection issues and to assure group equivalence (Cook & Campbell, 1979). As a result, the statistical analyses that were conducted on the posttest scores for both science content knowledge and attitudes toward science used the pretest measures as covariates. The covariates adjusted the analyses for initial group differences.

Mortality

In this study, it was difficult to control for mortality issues. To address absentee issues, any participant absent for more than 34% of the workshops was excluded from the study. Mortality and absentee rates for each treatment group were similar. Each experimental group in the study began with 22 participants and concluded with 19 participants.

Selection-maturation Interaction

As in many quasi-experimental designs, selection differences and resulting interactions with maturation can pose threats to internal validity. However, due to the method of group selection and the brief duration of the professional development workshops (treatments), selection differences and interactions with maturity had only minimal negative effects on the internal validity of the study.

Regression

In this study, participants registered for one of two different series of elementary science professional development workshops. Many participants opted for the series of workshops (Tuesdays or Thursdays) that best fit their schedule. However, some participants let the researcher assign the individual workshop. As a result, the researcher attempted to make the non-randomly assigned groups as similar as possible. Statistical tests indicated no significant differences existed between groups on either the science content knowledge or attitudes toward science pretest measures.

Summary of Internal Validity Concerns

Having reviewed the factors affecting internal validity, only selection, mortality, and regression threatened the internal validity of this study. While these factors may have diminished the internal validity of this study, each factor was addressed in an effort to minimalize its negative influences on the internal validity of this study.

External Validity Concerns

In addition to addressing internal validity issues, it is also important to control for external validity, or generalizability, concerns. In non-equivalent control group designs, four variables can potentially confound the effects of the treatment. Campbell and Stanley (1963) identified these threats as testing-interaction effects, maturation, treatment-interaction effects, and other interactions with the treatment. In this study, these threats to external validity were addressed in the following ways.

Testing-interaction Effects

In this study, a pretest measure was administered for each of the dependent variables, science content knowledge, and attitudes toward science. By either increasing or decreasing a participant's responsiveness to the experimental variable, the use of a pretest measure may significantly reduce the generalizability of a study. Therefore, a pretest was administered to both experimental groups and the control group.

Maturation

In non-equivalent control group research designs, maturation can be a threat to both internal and external validity. As mentioned previously, maturation concerns were minimal in this study due to the brief duration of the professional development workshops. As a result, maturation had little impact on participants and/or the results of this study.

Treatment-interaction Effects

Treatment-interaction effects can also influence the external validity of a study. In this study, because participants underwent a variety of experiences throughout the school day, and that the treatment, combined with these experiences, may have unique effects, the generalizability of the study may be compromised. However, in an effort to control for these effects, participants experienced workshops typical of the Duval County professional development program. Due to similarities in participants' schools and the in-school events that occur at the end of the school year, it is reasonable to presume that the experiences of the participants were similar enough to only minimally influence the external validity of the study.

Other Interactions with the Treatment

Another potential threat to external validity was the interaction of selection with the treatment. This relates to the generalizability of the findings of this study in that if the participants do not accurately represent the larger population, it is difficult to generalize the findings. However, demographic information collected from participants indicated a wide array of backgrounds. While the vast majority of the participants were female, as is typical at the elementary level, other demographic information, such as number of years teaching, grade taught, and comfort level with computers all showed a wide array of responses. As a result, the interaction of selection with the treatment had a minimal impact on the external validity of this study.

An additional potential threat to external validity was the "Hawthorne Effect," or the Reactive Effects of Experimental Arrangements. This potential threat occurs when participants, as a result of taking part in an experimental study, react strongly to the treatment. While participants in this study knew they were part of an experimental study, they were provided with professional development opportunities that paralleled experiences they would typically experience in the professional development setting. As a result, the reactive effects to the treatments had no effect on the external validity of this study.

Summary of External Validity Concerns

In examining the factors that influence external validity, it was determined that there were only minimal influences on the study's external validity. While issues such as treatment-interaction effects, maturity, testing-interaction effects, and other interactions with the treatment were present, they were adequately controlled in the design of the study. Although these factors were controlled other issues restricted the generalizability of the study. These issues included the length of the workshops, the lack of measures of treatment over time, and the absence of measures of student achievement. Without further research, the generalizability of this study to other populations is limited.

CHAPTER 4
RESULTS

Introduction

The purpose of this study was to examine the growth in science content knowledge and changes in attitudes toward science with the integration of hypermedia into professional development workshops for elementary teachers. In particular, this study observed whether or not a professional development setting that implemented a hypermedia environment had a positive influence on elementary teachers' attitudes toward science and knowledge of scientific topics and processes. In this chapter, the results of the statistical analyses for the study are presented. An explanation of the findings will occur in Chapter 5. Study questions and corresponding research hypotheses were as follows:

Research Question 1. To what extent does the use of hypermedia during inservice professional development increase elementary teachers' understanding of elementary science concepts?

> **Hypothesis 1.** There is a significant difference in scores on the PIES Science Knowledge test between the control group and the traditional group after inservice professional development.
>
> **Hypothesis 2.** There is a significant difference in scores on the PIES Science Knowledge test between the control group and the hypermedia group after inservice professional development.

Hypothesis 3. There is a significant difference in scores on the PIES Science Knowledge test between the traditional group and the hypermedia group after inservice professional development.

Research Question 2. To what extent does the use of hypermedia during inservice professional development influence elementary teachers' attitudes toward science?

Hypothesis 4. There is a significant difference in scores on the Science Attitude Scale between the control group and the traditional group after inservice professional development.

Hypothesis 5. There is a significant difference in scores on the Science Attitude Scale between the control group and the hypermedia group after inservice professional development.

Hypothesis 6. There is a significant difference in scores on the Science Attitude Scale between the traditional group and the hypermedia group after inservice professional development.

General Study Details

This non-equivalent control group quasi-experimental study took place from April 27 to May 13, 2004, in a physics lab and computer lab at Edward H. White High School in Jacksonville, Florida. A total of 57 inservice elementary teachers from Duval County comprised three groups: a control group and two experimental groups (one with and one without hypermedia). Participants in each of the experimental groups experienced a series of three two-hour professional development workshops addressing issues, concepts, and skills associated with teaching science in the elementary classroom.

Study Sample

The sample in this study consisted of 57 inservice elementary teachers from 21 schools in the Duval County school system. In the study, 95% of the teachers were female and 5% were male; 77% of the participants were non-Hispanic white individuals, and 23% were African-American. All participants had a bachelor's degree, and 25% listed a master's degree as their highest level of education. Almost three-quarters (70.2%) of the participants taught in the upper elementary grades (third through fifth), and the remaining participants (29.8%) taught in the lower elementary grade levels (kindergarten through second). In this study, 40% of participants had less than five years of teaching experience. Yet, there were also participants (22.8%) with more than 20 years of teaching experience. Hence, the experience level of the sample varied.

While many of the teachers (38.6%) have participated in science professional development activities within the past year, 61.2% have not participated in science professional development activities in more than a year, and 36.8% have not participated in elementary science professional development activities in more than three years. Nearly 90% of the participants rated themselves as an average or above-average computer user. Yet only 38.7% of the participants rated themselves as an average or above hypermedia user. Participants also reported using computers more for productivity purposes (93%) than for instructional purposes (81%).

Participants were also surveyed on their attitudes, knowledge, and comfort level toward science. Nearly all participants (94.7%) "liked" science and many participants (88.7%) felt comfortable teaching elementary science concepts. Yet only 56.1% felt they had sufficient science content knowledge.

Assignment to Groups

This research study had 57 participants in three groups: control, hypermedia, and traditional. Due to issues related to availability of participants, duration of the workshops, and lab space for the workshops, random assignment was not implemented in this study. During the recruitment process, teachers from Duval County were asked to register for one of two series of workshops (either Tuesdays or Thursdays), unaware of any differences between the series of workshops. The researcher decided prior to the selection of teachers that the Tuesday workshops would be the hypermedia group and the Thursday workshops would comprise the traditional group. Control group participants were also recruited from Duval County. These participants consisted of teachers who were asked to complete the pretest and posttest measures at designated times. Control group participants were aware they would not be receiving a treatment. Both the traditional group and the hypermedia group began with 22 participants. Due to resignation, illness, and other reasons, each group concluded the study with 19 participants. Participants in the experimental groups received an hourly stipend and inservice points from the Duval County school district as part of their continuing professional development.

Statistical Analyses

Statistical Tests

In order to increase power and to account for initial group differences, an analysis of covariance (ANCOVA) was conducted to determine if there were significant main effects and interaction effects between groups (Borg & Gall, 1989). When there were significant effects or effects approaching significance, Tukey HSD post-hoc pairwise comparisons were conducted to further examine the results. An a priori alpha level was set at .05 to determine the level of significance. The pretest measures for science content knowledge (PIES Science Knowledge Test) and attitudes toward science (Science Attitude Scale for Inservice Elementary Teachers II) acted as the baseline measures.

Descriptive and Inferential Statistics

Descriptive statistics for both science content knowledge and attitudes toward science on the pretest and posttest measures are reported in Tables 23 and 24. Table 19 reports each group's mean and standard deviation on the pretest and posttest measures for science content knowledge. Table 20 provides each group's mean and standard deviation of the pretest and posttest measures of attitudes toward science.

Table 19. Means and Standard Deviations of Science Content Knowledge Scores

	Pretest		Posttest	
	M	SD	M	SD
Control (N=19)	15.63	2.83	16.11	2.75
Traditional (N=19)	15.95	3.75	19.26	2.45
Hypermedia (N=19)	16.37	3.56	19.38	1.73

Table 20. Means and Standard Deviations on Science Attitude Scale

	Pretest		Posttest	
	M	SD	M	SD
Control (N=19)	95.00	17.17	94.68	16.35
Traditional (N=19)	95.32	16.04	92.84	15.82
Hypermedia (N=19)	92.05	17.66	99.68	14.55

Means on the pretest measure for science content knowledge were similar for all groups ($F_{2,57}$=.224, p=.800). Group mean scores on the pretest measure of science content knowledge were 15.63 (control group), 15.95 (traditional group), and 16.37 (hypermedia group). Posttest scores were greatest for the hypermedia group (M=19.38, SD=1.73), followed closely by the traditional group (M=19.26, SD=2.45) and further by the control group (M=16.11, SD=2.75). Means on the pretest measure for attitude toward science were also similar for all groups ($F_{2,57}$=.214, p=.808). Group mean scores on the pretest measure of attitudes toward science were 95.00 (control group), 95.32 (traditional group), and 92.05 (hypermedia group). Posttest scores were greatest for the hypermedia group (M=99.68, SD=14.55), followed by the control group (M=94.68, SD=16.35) and further by the traditional group (M=92.84, SD=15.82).

Science Content Knowledge

Data from Table 19 provide the mean and standard deviation of science content knowledge for each group, as measured by the Project to Improve Elementary Science (PIES) Science Content Knowledge Test. Pretest scores were greatest for the hypermedia group (M=16.37, SD=3.56), followed by the traditional group (M=15.95, SD=3.75) and the control group (M=15.63, SD=2.83). Posttest scores were greatest for the hypermedia group (M=19.38, SD=1.73), followed closely by the traditional group (M=19.26, SD=2.45) and concluding with the control group (M=16.11, SD=2.75). To analyze the results of each group's pretest and posttest scores for science content knowledge, an analysis of covariance was conducted. Adjusted means and standard errors of the science content knowledge scores, which result from the analysis of covariance, are reported in Table 21. In this analysis, the fixed factor was the group (treatment) with three levels (control, traditional, and hypermedia), the covariate was the PIES Science Content Knowledge pretest score, and the dependent variable was the PIES Science Content Knowledge posttest score. Results of the ANCOVA (see Table 22) revealed that the pretest covariate was significantly related to the corresponding posttest scores (F=42.782, p<.001, ES=.456), and the professional development workshops (groups) explained 62% of the variance in the posttest (Adjusted R^2=.62). There were also significant group effects ($F_{1,57}$=11.444, p<.001, ES=.310) and interaction effects between the pretest scores and the groups ($F_{1,57}$=6.679, p=.003, ES=.208).

Table 21. Adjusted Means and Standard Error of Science Content Knowledge Scores (Dependent Variable: PIES Posttest Score)

	Mean	SE
Group		
Control	16.248	.439
Hypermedia	19.527	.439
Traditional	19.277	.438

a. Evaluated covariates appeared in the model: PIES Pretest Score = 15.98.

Table 22. Tests of Between-Subjects Effects for Group Means (Dependent Variable: PIES Posttest Score)

Source	SS	df	MS	F	p	η^2
Corrected Model	289.645	5	57.929	19.267	.000	.654
Intercept	268.601	1	268.601	89.336	.000	.637
GROUP	68.814	2	34.407	11.444	.000	.310
PIESPRE	128.631	1	128.631	42.782	.000	.456
GROUP * PIESPRE	40.161	2	20.080	6.679	.003	.208
Error	153.338	51	3.007			
Total	19638.000	57				
Corrected Total	442.982	56				

a R Squared = .654 (Adjusted R Squared = .620)

It appears that there may have been a main effect ($F_{1,57}$=11.444, p<.001, ES=.310) of the treatment on science content knowledge. However, this may be somewhat misleading because of the interaction effect between the pretest scores and the groups ($F_{1,57}$=6.679, p=.003, ES=.208). In essence, the effects of the treatment (groups) depended on the pretest scores. To examine the interaction effects, a plot of pretest and posttest scores for each group was investigated (see Figure 1)

For the control group members, PIES Science Knowledge Test pretest and posttest scores correlated highly (R=.7934), as seen in Figure 1. Control group participants with low PIES Science Knowledge Test pretest scores also had low PIES Science Knowledge Test posttest scores. Control group participants with high PIES Science Knowledge Test pretest scores also had high PIES Science Knowledge Test posttest scores. Overall, there was little increase in science content knowledge scores for the control group. For traditional group members, PIES Science Knowledge Test pretest and posttest scores had a smaller correlation (R=.2365). Traditional group participants with low PIES Science Knowledge Test pretest scores had relatively large increases in PIES Science Knowledge Test posttest scores. Traditional group participants with high PIES Science Knowledge Test pretest scores had smaller increases in PIES Science Knowledge Test posttest scores. This indicated that the professional development workshops had a more significant positive influence on the science content knowledge of participants that entered the professional development setting with limited science content knowledge and less influence on the science content knowledge of participants that entered the professional development setting with more science content knowledge. This trend was similar for the hypermedia group. Hypermedia group participants with low PIES Science Knowledge Test pretest scores had relatively large increases in PIES Science Knowledge Test posttest scores. Hypermedia group participants with high PIES Science Knowledge Test pretest scores had smaller increases in PIES Science Knowledge Test posttest scores. Again, this indicated that the professional development workshops with hypermedia had a more significant positive influence on the science content knowledge of participants that entered the professional development setting with limited science content knowledge and less influence on the science content knowledge of participants that entered the professional development environment with more science content knowledge. Evidence of these interaction effects are illustrated in Table 22 and Figure 1.

