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THE EFFECTS OF COMPUTER AND VIDEO GAMING
AS PLAY EFFECTS ON ELEMENTARY STUDENTS’
COGNITIVE PROCESSES AND LEARNING ACHIEVEMENTS IN TAIWAN

A Thesis in

Curriculum and Instruction

by

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ABSTRACT

This experimental study investigated the effects of computer and video game playing on students’ cognitive learning achievement. A subsidiary purpose included determination of the effect of prior knowledge on student’s learning performance.

This study employed a 2 X 2 factorial design. The independent variables were (1) different types of instructional treatments (the computer-assisted instruction versus computer and video game playing) and (2) students’ prior examination scores (high score versus low score in “Nature and Technology” examination). The dependent variables used in the study were the outcome of participants’ post-test scores and the results of the three sub-categories in the post-test.

One hundred and thirty-six third-grade students from Chunghsueh Elementary School in Tainan, Taiwan were recruited to participate in this study. Two different instructional materials were used in this study: a plain text hypertext format and a computer game. One post-test was used to assess participants’ learning achievements of different instructional treatments.

The results from a two-way multivariate analysis of variance (MANOVA) indicated that playing computer and video games was determined to be more effective significantly in facilitating participants’ average learning outcome than plain text computer-assisted instruction. The findings from this study provide experimental evidence to support the notion that the use of computer games facilitates students’ cognitive learning process. In addition, its multimedia functionality and instructional capability should be considered as much as CAI programs.
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Chapter 1

INTRODUCTION

Problem Identification

The uses of computer-assisted instruction (CAI) and multimedia in education have significantly changed our children’s learning and cognitive processes. Results from a number of research studies indicate that appropriately designed CAI programs enhance students’ learning performance in science, mathematics, and literacy. Interestingly, despite having the same multimedia capability as CAI, the potential learning impact of computer and video games is often discounted by parents and educators. This negative impression toward children playing video games comes from results of outdated studies about children’s game-playing behaviors. However, the rapid development of emerging technologies in the past few years has changed the way people might think about gameplay. Re-scrutinization of the influence of computer and video games for today’s education is vital.

Purpose of Study

The purpose of this study is to determine if computer and video games facilitate students’ cognitive learning processes. In comparison to tradition lecture or CAI approach, this study investigates the impact of the different types of instructional treatments and students’ prior examination scores on students’ learning achievement.
The results also analyze students’ prior knowledge to assess the effect of different instructional treatments in increasing students’ learning achievement.

**Educational Justification**

No matter how much educators try to ignore or deny, technology and new media have strongly impacted children’s learning in the last two decades. Today, children are immersed in electronic media. Research results from the Kaiser Family Foundation and the Children’s Digital Media Centers (Rideout, Vandewater, & Wartella, 2003) found that children in the United States are growing up with media, spending hours a day watching television and videos, using computers and playing video games. Some of the impressive data from this study shows:

- Children six and under spend an average of two hours a day using screen media (1:58), about the same amount of time they spend playing outside (2:01), and well over the amount they spend reading or being read to (39 minutes).
- Forty-three percent of those under two watch TV every day, and 26% have a TV in their bedrooms.
- Nearly half (48%) of children six and under have used a computer (31% of 0-3 year-olds and 70% of 4-6 year-olds).
- Just under a third (30%) have played video games (14% of 0-3 year-olds and 50% of 4-6 year-olds).
- In a typical day about one in four (27%) 4-6 year-olds use a computer, and those who do, spend an average of just over an hour at the keyboard (1:04).
More than a third (39%) of 4-6 year-olds use a computer several times a week or more; 37% in this age group can turn the computer on by themselves, and 40% can load a CD-ROM.

Half (50%) of all 4-6 year-olds have played video games, and one in four (25%) play several times a week or more.

All these statistics show that today’s children are exposed to, and starting to use technologies and media at a much younger age than previously thought. Therefore, educators’ investigations become critical concerning the impact of technologies and media on children’s development. Through this study investigates two main questions: (1) Can computer and video games be instructional tools in early childhood education? (2) Should instructional strategies be modified to fit into young children’s media experience?

**Theoretical Justification**

Play theories for child development provide the theoretical justification:

- Vygotsky’s (Vygotsky & Cole, 1978) considered play to be important to the social and emotional development of children, as well as to their cognitive development.

- Play contributes to children’s ability to solve problems by increasing their behavioral options (Bruner, Jolly, & Sylva, 1976).

- Children play to release the stress they build up from all the pressure exerted on them by socialization agents in today’s fast-paced society (Johnson, Christie, & Yawkey, 1999).
In terms of play materials and child development, the theoretical justification is explained as follows:

Play materials indirectly influence development by affecting the type of play in which children engage and the content of their play. Play materials may also directly affect development by providing opportunities for learning (Johnson, Christie, & Yawkey, 1999).

This study applies and adjusts these theories to investigate the correlation between child development and new play materials: computer and video games.