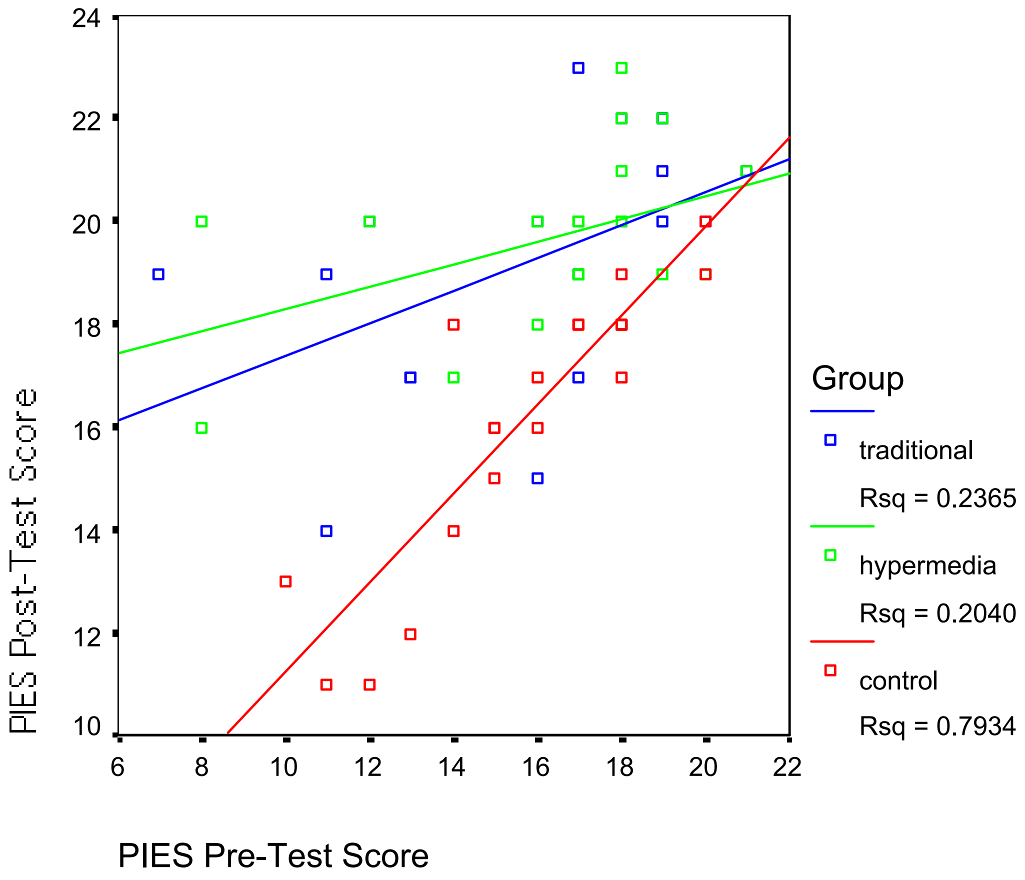


Figure 1. Plot of PIES Pretest and Posttest Scores for each group.

In determining the extent to which the treatment (the use of hypermedia) influenced changes in science content knowledge, the effect size was examined. The effect size for the change in science content knowledge indicated a small practical significance (ES=.31). Examining the mean score gains (see Table 19), the growth in science content knowledge was greater for the traditional group (3.31) and the hypermedia group (3.01) than it was for the control group (.48). This analysis shows the traditional group had the greatest growth in science content knowledge, followed closely by the hypermedia group. There was little growth in science content knowledge for the control group. Hence, the extent of the hypermedia environment workshops on growth in science content knowledge was negligible.

Attitudes Toward Science

Data from Table 20 provide the means and standard deviations of attitudes toward science for each group, as measured by the Science Attitude Scale for Inservice Teachers II. Pretest scores were greatest for the traditional group (M=95.32, SD=16.04), followed by the control group (M=95.00, SD=17.17) and the hypermedia group (M=92.05, SD=17.66). Posttest scores were greatest for the hypermedia group (M=99.68, SD=14.55), followed by the control group (M=94.68, SD=16.35) and further by the traditional group (M=92.84, SD=15.82). An analysis of covariance was conducted to analyze the results of each group's pretest and posttest scores of attitudes toward science. Adjusted means and standard errors of attitudes toward science scores, which resulted from the analysis of covariance, are reported in Table 23. In this analysis, the fixed factor was the group (treatment) with three levels (control, traditional, and hypermedia), the covariate was the Science Attitude Scale for Inservice Teachers II pretest score, and the dependent variable was the Science Attitude Scale for Inservice Teachers II posttest score. Results of the ANCOVA (see Table 24) revealed the pretest covariate was significantly related to the corresponding posttest scores ($F_{2,57}$=192.666, p<.001, ES=.791). The professional development workshops (groups) explained 78.1% of the variance in the posttest (Adjusted R^2=.781). There were no significant group main effects ($F_{1,57}$=2.980, p<.060, ES=.105) or interactions between the pretest scores and the groups ($F_{1,57}$=1.724, p=.189, ES=.063).

Table 23. Adjusted Means and Standard Error of Attitudes Toward Science Scores (Dependent Variable: Science Attitude Scale Posttest Score)

	Mean	SE
Group		
Control	93.973	1.695
Hypermedia	101.364	1.699
Traditional	91.874	1.696

Table 24. Tests of Between-Subjects Effects for Attitudes Toward Science (Dependent Variable: Science Attitude Scale Posttest Score)

Source	SS	df	MS	F	p	η^2
Corrected Model	10891.159	5	2178.232	41.024	.000	.801
Intercept	610.635	1	610.635	11.501	.001	.184
GROUP	316.419	2	158.210	2.980	.060	.105
ATTPRE	10229.804	1	10229.804	192.666	.000	.791
GROUP * ATTPRE	183.068	2	91.534	1.724	.189	.063
Error	2707.894	51	53.096			
Total	536035.000	57				
Corrected Total	13599.053	56				

a. R Squared = .801 (Adjusted R Squared = .781)

Although the ANCOVA results showed no significant group main effects, Tukey HSD post-hoc pairwise comparisons were conducted because the level was close to the pre-determined alpha level ($F_{1,57}$=2.980, p=.060). These analyses indicated a significant difference in the Science Attitude for Inservice Teachers II posttest scores for the control group and hypermedia group ($F_{1,57}$=9.463, p=.003) as noted in Table 25. Table 26 data did not illustrate a significant difference in the Science Attitude Scale for Inservice Teachers II posttest scores between the control group and traditional group ($F_{1,57}$=.767, p=.385). Finally, data from Table 27 indicated a significant difference between the hypermedia group and the traditional group scores ($F_{1,57}$=15.581, p<.001).

Table 25. Tests of Significant Differences Between Control Group's and Hypermedia Group's Attitudes Toward Science (Dependent Variable: Science Attitude Scale Posttest Score)

Source	SS	df	MS	F	p
Contrast	516.199	1	516.199	9.463	.003
Error	2890.962	53	54.546		

Table 26. Tests of Significant Differences Between Control Group's and Traditional Group's Attitudes Toward Science (Dependent Variable: Science Attitude Scale Posttest Score)

Source	SS	df	MS	F	p
Contrast	41.823	1	41.823	.767	.385
Error	2890.962	53	54.546		

Table 27. Tests of Significant Differences Between Traditional Group's and Hypermedia Group's Attitudes Toward Science (Dependent Variable: Science Attitude Scale Posttest Score)

Source	SS	df	MS	F	p
Contrast	849.889	1	849.889	15.581	.000
Error	2890.962	53	54.546		

In determining the extent to which the treatment (the use of hypermedia in the workshop) influenced changes in attitudes toward science, effect size was examined. The effect size for the change in attitudes toward science (ES=.791) indicated more practical significance than existed for changes in science content knowledge. Examining the mean score gains, the increase in positive attitudes toward science was significantly greater for the hypermedia group (7.63) than it was for the traditional group (-2.48) and the control group (-.32). Examining the pretest and posttest differences, there were slight decreases in positive attitudes toward science for both the traditional and control group. Hence, the professional development workshop with hypermedia contributed to change in attitudes.

Research Hypotheses

Using the results from the data analysis, the research hypotheses findings will be presented. A discussion of the meaning, significance, and implications of the findings will be presented in Chapter 5.

Research Hypothesis #1

Hypothesis #1 of this study was there will be a significant difference in scores on the Project to Improve Elementary Science (PIES) Science Content Knowledge Test between the control group and the traditional group after the science inservice professional development workshops. A pairwise comparison indicated there was a significant difference ($p<.001$) between the control group and traditional group on science content knowledge. Therefore, this study fails to reject research hypothesis #1.

Research Hypothesis #2

Research hypothesis #2 of this study was there will be a significant difference in scores on the Project to Improve Elementary Science (PIES) Science Content Knowledge Test between the control group and the hypermedia group after the science inservice professional development workshops. A pairwise comparison indicated there was a significant difference ($p<.001$) between the control group and the hypermedia group. Therefore, this study fails to reject research hypothesis #2.

Research Hypothesis #3

Research hypothesis #3 of this study was there will be a significant difference in scores on the Project to Improve Elementary Science (PIES) Science Content Knowledge Test between the traditional group and the hypermedia group after a series of science inservice professional development workshops. A pairwise comparison indicated there was no significant difference ($p=.690$) between the traditional group and the hypermedia group. Therefore, this study rejects research hypothesis #3.

Research Hypothesis #4

Research hypothesis #4 of this study was there will be a significant difference in scores on the Science Attitude Scale between the control group and the traditional group after the science inservice professional development workshops. A Tukey HSD post-hoc pairwise comparison indicated no significant difference ($F_{1,57}=.767$, $p=.385$) between the control group and the traditional group. Therefore, this study rejects research hypothesis #4.

Research Hypothesis #5

Research hypothesis #5 of this study was there will be a significant difference in scores on the Science Attitude Scale between the control group and the hypermedia group after the science inservice professional development workshops. A Tukey HSD post-hoc pairwise comparison indicated a significant difference ($F_{1,57}=9.463$, $p=.003$) between the control group and the hypermedia group. Therefore, this study fails to reject research hypothesis #5.

Research Hypothesis #6

Research hypothesis #6 of this study was there will be a significant difference in scores on the Science Attitude Scale between the traditional group and the hypermedia group after the inservice professional development workshops. A Tukey HSD post-hoc pairwise comparison indicated a significant difference ($F_{1,57}=15.581$, $p<.001$) between the traditional group and the hypermedia group. Therefore, this study fails to reject research hypothesis #6.

Summary

The range and means of the pretest and posttest scores on both science content knowledge and attitudes toward science were analyzed in this study. In order to increase statistical power and to adjust for initial group differences, an analysis of covariance was the statistical procedure conducted on the data. The pretest scores provided baseline data for measures of science content knowledge and attitudes toward science. Tukey HSD post-hoc pairwise comparisons were conducted when either significant effects or effects approaching significance were present.

As a result of the participants' participation in a series of professional development workshops in science with or without hypermedia, it was expected there would be significant differences in science content knowledge increases between the control group and each of the experimental groups. Although both experimental groups addressed identical content, it was expected there would be a difference in increases in science content knowledge between the traditional treatment group and the hypermedia group. These expectations were not fully supported by the data analysis. While the ANCOVA indicated significant group main effects ($F_{1,57}$=11.444, p<.001), these were somewhat misleading as there were also significant interaction effects ($F_{1,57}$=6.679, p=.003, ES=.208). Pairwise comparisons indicated significant differences on the increase in science content knowledge between the control group and the traditional group (p<.001) and between the control group and the hypermedia group (p<.001). A pairwise comparison indicated no significant difference between the traditional group and the hypermedia group (p=.690). Implications of these results will be further discussed in Chapter 5.

Because of some participants' experiences in professional development in science utilizing hypermedia, it was expected there would be significant differences in the increases of positive attitudes toward science between the hypermedia group and the control group, between the hypermedia group and traditional group, and between the control group and the traditional group. The analysis of covariance values resulted in group main effects that approached significance ($F_{1,57}=2.980$, $p=.060$). Therefore, Tukey HSD post-hoc pairwise comparisons were performed. Tukey HSD pairwise comparisons indicated significant increases in positive attitudes toward science in the hypermedia group when compared to both the control group and the traditional group. There was no significant difference in increases in positive attitudes toward science for the control group and the traditional group. Implications of these results will be further discussed in Chapter 5.

CHAPTER 5
DISCUSSION

Introduction

Past research has indicated that a number of problems in the teaching of science in elementary classrooms are rooted in the preparation of inservice teachers (Ginns & Watters, 1998; Plourde, 2002). Two problems prevalent in the research include elementary teachers' lack of science content knowledge and negative attitudes toward science. As indicated by numerous research studies reporting positive results, one method of addressing these problems is through inservice teacher professional development workshops (Henson, 1987; Monk, 1994; Smith et al., 2002; Tilgner, 1990). Positive results of the professional development workshops include improved content knowledge (Kahle, 2000), increased attitudes toward specific content areas (Tilgner, 1990; Henson, 1987), increased confidence in teaching (Shrigley, 1977), and increased student achievement (Anderson & Smith, 1986; Monk, 1994). However, elementary science professional development workshops have not resulted in the same success levels as other subject areas. This study examined whether the integration of hypermedia into elementary science professional development workshops resulted in more positive outcomes than traditional methods of elementary science professional development workshops.

Review of the Study

Purpose

The aim of this study was to examine whether or not the integration of a hypermedia environment into a series of inservice professional development workshops would result in increases of elementary teachers' science content knowledge and more positive attitudes toward science. To accomplish this, two series of inservice science professional development workshops were conducted to address major topics in the elementary science curriculum. Both series of workshops were designed from a cognitive constructivist perspective and implemented a hands-on approach. They focused on the development of scientific content knowledge, as well as modeling a variety of pedagogical methods appropriate for effective elementary science instruction. While both series of workshops addressed the same content, one series of workshops included the integration of a hypermedia environment while the other series of workshops was conducted without the hypermedia environment. A control group receiving no treatment was used to measure and limit the effects of confounding variables.

Design of the Study

In this study, a non-equivalent control group quasi-experimental design was used (Affleck, Madge, Adams, & Lowenbraun, 1988; Campbell & Stanley, 1963). Each experimental group experienced three, two-hour professional development workshops conducted over a three-week period. Two measures, the Project to Improve Elementary Science (PIES) Science Knowledge Test (Zielinski & Smith, 1990) and the Science Attitude Scale for Inservice Elementary Teachers II (Shrigley & Johnson, 1974), were administered to the control group and each experimental group. They were given prior to the administration of the elementary science workshops and at the conclusion of the series of workshops.

Additional Data Collection

While the PIES Science Knowledge Test and Science Attitude Scale for Inservice Teachers II were administered as pretest and posttest measures, at the conclusion of the workshops, all participants also completed an evaluation of the professional development workshops. This evaluation form (see Appendix C) was provided by the Professional Development Department of the Duval County School Board and is required to be completed by all participants of all inservice professional development opportunities. Data from these evaluation forms was used in the discussion of the results related to each of the study's research questions.

Participants

A total of 57 inservice elementary teachers participated in this study. Participants were recruited from 21 schools in the northeast Florida school district of Duval County. Three groups, each consisting of 19 participants, were formed and included a control group and two experimental groups. The first experimental group experienced professional development workshops with hypermedia, and the second experimental group experienced professional development workshops without hypermedia. The control group received no treatment.

Research Questions

The following research questions and associated research hypotheses were addressed in this study:

Research Question 1. To what extent does the use of hypermedia during inservice professional development increase elementary teachers' understanding of elementary science concepts?

Hypothesis 1. There is no significant difference in scores on the PIES Science Knowledge Test between the control group and the traditional group after the inservice professional development workshop.

Hypothesis 2. There is no significant difference in scores on the PIES Science Knowledge Test between the control group and the hypermedia group after the inservice professional development workshop.

Hypothesis 3. There is no significant difference in scores on the PIES Science Knowledge Test between the traditional group and the hypermedia group after the inservice professional development workshops.

Research Question 2. To what extent does the use of hypermedia during inservice professional development influence elementary teachers' attitudes toward science?

Hypothesis 4. There is no significant difference in scores on the Science Attitude Scale between the control group and the traditional group after the inservice professional development workshop.

Hypothesis 5. There is no significant difference in scores on the Science Attitude Scale between the control group and the hypermedia group after the inservice professional development workshop.

Hypothesis 6. There is no significant difference in scores on the Science Attitude Scale between the traditional group and the hypermedia group after the inservice professional development workshop.

Research Question #1

The first question examined if and to what extent hypermedia influenced growth in science content knowledge when integrated into a professional development environment. The statistical analysis of the PIES Science Knowledge Test posttest using an analysis of covariance provided evidence of significant group main effects ($F_{1, 57}=11.444$, $p<.001$) and interactions between the pretest scores and the groups ($F_{1,57}=6.679$, $p=.003$) for science content knowledge. The results are interpreted in the following manner: While there was a significant difference in the increase in science content knowledge between the control group and the two experimental groups, there was no significant difference in the increase in content knowledge between the two experimental groups. Therefore, while the treatments resulted in statistically significant gains in science content knowledge as compared to the control group, there was no significant difference in the gains between the two types of treatments (hypermedia vs. no hypermedia). Also, increases in science content knowledge for each treatment group was somewhat dependent upon PIES Science Knowledge Test pretest scores. Traditional and hypermedia group members who entered the professional development setting with limited science content knowledge had the greatest increases in science content knowledge. Traditional and hypermedia group members who entered the professional development environment with higher PIES Science Knowledge Test pretest scores had smaller increases in science content knowledge.

It was also important to examine the extent to which the professional development workshops influenced changes in science content knowledge. To do this, the effect size for the science content knowledge data analysis was examined and indicated a practical significance (ES=.31) on the influence of the use of hypermedia in professional development workshops on science content knowledge (Bialo & Sivin-Kachala, 1996; Cohen, 1988). Exploring further, the mean score gains were greatest for the traditional group (3.31) and hypermedia group (3.01). As expected, there were negligible mean score gains in the control group (.48). In this study, the use of hypermedia in professional development workshops did not significantly contribute to an increase in science content knowledge.

Although study results show a negligible difference in the increase in science content knowledge between the two experimental groups, it should be noted that providing professional development workshops that demonstrate best practices in teaching and strong content contribute to increasing elementary teachers' science content knowledge. This finding supports other studies in the literature (Anderson, 1984; Kahle, 2000; Monk, 1994; Shrigley, 1977; Smith et al., 2002). In addition, a number of factors possibly contributed to and potentially hindered the effectiveness of both the traditional and hypermedia groups. These factors will be discussed in detail.

The first factor that contributed to positive gains in science content knowledge was the constructivist approach taken in designing and conducting the workshops. Comments by participants in both groups indicated the hands-on approach was more beneficial to them. One participant in the traditional workshop stated, "I liked being active and engaged instead of just listening to lectures." A member of the hypermedia group paralleled this statement in saying, "Hands-on experiments were very helpful in explaining concepts". The constructivist approach promoted the integration of the workshop content into participants' existing knowledge structures.

A second factor that positively influenced gains in science content knowledge was the variety of activities implemented in the workshops. Having numerous types of activities allowed participants to address topics and issues through a variety of methods. Activities such as small group discussions, whole group discussions, small group hands-on activities, and demonstrations promoted an active and collegial environment in the workshops, contributing to more significant gains in science content knowledge.

While a number of factors increased the extent of the influence of the hypermedia workshops on science content knowledge, a number of factors also inhibited more positive gains in science content knowledge. The first factor was the length of the study. As previously mentioned, each series of workshops was a total of six hours in length. Participants in both experimental groups commented on the brief length of the workshops. One participant in the traditional group noted, “The workshop was insightful and informative. I just wish it was longer. There is much more I need to learn!” A participant in the hypermedia group stated, “Each and every time I witness knowledgeable instructors ‘model’ the concepts with demonstrations, the more comfortable and excited I become regarding providing my students with in-depth instruction in science. Unfortunately, six-hours was not enough time to cover many of the subjects for my grade level.” This theme was common in other participants’ comments. With a longer series of workshops, it is expected there would be more significant differences in science content knowledge gains by the two experimental groups and possibly larger gains by the hypermedia group.

A second factor that may have hindered more positive gains in science content knowledge was the time of year in which the professional development workshops were conducted. All workshops took place during the last month of the 2004 school year. As a result, extraneous events that typically occur at the end of the school year may have obstructed more positive gains in science content knowledge. Also, because of the time of the year, participants may not have been completely focused on the content or may not have seen immediate results from the workshops. One participant commented, "I had a lot of fun with the experiments. They made me want to go back to school (referring to the fact that it was the end of the school year)." Another participant noted, "I wish we had this opportunity earlier in the year. I look forward to using some of these lessons next year."

A third factor that may have hindered more positive increases in science content knowledge was that the full benefits of hypermedia were not accessible to the hypermedia workshop participants. In order to control for confounding variables and to keep the study as sound as possible, participants in the hypermedia group had extremely limited access to the ELLIPS tool. Although this allowed the researcher to ensure that the access to content was consistent between the traditional and hypermedia groups, this may have hindered the effectiveness of the integration of hypermedia into the professional development environment. Participants saw value in the use of Elementary Level Lessons In Physical Science (ELLIPS), the hypermedia environment implemented in the study. One participant affirmed, "The ELLIPS program will be a lifesaver as I believe children learn best by seeing and doing. ELLIPS will provide an easy and effective way to utilize experiments in the classroom." Another participant stated, "With science textbooks and materials being very scarce in kindergarten, first, and second grade, by attending this workshop I am now able to teach science to my students without the need to borrow a teachers' manual from my colleague down the hall." It is expected that continuous access to the hypermedia environment used would have resulted in more positive increases in science content knowledge for the hypermedia group members.

Another factor that may have contributed to smaller increases in science content knowledge was the time of day in which the workshops were conducted. Workshops were held from 4:00 to 6:00 p.m., on a weekly basis. As a result, teachers were tired and most likely less focused on the content. This, coupled with the fact that the workshops were being conducted at the end of the school year, could have had a significant effect on the outcomes of the study.

In this study, the resulting lack of a significant difference in the increases in science content knowledge of the hypermedia group and the traditional group is important to note. Both groups, however, did have significantly greater increases in science content knowledge than the control group. Examining the statistical results, this study provides evidence that the integration of hypermedia into the professional development environment does not result in significantly smaller increases in science content knowledge. In other words, integrating hypermedia into the professional development environment can result in content knowledge increases that are at least equal to traditional professional development settings. This is important for a number of reasons. First, hypermedia environments have the potential to more adequately address individual needs of inservice teachers than traditional professional development settings. Second, one major goal of education, at any level, is the creation of new mental schemas that promote our ability to make sense of and adapt to changes in our world. According to Piaget (1971) and Vygotsky (1978), this is accomplished by interacting with our surrounding physical and social worlds. In a professional development environment, hypermedia allows this to be done more easily. Third, integrating hypermedia into professional development opportunities increases access to both professional development opportunities and teacher resources. In this study, for example, inservice teachers left the professional development setting with access to numerous lessons, content resources, and communication tools. Finally, integrating hypermedia into professional development environment promotes collaborative learning. According to Bruner (1961), Vygotsky (1978), and Piaget (1970), learners should not be isolated in the learning environment, but should be engaged in a dialogue. Integrating hypermedia into the professional development environment encourages dialogue and promotes a more meaningful learning environment (Spencer, 1991). Hence, while empirical researchers are still interested in statistical significance, it is still important to consider the educational importance of various instructional technologies and methods as well as the added value of the integration of technology into the learning environment (McIsaac & Gunawardena, 1996). In this study, integrating hypermedia into the professional development setting resulted in equivalent increases in science content knowledge as in the traditional professional development setting. However, the added value of integrating hypermedia into the learning environment offers promising reasons for providing elementary science professional development opportunities that include the integration of hypermedia.

Findings from this study illustrate that while professional development workshops resulted in increased knowledge of scientific concepts and processes, this increase was not dependent on the integration of hypermedia into the professional development setting.

As illustrated by the statistical analysis, there was no significant difference in the increase of science content knowledge between the two treatment groups. Yet there are indications that given certain circumstances, such as length of time of the workshop and full exposure to hypermedia applications, hypermedia environments could influence gains in science content knowledge in a positive manner.

Research Question #2

The second research question in this study examined if and to what extent hypermedia influenced positive attitudes toward science when integrated into professional development workshops. The analysis of covariance statistical analysis of the Science Attitude Scale for Inservice Elementary Teachers II posttest resulted in group main effects that approached significance ($F_{1,57}=2.980$, $p=.060$). As a result, Tukey HSD post-hoc pairwise comparisons were conducted. The results are interpreted in the following manner: Increases in positive attitudes toward science were dependent on the type of workshop (the treatment). There was no significant difference in the increases in positive attitudes toward science between the control group and the traditional group ($F_{1,57}=41.823$, $p=.385$). However, there was a significant difference in the increases in positive attitudes toward science between the hypermedia group and the control group ($F_{1,57}=9.463$, $p=.003$) and between the hypermedia group and the traditional group ($F_{1,57}=15.581$, $p<.001$). Although professional development workshops alone did not result in increased positive attitudes toward science, the integration of hypermedia into the professional development workshops did result in increased positive attitudes toward science.

To fully answer the second question, it is important to examine the extent to which the integration of hypermedia into professional development workshops influenced changes in attitudes toward science. To do this, the effect size for the attitudes toward science data analysis was examined and provided an indication of practical significance (ES=.78). Effect sizes of .78 are traditionally considered to be medium to large effects (Bialo & Sivin-Kachala, 1996; Cohen, 1988). This effect size not only shows the confidence in hypermedia's ability to improve attitudes toward science, but also the practical significance of this study. Examining individual changes in the pretest and posttest mean scores, the mean score gains were largest for the hypermedia group (7.63). Both the traditional group (-2.48) and the control group (-.32) resulted in decreases in mean score gains, indicating a reduction in positive attitudes toward science for these groups. Of the two experimental groups, only the hypermedia group experienced increases in positive attitudes toward science. Hence, we have a strong indication the integration of hypermedia into science professional development workshops played a part in increasing participants' attitudes toward science.

Throughout the study, a number of factors arose that potentially contributed to the effectiveness of the workshops at increasing the attitudes toward science of participants in the experimental groups. First, the constructivist approach in the design and implementation of the workshops could have influenced more significant increases in positive attitudes toward science. Participants from each experimental group commented that one of the more beneficial characteristics of the workshops was the "hands-on" approach and avoidance of the "lecture" approach to conducting the workshops.

The second factor that potentially contributed to the success of the workshops at increasing participants' attitudes toward science was the length of each workshop session. A number of participants from each treatment group noted they enjoyed the two-hour workshops as opposed to more traditional full-day workshops. While the time of day and time of school year in which the workshops were conducted contributed to smaller or no increases in positive attitudes toward science, the two-hour workshop sessions appeared to promote a more focused environment for participants.

Another factor that potentially contributed to more positive increases in attitudes toward science was the variety of instructional methods implemented throughout the workshops. A variety of activity types and instructional strategies were implemented and modeled in an effort to increase teacher engagement, focus, motivation, and participation. This could have played a significant role in counteracting a number of the factors that resulted in smaller increases in positive attitudes toward science.

A final factor that may have resulted in more positive attitudes toward science was the integration of teacher resources into the hypermedia workshops. Although access to the hypermedia environment was limited for the duration of the professional development workshops, participants in the hypermedia group used the tool throughout the workshops and were provided full access at the conclusion of the workshops. Participants in the traditional workshop took home their workshop book containing a multitude of resources. As a result of providing teacher resources in the professional development environment, teachers' attitudes toward science may have been improved.

While there were a number of issues that contributed to increases in positive attitudes toward science, there were also factors that could have inhibited gains in positive attitudes toward science. These factors included the length of the study, the time of year in which the study was conducted, limited access to the hypermedia environment, and the time of day in which the workshops were held.

First, the length of the study could have negatively influenced participants' attitudes toward science. Because the workshops totaled six hours, participants may have felt rushed to learn the content knowledge producing negative attitudes toward science. One participant noted, "More time would have been better," a theme that was common in participant comments.

A second factor that may have hindered an increase in attitudes toward science was the time of year in which the professional development workshops were held. As previously mentioned, all workshops were conducted toward the end of the academic school year. Because teachers are often tired and overwhelmed with end of the school year activities, the teachers may not have valued the workshops as much as if they had taken place earlier in the school year; hence, attitudes toward science could have been affected.

A third factor that may have resulted in diminished increases in positive attitudes toward science is that access to the hypermedia environment was limited throughout the study. While this was done to ensure equivalent access to content for the two experimental groups, this may have had negative influences on participants' attitudes toward science. For example, participants worked with a hypermedia tool in the workshop but were then denied full access to that tool when they left the professional development environment. Although there was an increase in positive attitudes toward science in the hypermedia group, this may have resulted in smaller increases in positive attitudes toward science than would have occurred if participants had full access to the tool.

Finally, the time of day in which the workshops were held may have contributed to smaller increases in positive attitudes toward science. Because the workshops were held at the end of the normal school day, teachers may have been both unfocused and tired. This factor potentially had a significant negative effect on the participants' attitudes toward science.

Contributions to the Body of Knowledge

This research may be especially significant to the fields of inservice science professional development and hypermedia.

Inservice Science Professional Development

Significant research indicates that professional development is beneficial to the development of for inservice teachers (Anderson & Smith, 1986; Henson, 1987; Shrigley, 1977; Smith et al., 2002; Tilgner, 1990). Two major areas addressed in the literature related to the benefits of professional development are the improvement of teacher content knowledge and attitudes toward particular subject areas (Anderson, 1984; Kahle, 2000; Klein et al., 1999; Monk, 1994). Yet research related to inservice science professional development has not shown the same positive results as other areas. This study, however, provided evidence of the effectiveness of inservice science professional development and its positive influences on both content knowledge and attitudes. More specifically, the results of this study provide support and rationale for the development of elementary science inservice professional development opportunities utilizing a cognitive constructivist approach.

This study also provided quantitative data illustrating the effectiveness of inservice science professional development at increasing elementary teachers' science content knowledge. While there were increases in participants' science content knowledge in both experimental groups, the effect of the professional development workshops, with respect to the integration of hypermedia, was small (ES=.31). As a result of the small increases in science content knowledge, a closer look was taken at constraining factors in the study. It was determined that longer, more appropriately timed workshops would provide more significant increases in content knowledge and attitudes toward science. This study also provided evidence that workshops should integrate more than six hours of professional development and should not be conducted within the last month of the school year.

As a result of negative attitudes being commonplace among elementary teachers, many studies have examined methods of improving elementary teachers' attitudes toward science (Bogut & McFarland, 1975; Kennedy, 1973; Stollberg, 1969). As with improving content knowledge, professional development workshops have been one method of improving attitudes toward science that has received a great deal of attention (Tilgner, 1990; Shrigley, 1977). This is because professional development workshops provide opportunities for elementary teachers to increase their content knowledge and teaching skills (Shrigley, 1977), hence increasing teachers' comfort level and attitudes. In this study, evidence was provided for effectiveness of integrating hypermedia environments into professional development workshops in improving elementary science teachers' attitudes toward science.

In conclusion, this study supported the ideas that elementary science inservice professional development opportunities, which can be developed from a cognitive constructivist approach, can increase elementary teachers' content knowledge. Also, integrating hypermedia into professional development settings can result in more positive attitudes toward science and potentially a gain in science content knowledge. This study indicates that the integration of hypermedia does not appear to decrease science content knowledge. This research also provides alternatives to traditional professional development workshops that are effective in increasing elementary science teachers' content knowledge and attitudes toward science.

Hypermedia

As a result of the increased use of hypermedia into teaching and learning environments, the benefits and constraints of hypermedia have become common themes in the body of literature related to hypermedia. The results of this study complement other studies that suggest the integration of hypermedia into the learning environment results in more positive attitudes toward science (Bogut & McFarland, 1975; Kahle, 2000; Kennedy, 1973; Stollberg, 1969). Further, this study provided evidence that the integration of hypermedia into a structured learning environment (professional development workshops) can diminish the experiential constraints of hypermedia, such as inexperience with the content or the hypermedia application, on improving attitudes. The results of greater increases in attitudes toward science with the integration of hypermedia into professional development workshops are promising. These results provide preliminary evidence that hypermedia can be a powerful tool in the professional development of inservice elementary teachers of science.

Implications for Inservice Science Professional Development

The results of this study provide evidence that integrating hypermedia into professional development workshops, while not necessarily effective at increasing elementary teachers' science content knowledge more than traditional professional development workshops, can be effective at increasing positive attitudes toward science.

As a result, this study provides a number of implications for educators involved in providing inservice elementary science professional development opportunities in the area of teaching science in the elementary curricula.

First, the results of this study suggest that professional development workshops short in duration are not as effective in increasing content knowledge. In this professional development environment, it was evident that having only three two-hour workshops limited the effectiveness on the gain in content knowledge. While there were significant increases in the science content knowledge of both experimental groups, the increases were small. This idea was also supported by participant comments such as, "More time would have been better." Increasing the duration of professional development workshops would potentially increase their effectiveness at improving science content knowledge. This idea that change takes time and is a process also complements other research findings on change (Ely, 1990; Fullan & Stiegelbauer, 1991; Hall, 1974; Rogers, 1995).

Study findings also suggest that the time of year in which the opportunities are conducted could be a second factor that influences the effectiveness of professional development workshops is the time of year in which the opportunities are conducted. It was apparent throughout this study that teachers were less focused and less motivated in the workshops. Because the workshops were offered at the end of the academic year, teachers potentially had difficulty seeing the immediate benefit of the knowledge they were gaining. This suggests that it is important to schedule workshops at the time of year in which teachers can immediately utilize the information they obtain in the professional development environment. This implication meshes with one of the tenets in Knowles's (1970) theory of adult learning.

Third, this study suggests that teachers enjoy having access to tools and resources that will assist them in the classroom as a product of their professional development opportunities. In this study, the hypermedia environment utilized had a number of characteristics teachers found beneficial. These included a collection of searchable lessons, teacher content resources, lesson reviews, and a discussion board. Therefore, teachers find professional development environments that provide useful resources as more engaging and useful. This was illustrated by a number of comments regarding the ELLIPS hypermedia environment. These included, "The website is a wonderful resource," "The web site will be helpful in planning lessons for next year, now that I understand the third grade curriculum a little bit more," and "The ELLIPS program will be a lifesaver." Participants in the traditional workshop had printed materials that could be used as a resource in the classroom and provided positive statements about their usefulness. These comments suggest that professional development workshops can potentially be more effective by providing participants with practical resources that will enhance their classroom.

Data in this study did not specifically examine aspects of the hypermedia environment that teachers found most beneficial. However, from workshop reviews and comments, it can be inferred that participants enjoyed participating in a professional development opportunity that used a hypermedia environment and leaving the workshop with a resource that can be utilized when teaching science. Knowing that integrating hypermedia into the elementary science professional development settings can result in increased positive attitudes toward science, educators who develop professional development opportunities should consider hypermedia as an effective option.

Recommendations for Future Research

The goal of this study was to investigate the effects of integrating hypermedia into elementary science professional development workshops on science content knowledge and attitudes toward science. The results of this study provide some encouraging results, but also lead to new questions. Because random assignment was not possible in this study groups could have been different on variables, such as teaching experience and hypermedia experience, other than the covariates. Hence, the need for further research. Based on this idea, as well as the limitations and findings for this study, the following are suggestions for future research.

One of the delimitations of this study was that there were no measures of the effectiveness of the teachers' growth in terms of their students' achievement. As a result, it would be beneficial to further study whether or not the increases in science content knowledge and positive attitudes toward science by teachers influence student achievement. Measures of student achievement would provide information on whether or not integrating hypermedia into the professional development setting influenced teacher behaviors in the classroom. More importantly, measures of student achievement would provide information on whether or not increases in teacher content knowledge and attitudes toward science influence student performance in elementary science.

Another limitation of this study was there were no measures of treatment effects over time. It would be beneficial to administer the measures of science content knowledge and attitudes toward science at various time intervals in the future in an attempt to examine the sustained effects of integrating hypermedia into elementary science professional development workshops. This would also assist in determining whether or not initial increases in content knowledge and positive attitudes toward science were superficial or substantial.

The structured settings of workshops may not provide environments that are conducive to the strengths of hypermedia. One of the tenets of hypermedia is the user controls his own learning. In some professional development workshops, this is difficult to attain. Therefore, research on the integration of hypermedia into less structured professional development settings might result in more positive increases in science content knowledge and greater increases in positive attitudes toward science.

Another beneficial research strand would be the examination of which characteristics of hypermedia result in greater teacher and student growth. For example, a variety of hypermedia tools were used in the study. These included a variety of lesson searches, a discussion board, teacher content resources, and a lesson review feature. These characteristics were integrated into the hypermedia environment in an effort to address problems in elementary science education. However, future research should examine which aspects of hypermedia have the greatest influence on increases in teachers' science content knowledge, positive attitudes toward science, and ultimately student achievement.

Summary

This non-equivalent control group quasi-experimental study consisted of a total of 57 inservice elementary teachers participating in one of three groups: a control group and two experimental groups (one with and one without hypermedia). Each experimental group participant underwent three two-hour workshops aimed at improving inservice teachers' science content knowledge and positive attitudes toward science. This study found that those workshops that integrated hypermedia into the professional development environment resulted in a significant increase in inservice elementary teachers' science content knowledge. When compared to the control group, there was a significant difference in increases of science content knowledge. When compared to the experimental group that participated in workshops without hypermedia, however, there was no significant difference in increases of science content knowledge. This study also attempted to determine whether or not integrating hypermedia professional development workshops had a positive effect on inservice elementary teachers' attitudes toward science. It was found there were significant increases in teacher attitudes toward science in the hypermedia group when compared to both the control group and the traditional workshop group.

The results of this study complement other studies that have suggested the integration of hypermedia into the learning environment results in more positive attitudes toward science (Bogut & McFarland, 1975; Kahle, 2000; Kennedy, 1973; Stollberg, 1969). The results of greater increases in attitudes toward science with the integration of hypermedia into the professional development workshops are promising. They provide preliminary evidence that hypermedia can be a powerful tool in the professional development of inservice elementary teachers of science. Although there were limiting factors present in this study, the findings of this study are encouraging and provide a sound basis for future research regarding the integration of hypermedia into professional development environments.

APPENDIX A
SCIENCE ATTITUDE SCALE FOR INSERVICE ELEMENTARY TEACHER II

Directions: This is not a test. You are to indicate your feelings toward the subject of science and the teaching of science. You may react to the statements in one of five ways.

A: Strongly Agree
B: Agree
C: Undecided
D: Disagree
E: Strongly Disagree

Please mark your choice on the answer sheet.

Statements:

1. As a teacher, I am afraid that science demonstrations will not work.
2. I enjoy discussing science topics with fellow teachers.
3. If I had time, I would like to attend an elementary science workshop during the summer.
4. If I were to enroll in a college science course, I would enjoy the laboratory periods of the course.
5. I am afraid that I do not have enough background to teach science adequately.
6. If I were to return to college for additional graduate work, I would enroll in at least one science course.
7. I enjoy manipulating science equipment.
8. I believe science is too difficult for me to learn.
9. I would like to have a desk barometer that measures air pressure.
10. I would like to work with the science consultant on my science program.

11. Most science equipment confuses me.
12. I enjoy constructing simple equipment.
13. I would not enjoy working in a science laboratory for a summer.
14. I enjoy science courses.
15. I would enjoy participating in a science inservice program in my school district.
16. I eagerly anticipate the teaching of science to elementary school children.
17. Science is my favorite subject.
18. If I were to enroll in any college science course, I would likely be bored.
19. I prefer teaching science over any other subject of elementary school.
20. I would not like to keep a hamster in my classroom.
21. In a departmental situation or similar situation, I would like to be responsible for teaching all of the science.
22. I am apprehensive about anything that is associated with science.
23. I would read an issue of the professional journal, *Science and Children*, if it were in the teacher's room.
24. I would be interested in working in an experimental science curriculum project.
25. If given a choice in professional improvement, I would choose any area but science.
26. I would prefer to be a team leader in any curriculum area but science.

APPENDIX B
PROGRAM TO IMPROVE ELEMENTARY SCIENCE (PIES) SCIENCE KNOWLEDGE TEST

Directions: For each of the questions below, blacken in the correct answer on the enclosed answer sheet.

Questions 1-5: The following story is broken into numbered segments. Each of the numbered statements refers to one of the science process skills lettered A, B, C, D, & E. For each of the numbered statements, blacken in the letter of correct science process skill onto the answer sheet.

(1) John and Mary were walking in the forest looking at the leaves on the trees. Mary noticed the leaves possessed a wide variety of shapes.

(2) John said to Mary, I think these trees are different species. Mary began to assemble leaves from each of the trees into a pile. She counted the number of points on each

(3) leaf and placed it into a pile according to the shape and number of points on each of the leaves.

(4) John drew a sketch of each type of leaf and wrote down the number of leaves in each of the piles.

(5) "I believe we need to determine the size of the area we just observed," John said.

A. Recording data
B. Measuring
C. Inferring
D. Observing
E. Classifying

Questions 6-10: The story continues. Each of the numbered statements below refers to one of the science process skills lettered A, B, C, D, E, for each of the numbered statements, blacken in the letter of correct science process skill onto the answer sheet.

(6) Mary said, "I think that if we move to another part of the forest, we will see the same kinds of leaves on the trees."

(7) We need to insure that all of the conditions of the first investigation are repeated exactly in the second experiment.

(8) Mary said she thought they could find out if forests everywhere were similar. All they need to do is write a procedure which controls the variables necessary to determine whether there is support for the hypothesis that all forests are the same.

(9) They went to another part of the forest, constructed a hypothesis, designed and conducted an investigation to demonstrate whether or not the hypothesis was acceptable.

(10) John said, "Let's write a report so everyone can learn about the trees in this forest."

A. Experimenting
B. Controlling variables
C. Predicting
D. Communicating
E. Designing experiments

11-20: Please choose the best answer and "blacken it in" on the answer sheet.

11. A simple machine can be used to

A. store energy
B. gain work from the operation of a small force
C. change the direction of a force.
D. increase energy put into it.

12. A drinking glass containing water and ice is placed on a table in a warm room. After a time during which the glass remains untouched, droplets of moisture can be seen on the outside surface of the glass below the water line. The most likely explanation for the appearance of moisture on the outside of the glass is

A. the water has come out through the glass, something like osmosis in plants.
B. the ice in the water has cooled the glass below the dewpoint of the surrounding air.
C. the water from inside the glass has moved over the edge of the glass by capillary action.
D. transpiration has occurred due to uneven cooling and heating.

13. When you see a brown-eyed person, his/her eye color is caused by

A. reflection of light from the iris of the eye.
B. refraction of light by the lens of the eye.
C. emission of blue light by the iris.
D. diffraction of light through the pupil of the eye.

14. A boy some distance up the railroad track from a workman holds his ear to the rail and listens to the workman drive spikes. He notes that he hears the sound of each blow twice and correctly decides it is because

A. part of the wave is reflected between the rails.
B. longitudinal and transverse waves have different speeds.
C. the speed of sound is greater in air than in a solid.
D. the speed of sound is greater in a solid than in air.

15. Of the following, the ultimate source of all food in a freshwater pond is/are the

A. microscopic green plants.
B. minnows, aquatic insects and mollusks.
C. large fish.
D. bacteria and fungi.

16. Water (150 g.) at 80 degrees Celsius is added to 150 g. of water at 20 degrees Celsius resulting in a beaker containing 300 g. of water. The best predicted temperature of the 300 g. of water would be

A. 100 degrees Celsius.
B. 60 degrees Celsius.
C. 50 degrees Celsius.
D. 40 degrees Celsius.

17. Air expired from human lungs usually contains

A. approximately the same amount of nitrogen as is present in inhaled air.
B. practically no oxygen.
C. less carbon dioxide than is present in inhaled air.
D. less water vapor than is present in inhaled air.

18. During the summer (approximately June 21 to September 21) in Pennsylvania, the noon shadow of a flagpole in a schoolyard will

A. be shortest half way through the summer period.
B. be longest half way through the summer period.
C. lengthen as the summer goes on.
D. shorten as the summer goes on.

19. An acidic substance can be distinguished from a basic substance by bringing the substance into contact with

A. filter paper.
B. vinegar.
C. iodine
D. litmus paper.

20. Which of the following has the largest mass?

A. 1 kg of feathers.
B. 1 lb. of feathers.
C. 1 lb. of gold.
D. 100 g. of gold.

21. Which of the following is an example of a chemical change?

A. Rust on a bike.
B. An Alka-Seltzer tablet in H_2O.
C. Fermentation of fruit juice.
D. All of the above.

22. A student is given a graduated cylinder containing 200 ml. of water. The student is also given a 4-cm3 sphere of aluminum and an equal size sphere of lead. The student gently lowers the aluminum sphere into the flask and observes the water level to be 204 ml. How much additional rise will occur in the water level when the lead sphere is lowered into the cylinder?

A. 4 ml. B. 6 ml. C. 8 ml. D. 16 ml.

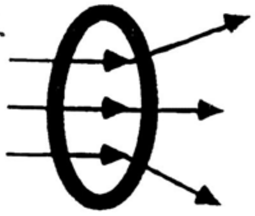
23. Which of the following <u>best</u> describes an inquiry or discovery investigation?

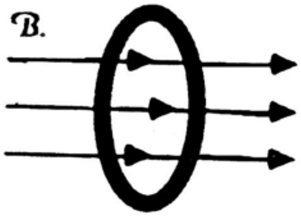
A. The teacher discusses the results that should be obtained by performing a certain investigation.
B. The teacher describes the step-by-step procedure that should be followed in performing an investigation.
C. The student performing the experiment does not know the outcome of the investigation until it is completed.
D. The student used the library to determine results by others who performed the same investigation.

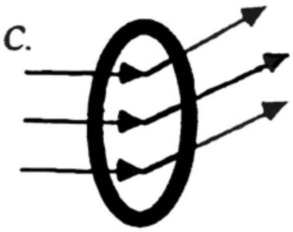
24. A child is given a closed show box containing an unknown object. He/She is directed to manipulate the box, using their senses to acquire some information about the object. They are further instructed to try to draw a picture of what they think the object is. This lesson is best designed to develop skill in

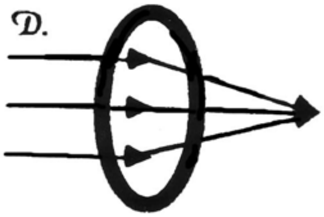
A. measuring and observing.
B. observing and data collecting.
C. observing and inferring.
D. data collecting and measuring.

25. Which of the following diagrams show the expected path of light rays passing from air into and through a convex (glass) lens?

A.


B.


C.


D.


APPENDIX C
EVALUATION OF INSERVICE ACTIVITY

Component Number: ____________ Instructor of Activity: _________________

Component Title: _________________________________ Date: __________

DIRECTION: The information requested on this form is used to evaluate the effectiveness of this inservice activity and is required as supportive data for future implementation of this component. If the answers provided do not reflect your opinion, or if you wish to add response, use the space provided for comments.

1. Were the objectives stated?

Yes_____ No_____ Comments: ____

____

2. Is the length of this component adequate for completion of the objectives?

Yes_____ No_____ Comments: ____

____

3. Were the materials used appropriate for the objectives?

Yes_____ No_____ Comments: ____

____

4. Did the consultant(s) and/or instructor(s) exhibit in-depth knowledge of the subject matter covered during this component?

Yes_____ No_____ Comments: ____

____

5. Was the method of instruction effective?

Yes_____ No_____ Comments: ____

____

6. Was the component, as presented, applicable to your area of instruction and/or your special interest?

Yes_____ No_____ Comments: ____

____

ADDITIONAL COMMENTS:

APPENDIX D
SCHEDULE/OUTLINE OF PROFESSIONAL DEVELOPMENT WORKSHOPS

Week 1: Workshop #1

Pretests: Science Attitude Scale & PIES Science Content Knowledge Test

Activity 1 Pre-structuring: Discussion, providing background knowledge and activity directions.

Activity 1: Kinematics: The Study of Motion Without Regard for Mass or Force.

Sunshine State Standards:

Strand C: Force and Motion

Standard 1: The student understands that types of motion may be described, measured, and predicted.

Benchmark SC.C.1.2.1: The student understands that the motion of an object can be described and measured.

Strand H: The Nature of Science

Standard 1: The student uses the scientific processes and habits of mind to solve problems.

Benchmark SC.H.1.2.1: The student knows that it is important to keep accurate records and descriptions to provide information and clues on causes of discrepancies in repeated experiments.

Benchmark SC.H.1.2.2: The student knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.

Benchmark SC.H.1.2.3: The student knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.

Standard 2: The student understands that most natural events occur in comprehensible, consistent patterns.

Benchmark SC.H.2.2.1: The student knows that natural events are often predictable and logical.

Benchmark SC.H.3.2.2: The student knows that data are collected and interpreted in order to explain an event or concept.

Activity 2 Pre-structuring: Discussion, providing background knowledge and activity directions.

Activity 2: Acceleration: The Act of Changing Velocity.

Sunshine State Standards:

Strand C: Force and Motion

Standard 1: The student understands that types of motion may be described, measured, and predicted.

Benchmark SC.C.1.2.1: The student understands that the motion of an object can be described and measured.

Standard 2: The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted.

Benchmark SC.C.2.2.2: The student knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.

Benchmark SC.C.2.2.4: The student knows that the motion of an object is determined by the overall effect of all of the forces acting on the object.

Strand H: The Nature of Science

Standard 1: The student uses the scientific processes and habits of mind to solve problems.

Benchmark SC.H.1.2.1: The student knows that it is important to keep accurate records and descriptions to provide information and clues on causes of discrepancies in repeated experiments.

Benchmark SC.H.1.2.2: The student knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.

Benchmark SC.H.1.2.3: The student knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.

Benchmark SC.H.1.2.4: The student knows that to compare and contrast observations and results is an essential skill in science.

Standard 2: The student understands that most natural events occur in comprehensible, consistent patterns.

Benchmark SC.H.2.2.1: The student knows that natural events are often predictable and logical.

Wrap-up (Post-discussion of activities):

Themes of discussion:

- Sunshine State Standards and integrating them into lessons
- Teacher content knowledge and knowledge of pedagogy
- Instructional Strategies (modeled and discussed: inquiry-based)
- The Nature of Science
- Developing a Community of Practice

Homework: Reflect upon today's activities: How could these activities/topics be implemented into the elementary classroom.

Week 2: Workshop #2

Discussion: The implementation of week 1 activities in the elementary classroom (homework).

Activity 1 Pre-structuring: Discussion, providing background knowledge and activity directions.

Activity 1: Mass: The Quantity of Matter Contained in an Object (A Measure of Its Inertia).

Sunshine State Standards:

Strand C: Force and Motion

Standard 1: The student understands that types of motion may be described, measured, *and predicted.*

Benchmark SC.C.1.2.1: The student understands that the motion of an object can be described and measured.

Benchmark SC.C.2.2.2: The student knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.

Standard 2: The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted.

Benchmark SC.C.2.2.1: The student recognizes that forces of gravity, magnetism, and electricity operate simple machines.

Benchmark SC.C.2.2.2: The student knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.

Benchmark SC.C.2.2.3: The student knows that the more massive an object is, the less effect a given force has.

Benchmark SC.C.2.2.4: The student knows that the motion of an object is determined by the overall effect of all of the forces acting on the object.

Strand H: The Nature of Science

Standard 1: The student uses the scientific processes and habits of mind to solve problems.

Benchmark SC.H.1.2.2: The student knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.

Benchmark SC.H.1.2.3: The student knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.

Benchmark S.H.1.2.4: The student knows that to compare and contrast observations and results is an essential skill in science.

Benchmark SC.H.1.2.5: The student knows that a model of something is different from the real thing, but can be used to learn something about the real thing.

Standard 2: The student understands that most natural events occur in comprehensible, *consistent patterns.*

Benchmark SC.H.2.2.1: The student knows that natural events are often predictable and logical.

Activity 2: Simple Electricity: "Static and Current".

Sunshine State Standards:

Strand A: The Nature of Matter

Standard 2: The student understands the basic principles of atomic theory.

Benchmark SC.A.2.2.1: The student knows that materials may be made of parts too small to be seen without magnification.

Strand B: Energy

Standard 1: The student recognizes that energy may be changed in form with varying efficiency.

Benchmark SC.B.1.2.2: The student recognizes various forms of energy (e.g., heat, light, and electricity).

Benchmark SC.B.1.2.5: The student knows that various forms of energy (e.g., mechanical, chemical, electrical, magnetic, nuclear, and radiant) can be measured in ways that make it possible to determine the amount of energy that is transformed.

Strand H: The Nature of Science

Standard 1: The student uses the scientific processes and habits of mind to solve problems.

Benchmark SC.H.1.2.2: The student knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.

Benchmark SC.H.1.2.3: The student knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.

Benchmark SC.H.1.2.4: The student knows that to compare and contrast observations and results is an essential skill in science.

Benchmark SC.H.1.2.5: The student knows that a model of something is different from the real thing, but can be used to learn something about the real thing.

Standard 2: The student understands that most natural events occur in comprehensible, consistent patterns.

Benchmark SC.H.2.2.1: The student knows that natural events are often predictable and logical.

Standard 3: The student understands that science, technology, and society are interwoven and interdependent.

Benchmark SC.H.3.2.1: The student understands that people, alone or in groups, invent new tools to solve problems and do work that affects aspects of life outside of science.

Benchmark SC.H.3.2.2: The student knows that data are collected and interpreted in order to explain an event or concept.

Wrap-up (Post-discussion of activities):

Themes of discussion:

- Sunshine State Standards and integrating them into lessons
- Teacher content knowledge and knowledge of pedagogy
- Instructional Strategies (modeled and discussed: inquiry-based)
- The Nature of Science
- Developing a Community of Practice

Homework: Reflect upon today's activities: How could these activities/topics be implemented into the elementary classroom?

Week 3: Workshop #3

Discussion: The implementation of week 2 activities in the elementary classroom (homework).

Activity 1 Pre-structuring: Discussion, providing background knowledge and activity directions.

Activity 3 Pre-structuring: Discussion, providing background knowledge and activity directions.

Activity 3: Waves and Wave Properties.

Sunshine State Standards:

Strand A: The Nature of Matter

Standard 1: The student understands that all matter has observable, measurable properties.

Benchmark SC.A.1.2.1: The student determines that the properties of materials (e.g., density and volume) can be compared and measured (e.g., using rulers, balances, and thermometers).

Strand B: Energy

Standard 1: The student recognizes that energy may be changed in form with varying efficiency.

Benchmark SC.B.1.2.2: The student recognizes various forms of energy (e.g., heat, light, and electricity).

Benchmark SC.B.1.2.5: The student knows that various forms of energy (e.g., mechanical, chemical, electrical, magnetic, nuclear, and radiant) can be measured in ways that make it possible to determine the amount of energy that is transformed.

Standard 2: The student understands the interaction of matter and energy.

Strand C: Force and Motion

Standard 1: The student understands that types of motion may be described, measured, and predicted.

Benchmark SC.C.1.2.1: The student understands that the motion of an object can be described and measured.

Benchmark SC.C.1.2.2: The student knows that waves travel at different speeds through different materials.

Strand H: The Nature of Science

Standard 1: The student uses the scientific processes and habits of mind to solve problems.

Benchmark SC.H.1.2.2: The student knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.

Benchmark SC.H.1.2.3: The student knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.

Benchmark SC.H.1.2.4: The student knows that to compare and contrast observations and results is an essential skill in science.

Benchmark SC.H.1.2.5: The student knows that a model of something is different from the real thing, but can be used to learn something about the real thing.

Standard 2: The student understands that most natural events occur in comprehensible, consistent patterns.

Benchmark SC.H.2.2.1: The student knows that natural events are often predictable and logical.

Standard 3: The student understands that science, technology, and society are interwoven and interdependent.

Benchmark SC.H.3.2.2: The student knows that data are collected and interpreted in order to explain an event or concept.

Activity 2 Pre-structuring: Discussion, providing background knowledge and activity directions.

Activity 2: Simple Machines.

Sunshine State Standards:

Strand B: Energy

Standard 1: The student recognizes that energy may be changed in form with varying efficiency.

Benchmark SC.B.1.2.2: The student recognizes various forms of energy (e.g., heat, light, and electricity).

Benchmark SC.B.1.2.5: The student knows that various forms of energy (e.g., mechanical, chemical, electrical, magnetic, nuclear, and radiant) can be measured in ways that make it possible to determine the amount of energy that is transformed.

Strand C: Force and Motion

Standard 1: The student understands that types of motion may be described, measured, *and predicted.*

Benchmark SC.C.1.2.1: The student understands that the motion of an object can be described and measured.

Standard 2: The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted.

Benchmark SC.C.2.2.1: The student recognizes that forces of gravity, magnetism, and electricity operate simple machines.

Benchmark SC.C.2.2.2: The student knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.

Benchmark SC.C.2.2.3: The student knows that the more massive an object is, the less effect a given force has.

Benchmark SC.C.2.2.4: The student knows that the motion of an object is determined by the overall effect of all of the forces acting on the object.

Strand H: The Nature of Science

Standard 1: The student uses the scientific processes and habits of mind to solve problems.

Benchmark SC.H.1.2.2: The student knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.

Benchmark SC.H.1.2.3: The student knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.

Benchmark SC.H.1.2.4: The student knows that to compare and contrast observations and results is an essential skill in science.

Standard 2: The student understands that most natural events occur in comprehensible, consistent patterns.

Benchmark SC.H.2.2.1: The student knows that natural events are often predictable and logical.

Activity 3 Pre-structuring: Discussion, providing background knowledge and activity directions.

Wrap-up (Post-discussion of activities):

Themes of discussion:

- Sunshine State Standards and integrating them into lessons
- Teacher content knowledge and knowledge of pedagogy
- Instructional Strategies (modeled and discussed: inquiry-based)
- The Nature of Science
- Developing a Community of Practice

Posttests: Science Attitude Scale & PIES Science Content Knowledge Test

APPENDIX E
PROFESSIONAL DEVELOPMENT WORKSHOP ACTIVITIES

Activity 1:
Kinematics: The Study of Motion Without Regard for Mass or Force.

Can you define the word “motion” without using some form of the word "move"?

How can you measure a runner's speed?

Does running twice as far take twice as much time?

- We will measure off a track by placing marks at 0-, 5-, 10-, 15-, and 20-m.
- We will place a participant, with a stopwatch, at the 5-, 10-, 15-, and 10-m marks.
- A runner will be asked to traverse the assigned course.
- A starter will give a starting signal, such as, "Ready, Set, Go!"
- All watches should be started on the "Go" signal and each successive watch stopped as the runner passes the timer’s position.
- Produce a table to record the times it takes the runner to reach each mark.
- Calculate the time taken to run each 5-m interval and record this in your table. (This is called the “split time”). Use the equation $t = t2 - t1$. the symbol "Δ" means "the change in." Of course, "t" means time.
- Calculate the average speed during each 5-m interval. Use the equation: Average speed = Distance traveled/Time taken.
- Record the average speed during each 5-m interval in your table.

**The material for this activity was taken from "It's About Time,” "Active Physics,” "Sports."

Activity 2:
Acceleration: The Act of Changing Velocity

In this activity you will build and use an accelerometer. There are many different types of accelerometer, however, the one you will make today is called an "Inertial Accelerometer."

- To build the accelerometer, begin by hot gluing a short piece of thread (about 15 cm.) to the inside of the cap from a 1/2 liter water bottle. To the other end of the thread attach a small fishing cork. Fill the bottle with water and carefully insert the cork and thread into the bottle, screw on the top and invert the bottle. The cork should float freely at the end of the string. You now have an accelerometer.

- Take the accelerometer for a walk. Observe any movement of the cork, especially as you start from a resting position and speed up (accelerate). Walk at a fairly constant speed, and then slow down to a stoop (decelerate). Try it a few times--starting, walking, and stopping at normal rates.

- Repeat the above walk and observe what happens if you start faster, if you walk faster at a constant speed, and if you stop faster.

- Repeat the walk above, but walk backward.

- Using your observations from your "walks," describe the amount and the direction the cork leans in each of the following situations:

    1. standing at rest
    2. low acceleration while walking forward
    3. high acceleration while walking forward
    4. low constant speed while walking forward
    5. high constant speed while walking forward
    6. high deceleration (slowing down) while walking forward
    7. low deceleration while walking forward
    8. rotating slowly at a constant speed
    9. rotating quickly at a constant speed

What do you see as the cause of the acceleration? What relationship do you observe between the cause and the acceleration?

The relationship between acceleration, speed, and time can be written as:

Acceleration = Change in speed/Time interval or $a = \Delta v/\Delta t$

**The material for this activity was taken from "It's About Time," "Active Physics," "Sports."

Activity 3:
Mass:
The Quantity of Matter Contained In An Object.
(A Measure of Its Inertia)

Weight:
A Force Produced On An Objects Mass Due to Gravity.

Gravity:
The Attractions Between Masses.

If an object has a mass of 1 kg on Earth, what would be its mass on the moon?

If a 1 kg object weighs about 10 Newtons on Earth, what would be its weight on the moon?

We have prepared a number of plastic bottles labeled "1 kg Earth," and "1 kg Moon." To keep the simulation accurate and realistic, follow the rules below:

- Leave the bottles lying on their sides on the table; do not stand the bottles upright.
- You may move the bottles only by rolling them; do not lift the bottles.

Using the bottle labeled "1 kg Earth" roll the bottle back and forth with a partner across the table. Do this until you and your partner have the "feel" of the pushing force needed to accelerate and decelerate the "1 kg Earth" bottle.

Now change to the bottle marked "1 kg Moon" and do the same task.

- Based on your observations, how does the amount of force needed to accelerate a 1-kg mass on Earth compare to the amount of force needed to accelerate a 1-kg object by the same amount on the moon? Is the amount of force needed to produce equal accelerations significantly different or about the same?
- Keeping in mind Newton's Second Law, F=ma, if equal forces applied to two objects produce equal accelerations of the objects, what else must be equal about the objects?

Grasp the string attached to the bottle labeled "1 kg Earth" and lift the bottle vertically. Get the "feel" of the downward gravitational pull of the Earth on the bottle and then carefully lower it back to the table to rest in a vertical upright position. Attach a spring scale to the bottle and determine its weight in Newtons. Lower the bottle to the table as before.

Repeat the same steps for the bottle marked "1 kg Moon."

Divide the weight of the Earth bottle by the weight of the moon bottle. What is the ratio as an integer?

Why do you think the weights of equal masses, one on the Earth and one on the moon, are different?

To satisfy the two simulations, it may have been necessary to "fake" some of the bottles. Which bottles, if any, do you think were faked? Why and how?

**The material for this activity was taken from "It's About Time," "Active Physics," "Sports."

Activity 4:
Simple Electricity: "Static and Current"

Most people assume electrons to be safely contained within the atom, however, infinite numbers of them are freely and happily living on the surface of everything you see or touch.

How do we know? Have you ever walked across a carpet, touched a metal object or another person and felt a shock? If so, you experienced the movement of free electrons in what is known as "static discharge." Static discharge can occur in small or very large amounts (lightning). As far as practical usage of static electricity as a form of energy is concerned the outlook is doubtful. The discharge rate is too fast and collection and storage are prohibitive.

Current electricity, on the other hand, is quite practical. The simplest way to study current electricity is through batteries and simple circuitry.

Let's Build a Simple Battery.

A battery is a very simple device. All that is needed are two dissimilar metals. Some metals have a tendency to take on electrons, while others tend to release them. This tendency is defined by the electro-negativity of the metal. Metals, such as zinc, have a decided tendency to release electrons. Other metals, like copper, tend to collect or receive electrons, As a result, electrons would pass from the zinc to the copper, giving the zinc a positive charge and the copper a negative charge. A battery is born.

When bringing the two metals into contact will "do the trick,” the efficiency of the system would be very low. We much make sure to increase the surface contact area in some way. The easiest way is to introduce a liquid solution, which is conductive, between the metals in question. An acid or alkaline solution is what is needed. Fruit or root vegetables will do a great job of supplying the required liquids.

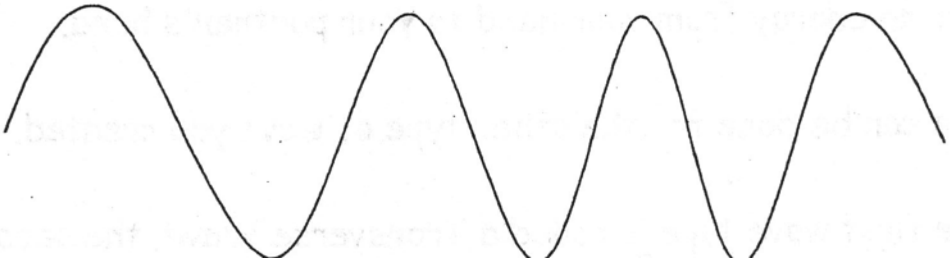
- To build a lemon cell, simply insert a piece of heavy gauge copper wire (#12 or larger) into one end of the fruit and an iron nail into the other. The lemon cell should produce voltage at this point.
- Using a voltmeter, test your cell to determine its output.
- Let’s try this with a variety of fruits and vegetables. Build a battery with each fruit at your station and measure its voltage. Record your group’s values on the chart at the front of the room.

Putting your cells in series should increase the voltage. Try it and see if it works.

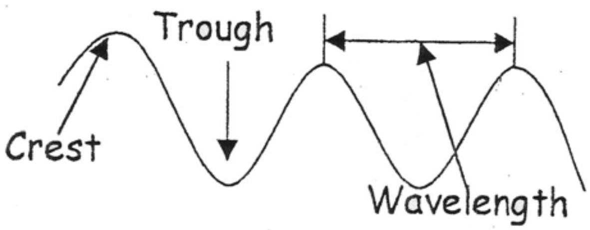
Activity 5:
Waves and Wave Properties

We will be using a slinky to help us simulate two different types of waves.

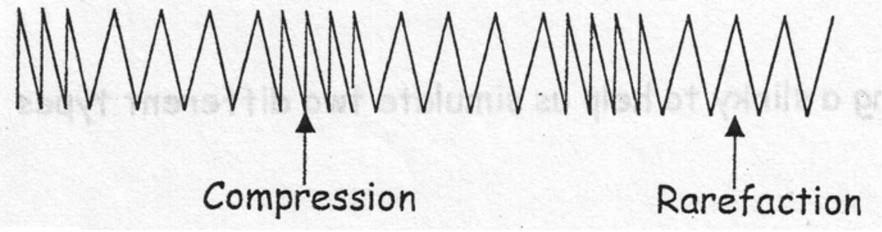
- Stretch your slinky out on a flat surface, such that the ends are about two meters apart.
- Mark the ends of the slinky on the surface with tape.
- Using your hand, snap the slinky side ways about 20-cm. This will send a pulse from your hand to your partner's hand.
- In which direction does the slinky move as the pulse moves along the slinky?
- Describe this motion in your own words.
- Next, pull back 10 to 15 loops of the slinky, release these loops. Describe the motion of the slinky as the new pulse moves along the slinky. How is this movement different?
- Compare the movement of the two pulses.
- Using a continuous side-to-side motion, set up a consecutive series of pulses in your slinky. Describe the appearance of these forms. Does your wave form look like this?



Let's identify the parts of this wave form:



- Quickly move your hand back and forth to set up a series of pulses in the slinky. Does your wave form look like this?



- Let's name the parts of this wave form: (see above)

- Are there any similarities in the forms? How are they different?

The speed you repeat pulses is called the "frequency." The distance between crests is called "wavelength". If you multiply the frequency by the wavelength, you will determine the velocity of the wave as it moves through the slinky.

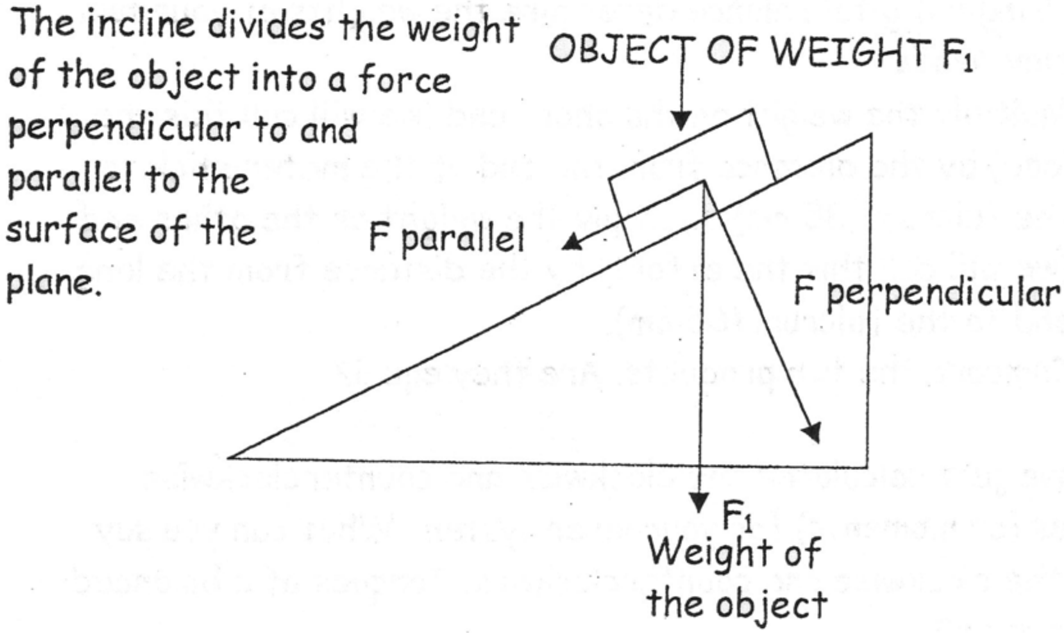
Moving your hand back and forth sets up crests and troughs in the wave. Count the number of times you make a complete back and forth motion in one minute (60 seconds), divide the number of repetitions by 60 seconds to calculate the frequency. Have one of your partners measure the distance from crest to crest in your waveform. Now multiply. You will now know the speed you are transferring energy from your hand to your partner's hand.

The same can be done for the other type of wave you created.

- The first wave type is called a "Transverse Wave", the second is called a "Longitudinal Wave."

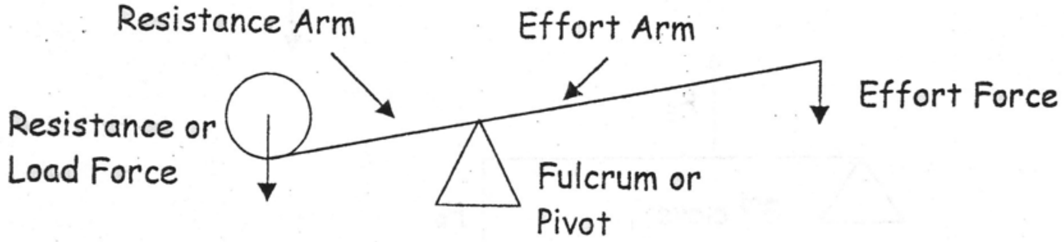
Activity 6:
Simple Machines

There are two types of simple machines, the passive (inclined plane) and the active (lever). The inclined plane does its job by dividing forces, due to its shape. See below:



How simple can you get? The angle of the plane controls the division of forces.

The lever, on the other hand, is a machine with motion. The lever is divided into three parts: the fulcrum or pivot point, the effort arm (the part your push or pull), and the resistance or load arm (the part that lifts your load). See below:



- Using a meter stick and a round glue stick, build a lever with a fulcrum at 35 cm.
- Place a lump of clay (or reasonable size) on the short end of your meter stick.

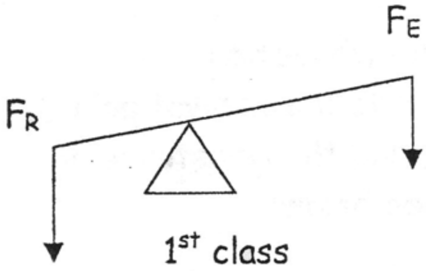
- Attempt to balance the lever system by using clay on the other end. Try to balance the system as best you can.

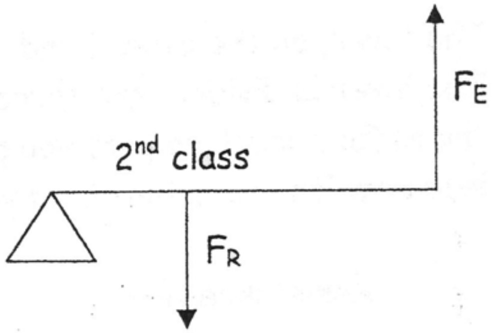
- Using a Digital balance, determine the weights of your two clay "wads."

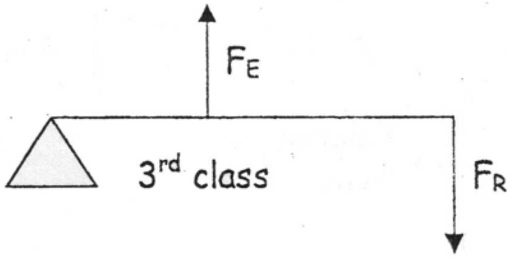
- Multiply the weight on the short end (we will call this the load) by the distance from the end of the meter stick to the fulcrum (35 cm). Multiply the weight on the other end (we will call this the "effort") by the distance from the long end of the fulcrum (65 cm).

- Compare the two products. Are they equal?

You have just calculated the clockwise and counterclockwise torques (or moments) for your lever system. What can you say about the clockwise and counterclockwise torques of a balanced lever system?
F_R x d_R = F_E x d_E is called the law of Torques and it controls all lever systems. 1st, 2nd, and 3rd class. See below:







APPENDIX F
WORKSHOP DETAILS

Traditional Workshop: Day 1	**Hypermedia Workshop: Day 1**
a. **Introduction**	a. **Introduction**
b. **Pretest Data Collection** - PIES Science Knowledge Test - Science Attitude Scale for Inservice Teachers II - Demographic Information Sheet	b. **Pretest Data Collection** - PIES Science Knowledge Test - Science Attitude Scale for Inservice Teachers II - Demographic Information Sheet
c. **Introductory Discussion**: Issues in the Elementary Science Classroom, conducted verbally	c. **Introductory Discussion**: Issues in the Elementary Science Classroom, conducted verbally
d. **Activity 1 Pre-structuring**: - Introduction to Workshop Packet - **PowerPoint presentation** providing background knowledge for lesson, accessed via Workshop Packet containing PowerPoint document - **PowerPoint presentation** of activity directions	d. **Activity 1 Pre-structuring**: - Introduction to ELLIPS - **PowerPoint presentation** providing background knowledge for lesson, accessed via Teacher Content Resources feature of ELLIPS - **PowerPoint presentation** of activity directions
e. **Break into Groups of 4**	e. **Break into Groups of 4**.
f. **Access Activity 1**: Kinematics, via Workshop Packet containing Word documents	f. **Access Activity 1**: Kinematics, via Lesson Search feature of ELLIPS
g. **Run Activity 1**: Kinematics	g. **Run Activity 1**: Kinematics
h. **Activity 2 Pre-structuring**: - **PowerPoint presentation** providing background knowledge for lesson , accessed via Workshop Packet containing PowerPoint documents - **PowerPoint presentation** of activity directions	h. **Activity 2 Pre-structuring**: - **PowerPoint presentation** providing background knowledge for lesson, accessed via Teacher Content Resources feature of ELLIPS - **PowerPoint presentation** of activity directions
i. **Break into Different Groups of 4**	i. **Break into Different Groups of 4**
j. **Access Activity 2**: Acceleration, via Workshop Packet containing Word documents	j. **Access Activity 2**: Acceleration, via Workshop Packet containing Word documents
k. **Run Activity 2:** Acceleration	k. **Run Activity 2:** Acceleration
l. **Closing discussion**: conducted verbally - Instructional strategies - Sunshine State Standards	l. **Closing discussion**: conducted verbally - Instructional strategies - Sunshine State Standards
m. **Distribute Homework:** Review of lessons conducted via handout	m. **Distribute Homework:** Review of lessons conducted via Lesson Review feature of ELLIPS (1 minute).

Traditional Workshop: Day 2	**Hypermedia Workshop: Day 2**
a. **Introduction**	a. **Introduction**
b. **Introductory Discussion**: Implementing Day 1 Activities in the elementary classroom, conducted verbally	b. **Introductory Discussion**: Implementing Day 1 Activities in the elementary classroom, conducted verbally
c. **Activity 3 Pre-structuring**: • **PowerPoint presentation** providing background knowledge for lesson, accessed via Workshop Packet containing PowerPoint documents • **PowerPoint presentation** of activity directions	c. **Activity 3 Pre-structuring**: • **PowerPoint presentation** providing background knowledge for lesson, accessed via Teacher Content Resources feature of ELLIPS • **PowerPoint presentation** of activity directions
d. **Break into Groups of 4**	d. **Break into Groups of 4**
e. **Access Activity 3**: Mass, Weight, and Gravity, via Workshop Packet containing Word documents	e. **Access Activity 3**: Mass, Weight, and Gravity, via Lesson Search feature of ELLIPS
f. **Run Activity 3**: Mass, Weight, and Gravity	f. **Run Activity 3**: Mass, Weight, and Gravity
g. **Activity 4 Pre-structuring**: • **PowerPoint presentation** providing background knowledge for lesson, accessed via Workshop Packet containing PowerPoint documents • **PowerPoint presentation** of activity directions	g. **Activity 4 Pre-structuring**: • **PowerPoint presentation** providing background knowledge for lesson, accessed via teacher Content Resources feature of the ELLIPS • **PowerPoint presentation** of activity directions
h. **Break into Different Groups of 4**	h. **Break into Different Groups of 4**
i. **Access Activity 4**: Simple Electricity: "Static and Current," via Workshop Packet containing Word documents	i. **Access Activity 4**: Simple Electricity: "Static and Current," via Lesson Search feature of ELLIPS
j. **Run Activity 4**: Simple Electricity: "Static and Current"	j. **Run Activity 4**: Simple Electricity: "Static and Current"
k. **Review of lessons** conducted via handout	k. **Review of lessons** conducted via Lesson Review feature of ELLIPS tool
l. **Closing discussion**: conducted verbally • Sunshine State Standards in the elementary science classroom • Instructional strategies • The Nature of Science	l. **Closing discussion**: conducted via ELLIPS Discussion Forum • Sunshine State Standards in the elementary science classroom • Instructional strategies • The Nature of Science

Traditional Workshop: Day 3	**Hypermedia Workshop: Day 3**
a. **Introduction**	a. **Introduction**
b. **Activity 5 Pre-structuring**: • **PowerPoint presentation** providing background knowledge for lesson, accessed via Workshop Packet containing PowerPoint documents • **PowerPoint presentation** of activity directions	b. **Activity 5 Pre-structuring**: • **PowerPoint presentation** providing background knowledge for lesson, accessed via Teacher Content Resources section of ELLIPS • **PowerPoint presentation** of activity directions
c. **Break into Groups of 4**	c. **Break into Groups of 4**
d. **Access Activity 5**: Waves and Wave Properties, via Workshop Packet containing Word documents	d. **Access Activity 5**: Waves and Wave Properties, via Lesson Search feature of E.L.L.I.P.S
e. **Run Activity 5**: Waves and Wave Properties	e. **Run Activity 5**: Waves and Wave Properties
f. **Activity 6 Pre-structuring**: • **PowerPoint presentation** providing background knowledge for lesson, accessed via Workshop Packet containing PowerPoint documents • **PowerPoint presentation** of activity directions	f. **Activity 6 Pre-structuring**: • **PowerPoint presentation** providing background knowledge for lesson, accessed via Teacher Content Resources feature of the ELLIPS tool • **PowerPoint presentation** of activity directions
g. **Break into Different Groups of 4**	g. **Break into Different Groups of 4**
h. **Access Activity 6**: Simple Machines, via Workshop Packet containing Word documents	h. **Access Activity 6**: Simple Machines, via Lesson Search feature of ELLIPS
i. **Run Activity 6**: Simple Machines	i. **Run Activity 6**: Simple Machines
j. **Lesson Reviews**, via handout	j. **Lesson Reviews,** via Lesson Review feature of ELLIPS
k. **Closing discussion**: conducted verbally • Sunshine State Standards in the elementary science classroom • Instructional strategies • The Nature of Science	k. **Closing discussion**: conducted verbally • Sunshine State Standards in the elementary science classroom • Instructional strategies • The Nature of Science
l. **Posttest Data Collection** • PIES Science Knowledge Test • Science Attitude Scale for Inservice Teachers II	l. **Posttest Data Collection** • PIES Science Knowledge Test • Science Attitude Scale for Inservice Teachers II

LIST OF REFERENCES

Abell, S. K., & Roth, M. (1991, April). *Coping with constraints of teaching elementary science: A case study of a science enthusiast student teacher*. Paper presented at the National Association for Research in Science, Lake Geneva, WI.

Abell, S., & Roth, M. (1992). Constraints to teaching elementary science: A case study of a science enthusiast student. *Science Education*, *76*(6), 581-595.

Abrams, A., & Streit, L. (1986). Effectiveness of the interactive video in teaching basic photography. *T.H.E. Journal*, *14*(2), 92-96.

Affleck, J. Q., Madge, S., Adams, A., & Lowenbraun, S. (1988). Integrated classroom versus resource model: Academic viability and effectiveness. *Exceptional Children*, *54*, 339-348.

American Association for the Advancement of Science. (1989). *Project 2061: Science for all Americans*. Washington, DC: AAAS.

American Association for the Advancement of Science. (1993). *Science for All Americans: Project 2061*. New York: Oxford University Press.

Anderson, R. C. (1984). Some reflections on the acquisition of knowledge. *Educational Researcher*, *13*(10), 5-10.

Anderson, C. W., & Smith, E. L. (1986). *Teaching science*. East Lansing, MI: Institute of Research on Teaching.

Ashton, P. (1984). Teacher efficacy: A motivational paradigm for effective teacher education. *Journal of Teacher Education*, *35*(5), 28-32.

Astleitner, H., & Leutner, D. (1995). Learning strategies for unstructured hypermedia: A framework for theory, research, and practice. *Journal of Educational Computing Research*, *13*(4), 387-400.

Atkins, M. J. (1992). Theories of learning and multimedia applications: An overview. *Research Papers in Education, 8*(2), 251-271.

Ayersman, D. J. (1995). Introduction to hypermedia as a knowledge representation system. *Computers in Human Behavior, 11*(3-4), 529-531.

Ayersman, D. J. (1996). Reviewing the research on hypermedia-based learning. *Journal of Research on Computing in Education*, *28*(4), 500-520.

Ayersman, D. J., & Reed, W. M. (1995). The impact of instructional design and hypermedia software type on graduate students' use of theoretical models. *Computers in Human Behavior*, *11*(3/4), 557-580.

Ayersman, D. J., & Reed, W. M. (1998). Relationships among hypermedia-based mental models and hypermedia knowledge. *Journal of Research on Computing in Education*, *30*(3), 222-240.

Baker, E. L., Niemi, D., & Herl, H. (1994). Using Hypercard technology to measure understanding. In E. L. Baker & H. F. O'Neil, Jr. (Eds.), *Technology assessment in education and training* (pp. 133-152). Hillsdale, NJ: Lawrence Erlbaum.

Bandura, A. (1976). *Social learning theory*. New York, NY: Prentice Hall.

Barab, S. A., Bowdish, B. E., & Lawless, K. A. (1997). Hypermedia navigation: Profiles of hypermedia users. *Educational Technology Research and Development*, *45*(3), 23-41.

Beaufils, A. (2000). Tools and strategies for searching in hypermedia environments, *Journal of Computer Assisted Learning, 16,* 114-124.

Beeman, W. O., Anderson, K. T., Bader, G., Larkin, J., McClard, A. P., McQuillan, P. J., & Shields, M. (1988). *Intermedia: A case study of innovation in higher education (Final report to the Annenberg/CPB Project)*. Providence, RI: Brown University, Office of Program Analysis, Institute for Research in Information and Scholarship.

Berman, P., McLaughlin, M. W., Bass, G., Pauly, E., & Zellman, G. (1977). *Federal programs supporting educational change. Vol. VII: Factors affecting implementation and continuation*. Santa Monica, CA: The Rand Corporation.

Bhaumik, A., Dixit, D., Glanares, R., Krishna, A., Tzagarakis, M., Vaitis, M., et al. (2001). Towards hypermedia support for database systems. In J.F. Nunamaker (Eds.). *Proceedings of the 34th Hawaii International Conference of Systems Sciences* (Maui, HI, January 3-6, 2001). Los Alamitos, CA: IEEE Computer Press,

Bialo, E., & Sivin-Kachala, J. (1996). *The effectiveness of technology in schools: A summary of recent research*. Washington, DC: Software Publishers Association.

Bogut, T. L., & McFarland, L. (1975). *The effects of instruction on elementary teachers' realistic and idealistic attitudes toward selected science related concepts*. Washington, DC: (ERIC Document No. ED106125). U.S. Department of Health, Education, and Welfare, National Institute of Education.

Borg, W. R., & Gall, M. D. (1989). *Educational research: An introduction* (5th ed.). New York: Longman.

Brown J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*, 32-42.

Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review*, *31*(1), 21-32.

Bruner, J. (1966). *Toward a theory of instruction*. Cambridge, MA:Harvard University Press.

Bruner, J. (1986). *Actual minds, possible worlds*. Cambridge, MA: Harvard University Press.

Burton, J. K., Moore, D. M., & Holmes, G. A. (1995). Hypermedia concepts and research: An overview. *Computers in Human Behavior*, *11*(3/4), 345-369.

Bush, V. (1945). As we may think. *Atlantic Monthly*, *176*(1), 101-108.

Bybee, R. W. (1993). *Reforming science education: Social perspectives and personal reflections*. New York: Teachers College Press.

Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research*. Boston: Houghton Mifflin.

Carroll, J. M. (1990). *The Nurnberg funnel: Designing minimalist instructions for practical computer skills*. Cambridge, MA: MIT Press.

Cohen, J. (1988). *Statistical power analysis for the behavioral science* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Cohen, A. R. (1964). *Attitude change and social influence.* New York: Basic Books, Inc.

Collier, G. H. (1987). Thoth-II: Hypertext with explicit semantics. *Proceeding of the ACM conference on Hypertext* (pp.269-289). New York: ACM Press.

Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 453-494). Hillsdale, NJ: Lawrence Erlbaum.

Conklin, J. (1987). Hypertext: An introduction and survey. *Computer*, *20*(9), 17-41.

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation*. Boston: Houghton-Mifflin.

Czerniak, C., & Schriver, M. (1994). An examination of preservice science teachers' beliefs and behaviors as related to self-efficacy. *Journal of Science Teacher Education*, *5*(3), 77-86.

Danielson, C. (1996). *Enhancing professional practices: A framework for teaching*. Arlington, VA: Association for Supervision and Curriculum Development.

Darling-Hammond, L. (2000). Teacher quality and student achievement: A review of state policy evidence. *Education Policy Analysis Archives*, *8*(1). Retrieved May 14, 2004, from http://olam.ed.asu.edu/epaa/v8n1/

Darling-Hammond, L., & Ball, D. L. (1998). *Teaching for high standards: What policy-makers need to know and be able to do*. Philadelphia: The Consortium for Policy Research in Education (CPRE). (ERIC Document No. ED426491)

DeTure, C., Gregory, H., & Ramsey, S. (1990, April). *The science of preparation of elementary teachers*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Atlanta, GA.

Dewey, J. (1938). *Experience and education*. New York: Collier Books.

Dillon, A., & Gabbard, R. (1998). Hypermedia as an educational technology: A review of the quantitative research literature on learner comprehension, control, and style. *Review of Educational Research*, *68*(3), 322-349.

Duffy, T. M., & Jonassen, D. H. (1991). Constructivism: New implications for instructional technology? *Educational Technology, 31*(5), 7-12.

Duval County Public Schools Research and Evaluation. (2004a). *District performance*. Retrieved April 23, 2004, from the Duval County Public Schools Web site: http://www.educationcentral.org/reseval/Default1.asp

Duval County Public Schools Research and Evaluation. (2004b). *Individual school performance*. Retrieved April 23, 2004, from the Duval County Public Schools Web site: http://www.educationcentral.org/reseval/Schools/Schools.asp

Ely, D. (1990). Conditions that facilitate the implementation of educational technology innovations. *Journal of Research on Computing in Education, 23*(2), 298-305.

Festinger, L. (1957). *A theory of cognitive dissonance.* Evanston, IL: Row, Peterson, & Evanston.

Franz, J. R., & Enochs, L. G. (1982). Elementary school science: State certification requirements in science and their implications. *Science Education, 66*, 287-292.

Fraser, B. J., & Walberg, R. J. (1995). *Improving science education*. Chicago: University of Chicago Press.

Fullan, M., & Stiegelbauer, S. (1991). *The new meaning of educational change*. New York: OISE/Teachers College Press.

Gall, M. D., Borg, W. R., & Gall, J. P. (1996). *Educational research: An introduction* (6th ed.). White Plains, NY: Longman.

Gardarin, G., & Yoon, S. (1995). Filtering hypermedia network by using view mechanism. *Proceedings of the ACM Workshop on Effective Abstractions in Multimedia*, San Francisco, CA: Retrieved on November 27, 2003, from http://www.cs.tufts.edu/~isabel/yoon/yoon.html

Ginns, I. S., & Watters, J. J. (1998, April 19-22). *Beginning elementary teachers and the effective teaching of science.* Paper presented at the National Association for Research in Science, San Diego, CA.

Grabowski, B. L., & Small, R. V. (1997). Information, instruction, and learning: A hypermedia perspective. *Performance Improvement Quarterly*, *10*(1), 156-166.

Halasz, F. G. (1988). Reflections on notecards: Seven issues for the next generation of hypermedia systems. *Communications of the ACM*, *31*(7), 836-852.

Hall, G. E., (1974). *The concerns-based adoption model: A developmental conceptualization of the adoption process within educational institutions*. Research and Development Center for Teacher Education, Austin: University of Texas.

Hanushek, E. A. (1992). The trade-off between child quantity and quality. *Journal of Political Economy*, *100*(1), 84-117.

Hardiman, B., & Williams, R. (1990). Teaching developmental mathematics: The interactive video approach. *T.H.E. Journal*, *17*(8), 154-159.

Harlen, W., & Holroyd, C. (1997). Primary teachers' understanding of concepts in science impact on confidence and teaching. *International Journal of Science Education*, *19*(1), 93-105.

Hassard, J. (1992). *Minds on science*. New York: Harper Collins.

Hays, W. L. (1994). *Statistics* (5th ed.) Fort Worth, TX: Harcourt-Brace.

Hede, A. (2002). An integrated model of multimedia effects on learning. *Journal of Educational Multimedia and Hypermedia*, *11*(2), 177-199.

Helgeson, S. L., Blosser, P. E., & Howe, R. W. (1977). *The status of pre-college science, mathematics, and social science education: 1955-1975. Volume 1: Science education*. Columbus, OH: Ohio State University.

Henson, K. T. (1987). Strategies for overcoming barriers to educational change. *NASSP Bulletin*, *71*(479), 125-127.

Higgins, K., & Boone, R. (1990). Hypertext computer study guides and the social studies achievement of students with learning disabilities, remedial students, and regular education students. *Journal of Learning Disabilities*, 23(9), 529-540.

Hilliard, A. (1997). The structure of valid staff development. *Journal of Staff Development. 18*(2), 28-34.

Hinkle, D., Wiersma, W., & Jurs, S. (1994). *Applied statistics for the behavioral sciences* (3rd ed.). Boston: Houghton-Mifflin.

Hone, E. (1970). Science scarecrows. *School Science and Mathematics*, *70*(4), 322-326.

Hughes, J. E., Packard, B. W., & Pearson, P. D. (1997). Reading classroom explorer: Visiting classrooms via hypermedia. *46th Annual National Reading Conference Yearbook*. Chicago: National Reading Conference.

Hurd, P. D. (1982). Scientific enlightenment for an age of science. *The Science Teacher*, *37*(1), 13-15.

International Assessment of Educational Progress. (1992). *Learning science (Report No. 22-CAEP-02)*. Princeton, NJ: Educational Testing Service.

International Association for the Evaluation of Achievement. (1988). *Science achievement in seventeen countries: A preliminary report.* Oxford, UK: Pergamon.

Jacobson, M. J., Maouri, C., Mishra, P., & Kolar, C. (1996). Learning with hypertext learning environments: Theory, design and research. *Journal of Educational Multimedia and Hypermedia*, *5*(3/4), 239-281.

Jacobson, M. J., & Spiro, R. J. (1995). Hypertext learning environments, cognitive flexibility, and the transfer of complex knowledge: An empirical investigation. *Journal of Educational Computing Research*, *12*(4), 301-333.

Janda, K. (1992). Multimedia in political science: Sobering lessons from a teaching experiment. *Journal of Educational Multimedia and Hypermedia*, *1*(3), 341-354.

Jesky-Smith, R. (2002). Me, teach science? *Science and Children*, *39*(6), 26-30.

Jonassen, D. H. (1988). Designing structured hypertext and structuring access to hypertext. *Educational Technology, 28*(11), 13-16.

Jonassen, D. H. (1989). *Hypertext/Hypermedia*. Englewood Cliffs, NJ: Educational Technology Publications.

Jonassen, D. H. (1993). Effects of semantically structured hypertext knowledge bases on users' knowledge structures. In C. McKnight, A. Dillon, & J. Richardson (Eds.), *Hypertext: A psychological perspective* (pp. 153-168). Chichester, UK: Ellis Horwood Limited.

Jonassen, D. H. (1996). *Computers in the classroom: Mindtools for critical thinking.* Englewood Cliffs, NJ: Prentice-Hall, Inc.

Jonassen, D. H. (1999). Designing constructivist learning environments. In C. M. Reigeluth (ed.) *Instructional design theories and models: A new paradigm of instructional theory,* Vol. II. (pp. 215-239). Mahwah, NJ: Lawrence Erlbaum.

Jonassen, D. H. (2000). *Computers as mindtools for schools: Engaging critical thinking* (2nd ed.). Upper Saddle River, NJ: Merrill.

Jonassen, D. H., & Wang, S. (1993). Acquiring structural knowledge from semantically structured hypertext. *Journal of Computer-Based Instruction*, *20*(1), 1-8.

Jung, C. G. (1978). *Psychology and the east*. Princeton, NJ: Princeton University Press.

Kahle, J. B. (2000). *Teacher professional development: Does it make a difference in student learning*? Draft testimony for U.S. House of Representatives Committee on Science.

Keeves, J. P. (Ed.). (1992). *The IEA study of sciences III: Changes in science education and achievement: 1970-1984*. Oxford, UK: Pergamon Press.

Keeves, J. P. (1995). Cross-national comparisons of outcomes in science education. In B. J. Fraser & R. J. Walberg (Eds.), *Improving science education* (pp. 211-233). Chicago: University of Chicago Press.

Kennedy, G. (1973). The effect of process approach instruction upon changing pre-service elementary teachers' attitudes toward science. *School Science and Mathematics*, *73*(7), 569-574.

Klein, S., Hamilton, L., McCaffrey, D., Stecher, B., Robyn, A., & Burroughs, D. (1999, May). *Teaching practices and student achievement: Report of first-year findings from the "Mosaic" study of systemic initiatives in mathematics and science*. Los Angeles: Rand Corporation.

Knowles, M. S. (1970). *The modern practice of adult education: Andragogy vs. pedagogy.* New York: Associated Press.

Knuth, R. A., Jones, B. F., & Baxendale S. (1991). *What does research say about science?* Retrieved October 15, 2003, from NCREL, EDUTECH web site: http://agora.unige.ch/tecfa/edutech/welcome_frame.html

Koballa, T. R., & Crawley, F. E. (1985). The influence of attitude on science teaching and learning. *School Science and Mathematics*, *85*(3), 222-231.

Koehler, M. J. (2002). Designing case-based hypermedia for developing understanding of children's mathematical reasoning. *Cognition and Instruction, 20*(2), 151-195.

Kumar, D., & Sherwood, R. (1997). Hypermedia in science and mathematics: Applications in teacher education. *Journal of Educational Computing Research*, *17*(3), 249-262.

Landow, G. (1992). Hypertext: The convergence of contemporary critical theory and technology. Baltimore: Johns Hopkins University Press.

Lee, Y. B., & Lehman, J. D. (1993). Instructional cuing in hypermedia: A study with active and passive learners. *Journal of Educational Multimedia and Hypermedia*, *2*(1), 25-37.

Lehrer, R. (1993). Authors of knowledge: Patterns of hypermedia design. In S. P. Lajoie, & S. J. Derry (Eds.), *Computers as cognitive tools* (pp. 197-227). Hillsdale, NJ: Lawrence Erlbaum.

Linn, M. C., & Hsi, S. (2000). *Computer, teachers, peers: Science learning partners*. Mahwah, NJ: Lawrence Erlbaum.

Loucks-Horsley, S. (1996). *Reforming professional development*. Paper presented at the NSTA Workshops.

Loucks-Horsley, S., Kaptian, R., Carlson, M. O., Kuerbis, P. J., Clark, R. S., Nelle, M. G., et al. (1990). *Elementary school science for the 90's.* Andover, MA: The National Center for Improving Science Education.

Lyddon, W. J. (1995). Forms and facets of constructivist psychology. In R. A. Neimeyer & M. J. Mahoney (Eds.), *Constructivism in psychotherapy*. (pp. 69-92) Washington, DC: American Psychological Association.

Manning, P., Elser, W., & Baird, J. R. (1982). How much elementary science is really being taught? *Science and Children*, *19*(8): 40-41.

Marchionini, G. (1988, November). Hypermedia and learning: Freedom and chaos. *Educational Technology, 28*(11), 8-12.

Marchionini, G., & Crane, G. (1994). Evaluating hypermedia and learning: Methods and results from the Perseus Project. *ACM Transactions on Information Systems, 12*(1), 5-34.

McGuire, E. G. (1996). Knowledge representation and construction in hypermedia environments. *Telematics and Informatics, 13*(4), 251-260.

McGuire, W. J. (1969). The nature of attitudes and attitude change. In G. Lindzey & E. Arondson (Eds.), *Handbook of Social Psychology,* Vol. 3. (pp. 136-314) Reading, MA: Addison-Wesley.

McIsaac, M. S., & Gunawardena, C. N. (1996). Distance Education. In D. H. Jonassen (Ed.) *Handbook of Research for Educational Communications and Technology*. New York: Simon & Schuster Macmillan.

Mechling, K., Stedman, C., & Donnellson, K. (1982). Preparing and certifying science teachers. *Science and Children*, *20*(2), 9-14.

Mitchner, C. P. & Anderson, R. D. (1989). Teacher's perspective: Developing and implementing an STS curriculum. *Journal of Research in Science Teaching*, *26*(4), 351-369.

Monk, D. H. (1994). Subject area preparation of secondary mathematics and science teachers and student achievement. *Economics of Education Review*, *13*(2), 125-145.

Moreno, R., & Mayer, R. E. 1999. Cognitive principles of multimedia learning: The role of modality and contiguity. *Journal of Educational Psychology, 91*(2), 358-368.

Morgan, S., Reichert, T., & Harrison, T. (2002). *From numbers to words: Reporting statistical results for the social sciences*. Boston: Allyn and Bacon.

Mulholland, J., & Wallace, J. (1996). Breaking the cycle: Preparing elementary teachers to teach science. *Journal of Elementary Science Education*, *8*(1), 17-38.

Muttlefehldt, B. (1985). Changing priorities in elementary science. *Curriculum Review*, *24*, 61-69.

National Academy on Science. (1995). *The national science education standards.* Washington, DC: National Academies Press.

National Assessment of Educational Progress. (1983). *The third assessment of science.* Denver, CO: Author.

National Center for Education Statistics. (2000). Teacher preparation and professional development. *Education Statistics Quarterly*, *3*(3). Retrieved September 25, 2003, from http://nces.ed.gov/programs/quarterly/vol_3/3_3/q3-3.asp

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform.* Washington, DC: U.S. Department of Education.

National Education Goals Panel. (1991). *The national education goals report: Building a nation of learners.* Washington, DC: Author.

National Research Council, 1996. *National science education standards*. Washington, DC: National Academies Press. Retrieved October 14, 2003, from http://nap.edu/catalog/4962.html

National Science Foundation. (1996). Chapter 7: Science and technology: Public attitudes and public understanding. In *National Science Foundation, Science, and Engineering Indicators, 1996*, (pp. 3-26). Washington, DC: U.S. Government Printing Office.

Nelson, W. A. (1994). Efforts to improve computer-based instruction: The role of knowledge representation and knowledge construction in hypermedia systems. In W. M. Reed, J. K. Burton, & M. Liu (Eds.), *Multimedia and megachange: New roles for educational computing* (pp. 371-400). New York: The Haworth Press.

Newman, F., & King, B. (2000). Professional development to improve schools. *WCER Highlights, 12*(1), 1-7.

Nielsen, J. (1995). *Multimedia and hypertext: The Internet and beyond*. London: Academic Press.

Olson, L. (1997). Bad news about bad teaching. *Education Week*, *16*(19), 22.

Park, O. (1991). Hypermedia: Functional features and research issues. *Educational Technology*, *31*(8), 24-31.

Phillips, D. C. (1995). The good, the bad, and the ugly: The many faces of constructivism. *Educational Researcher*, *24*(7), 5-12.

Phillips, D. C. (1997). How, why, what, when, and where: Perspectives on constructivism in psychology and education. *Issues in Education*, *3*(2), 151-194.

Piaget, J. (1970). *The science of education and the psychology of the child*. New York: Grossman.

Piaget, J., & Inhelder, B. (1973). *Memory and intelligence.* New York: Basic Books.

Plourde, L. (2002). Elementary science education: The influence of student teaching—Where it all begins. *Education*, *123*(2), 253-259.

Radford, D. L. (1998). Transferring theory into practice: A model for professional development for science education reform. *Journal of Research in Science Teaching, 35*(1), 73-88.

Raizen, S. (1998). *Increasing educational productivity through improving the science curriculum*. Washington, DC: NCISE.

Ramsey-Gassert, L., Shroyer, M. G., & Staver, J. R. (1996). A qualitative study of factors influencing science teaching self-efficacy of elementary level teachers. *Science Education*, *80*(3), 283-315.

Reed, W. M., & Oughton, J. M. (1997). Computer experience and interval-based hypermedia navigation. *Journal of Research on Computing in Education*, *30*(1), 38-52.

Richardson, K. (1999). Hyperstructures in brain and cognition. *Psycoloquy*, 10 (031). Retrieved March 14, 2004, from ftp://ftp.princeton.edu/pub/harnad/Psycoloquy/1999.volume.10/ psyc.99.10.031.hyperstructure.1.richardson http://www.cogsci.soton.ac.uk/psyc-bin/newspy?10.031.

Rieber, L. P. (1994). *Computers, graphics, and learning*. Dubuque, IA: Wm. C. Brown Communications, Inc.

Rogers, E. (1995). *Diffusion of innovations* (4th ed.). New York: The Free Press.

Rowe, M. B. (1992). Science education, elementary schools. In M. C. Alkin (Ed.) *Encyclopedia of Educational Research, (*6th ed., pp. 1172-1177). New York: Macmillan.

Sanders, W.L. & Rivers, J.C. (1996). *Cumulative and residual effects of teachers on future student academic achievement*. Knoxville, TN: University of Tennessee Value-Added Research and Assessment Center.

Schwerian, P. (1969). Characteristics of elementary teachers related to attitudes toward science. *Journal of Research in Science Teaching*, *6*, 203-213.

Shrigley, R. (1977). The function of professional reinforcement in supporting a more positive attitude of elementary teachers toward science. *Journal of Research in Science Teaching*, *14*(4), 317-322.

Shrigley, R., & Johnson, T. (1974). The attitude of inservice elementary teachers toward science. *School Science and Mathematics*, *74*(5), 437-446.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Shulman, L.S. (1992): Toward a pedagogy of cases. In J.H.Shulman (Ed.), *Case methods in teacher education*, (p. 1-33). New York: Teachers College Press.

Shyu, H., & Brown, S. (1995). Learner-control: The effects of learning a procedural task during computer based videodisk instruction. *International Journal of Instructional Media, 22*(3), 217-231.

Smith, L. C. (1987). Artificial intelligence and information retrieval. In M. E. Williams (Ed.), *Annual Review of Information Science and Technology* (Vol. 22,pp. 41-77). Amsterdam: Elsevier.

Smith, P. S., Banilower, E. R., McMahon, K. C., & Weiss, I. R. (2002). *The national survey of science and mathematics education: Trends from 1977 to 2000*. Chapel Hill, NC: Horizon Research.

Spencer, K. A. (1991). Modes, media, and methods: The search for educational effectiveness. *British Journal of Educational Technology, 22* (1), 12-22.

Spiro, R J., Coulson, R. L., Feltovich, P. J., & Anderson, D. K. (1988). Cognitive flexibility theory: Advanced knowledge acquisition in ill-structured domains. In V. Patel (Ed.), *Tenth Annual Conference of the Cognitive Science Society* (pp. 375-383), Hillsdale, NJ: Lawrence Erlbaum.

Spiro, R. J., Feltovich, P. J., Jacobson, M. J., & Coulson, R. L. (1991). Cognitive flexibility, constructivism, and hypertext. *Educational Technology*, *31*(5), 24-33.

Spiro, R., & Jehng, J. (1990). Cognitive flexibility and hypertext: Theory and technology for the linear and non-linear multidimensional traversal of complex subject matter. In D. Nix & R. Spiro (Eds.), *Cognition, education, and multimedia: Exploring ideas in high technology* (pp. 163-205). Hillsdale, NJ: Lawrence Erlbaum.

Stepans, J., & McCormack, A. (1986, March). *A study of scientific conceptions and attitudes toward science of prospective elementary teachers*. Paper presented at NSTA (AETS), San Francisco.

Stevens, C., & Wenner, G. (1996). Elementary preservice teachers' knowledge and beliefs regarding science and mathematics. *School Science and Mathematics*, *96*(1), 2-9.

Stolberg, R. (1969). The task before us. The education of elementary school teachers in science. Reprinted by L. I. Kuslan and A. H. Stone in *Readings on teaching children science,* Belmont, CA: Wadsworth.

Tao, S. (1998). Promotion of transfer of knowledge and skill through hypermedia-assisted comprehensive self-study procedures. *Global Journal of Engineering Education*, *2*(1), 87-97.

Thompson, A. G. (1992). Teacher's beliefs and conceptions: A synthesis of research. In D. A. Grows (ed.) *Handbook of research on mathematics teaching and learning*. (pp. 127-146) New York: Macmillan.

Tilgner, P. J. (1990). Avoiding science in the elementary school. *Science Education*, *74*(4), 421-431.

Tobin, K. (1993). Referents for making sense of science teaching. *International Journal of Science Teaching*, *15*(3), 241-254.

Tobin, K., Kahle, J. B., & Fraser, B. J. (Eds.). (1990). *Windows into science classrooms: Problems associated with higher-level learning in science*. London: Falmer Press.

Tobin, K., Tippins, D. J., & Gallard, A. J. (1994). Research on instructional strategies for teaching science. In D. L. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 45-93). New York: Macmillan.

Tosun, T. (2000). The beliefs of preservice elementary teachers toward science and science teaching. *School Science and Mathematics*, *100*(7), 374-379.

Tressel, G. W. (1998). *A strategy for improving science education*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Tuckman, B. W. (1978). *Conducting educational research*. New York: Harcourt-Brace-Jovanovich.

Vaidya, S. R. (1993). Restructuring elementary and middle school science for improved teaching and learning. *Education*, *114*(1), 63-70.

von Glaserfeld, E. (1987). Learning as a constructive activity. In C. Janvier (Ed.), *Problems of representation in the teaching and learning of mathematics*, (pp. 3-17*)*. Hillsdale, NJ: Lawrence Erlbaum.

von Glaserfeld, E. (1989). Constructivism in education. In T. Husén & T. L. Postlethwaite (Eds.), *The international encyclopedia of education*, (pp. 162-163). Oxford, UK: Pergamon.

Vrasidas, C. (2002). Systematic approach for designing hypermedia environments for teaching and learning. *International Journal of Instructional Media*, *29*(1), 13-25.

Vygotsky, L. (1978). *Mind in society*. Cambridge, MA: MIT Press.

Wayne, A. J., & Youngs, P. (2003). Teacher characteristics and student achievement Gains: A review. *Review of Educational Research*, *73*(1), 89-122.

Weiss, I. R. (1987). *Report of the 1985-1986 national survey of science and mathematics education*. Washington, DC: National Science Foundation.

Weiss, I. R. (1994). *A profile of science and mathematics education in the United States: 1993*. Chapel Hill, NC: Horizon Research.

Weiss, I. R. (1997). Comparing teacher views and classroom practice to national standards. *National Institute for Science Education Brief*, *1*(3), 1-11.

Weiss, I. R., Banilower, E. R., McMahon, K. C., & Smith, P. S. (2001). *Report of the 2000 national survey of science and mathematics education*. Chapel Hill, NC: Horizon Research.

Westerback, M. E. (1982). Studies on attitude toward teaching science and anxiety about teaching science in preservice elementary teachers. *Journal of Research in Science Teaching, 19*(7), 603-616.

Wittgenstein, L. (1953). *Philosophical Investigations*. New York: Macmillan.

Wolff, M. R., Tobin, K., & Ritchie, S. (2001). *Re/constructing elementary science*. New York: Peter Lang Publishing.

Yager, R. (1993). The need for reform in science teacher education. *Journal of Science Teacher Education*, *4*(4), 144-148.

Yager, R. E. (1996). *Iowa assessment handbook*. Iowa City, IA: University of Iowa, Science Education Center.

Zielinski, E. J., & Smith, B. G. (1990, April). *An evaluation of the program to improve elementary science (PIES)*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Atlanta, GA.

BIOGRAPHICAL SKETCH

C. Richard Hartshorne was born on September 21, 1971, in Ulysses, Kansas, and he is the eldest of four children. Richard's family moved to Florida when he was 6 years old. It was there he attended N.B. Forrest High School for his secondary schooling and then Jacksonville University for his undergraduate studies. At Jacksonville University he studied general and applied physics under Dr. Paul Simony and Dr. J. Steve Browder. He received his Bachelor of Science in physics in May, 1995.

After graduating from Jacksonville University, Richard immediately began a career as a high school physics teacher at Edward H. White High School. After five years of teaching he decided to pursue a graduate degree in educational technology at the University of Florida. During his master's studies Richard studied under Dr. Colleen Swain, Dr. Sebastian Foti, Dr. Kara Dawson, Dr. Lee Mullally, and Dr. Jeff Hurt. His major areas of study were rooted in the production aspects of educational technology. He received his Master of Education degree in curriculum and instruction with a focus in educational technology production in May, 2001.

While content with his teaching career, Richard was excited about his master's studies and the field of educational technology. In December, 2001, he and his wife Leigh Ann moved to Gainesville, Florida, so he could continue his graduate studies. In his doctoral studies, Richard worked closely with Dr. Colleen Swain (committee chairperson) and Dr. Richard Ferdig (committee cochairperson). It was with their guidance and mentorship that he merged his two major areas of (doctoral) study within the field of educational technology: production and technology in teacher education. In August, 2004, Richard received a Ph.D. in educational technology from the School of Teaching and Learning, College of Education, of the University of Florida. In the fall, 2004, Richard will begin a new career as an assistant professor in the Instructional Systems Technology program, Department of Educational Leadership, College of Education, at the University of North Carolina at Charlotte in Charlotte, North Carolina.