**Research Justification**

Most previous research studies related to computer and video games focused on the discussions of psychological study and child behavior. In psychological study, research results indicated that video games can promote hand-eye coordination, visual scanning, auditory discrimination, and spatial skills. For child behavior, evidence showed that violent video games may raise children’s aggressive play and violent behaviors. Separate from previous research, this study discusses computer and video games from an educational perspective:

- How some of the motivating aspects of computer and video games might be harnessed to facilitate learning? (Squire, 2003)
- How motivational components of popular computer and video games might be integrated into instructional design?
**Project Significance**

Two reasons explain why this study is valuable:

1. To raise the level of awareness of the importance of technologies in child learning.
2. To examine whether computer and video game facilitates children’s cognitive processes.

**Generalizations**

Several identified generalizations apply the findings from this study to individuals other than those who actually participated in the research:

1. Since the students involved in this study are from regular classes, it may be concluded that the general findings are appropriate to similar types of students.
2. No reason to believe that the phenomenon is only useful for age-nine students. Rather, the results may be an appropriate generalization and representative for use on any elementary-level learner population.
3. Although conduct of this study is in Taiwan, it is still an appropriate generalization for use in any similar geographical locale.

**Research Questions**

1. Are computer games effective in facilitating third-grade students’ cognitive processes?
2. Do students with different prior knowledge levels (high and low) achieve differently?
3. Does interaction exist between different instructional procedures and learners’ levels of prior knowledge?

**Research Hypotheses**

Ho(1): No statistically significant differences exist in students’ achievement when they receive different instructional treatments.

Ho(2): No statistically significant differences exist in students’ achievement between the students identified as having high prior knowledge and the students identified as having low prior knowledge of “Nature and Technology” scores.

Ho(3): No statistically significant interaction exits in students’ achievement of different instructional treatments (computer-assisted instruction versus computer and video game playing) and students’ prior knowledge (previous exam score: high and low).
Chapter 2

REVIEW OF LITERATURE

This chapter reviews current literature concerning the effects of computer and video games on children’s cognitive development. This review of literature begins by providing a theoretical framework of children’s play, followed by research studies on children’s cognitive development from play and play materials. Next, cognitive theories related to children’s play are elaborated. The review then elucidates how CAI programs carry out cognitive theories of play. Finally, the review summarizes current research trends of computer and video games for early childhood education.

Another purpose of this chapter is to create a connection between computer and video games with children’s cognition. This chapter is also intended to provide a three-dimensional framework (cognitive development, children’s play, and computer and video games) to supplement the insufficiency of existing research results. Connecting each two of this three-dimensional framework constructs a profound theoretical foundation for this study.
Children’s Play

Children’s Play: A Theoretical Framework

Everybody knows that play is fun and that is why it consumes so much time. In early childhood education, children’s play also has long been regarded as an important element in furthering children’s social, emotional, motor, and cognitive development. For example, Piaget and Vygotsky (in Huang, 2003) gave play central importance in children’s intellectual development by viewing it in a broader context. Both of them regarded play as a manifestation of children’s cognitive function development. As early as the eighteenth century, the recurring theme of children is learning through play had already appeared in Rousseau’s (in Wolfe, 2000)famous piece “Emile”. Rousseau wrote of the child:

Work and play are all one to him, his games are his work; he knows no difference. He brings to everything the cheerfulness of his interest, the charm of freedom, and he shows then bent of his own mind and the extent of his knowledge. (p. 46)

Rousseau truly revealed children’s potential through play. Of course, at that time, the general public had difficulty believing two extremely different concepts: “play” and “learning” combined as one. People kept questioning the value of play as a learning mode, and its benefits on children’s learning and development. Despite the conservative attitude that play is a waste of valuable time and the observed lack of appreciation for play as a meaningful behavior (Cohen, 1993; Landreth, 1991; Schaefer, Gitlin-Weiner, & Sandgrund, 1991), the value of play in early childhood education has been acknowledged by more and more significantly positive research results. Perhaps the tremendous growth
of research on children’s play in twentieth century has elucidated the important role of play in children’s learning (Christie, 1991; Johnson, Christie, & Yawkey, 1999; Shen, 1998). During this prime time of child’s play, many varied theories developed provided differing definitions made by educators and researchers. The range of definitions may be as diverse as Montessori’s “Play is a children’s work” to Dewey’s “Play is what we enjoy while we are doing it. Work is what we enjoy when we have accomplished it.” (Hendrick, 1994) The concept of theories varied from the psychodynamic theory (Freud & Strachey, 1961), to the cognitive theory (Bruner, Jolly, & Sylva, 1976; Piaget, 1962; Singer, 1973; Sutton-Smith, 1972; Vygotsky & Cole, 1978), the arousal-modulation theory (Ellis, 1973), and on to Bateson’s theory (Fein, Rivkin, & National Association for the Education of Young Children., 1986; Garvey, 1990). Nevertheless, they all point to one central belief: play is critical to the theorization of development; it reflects children’s development, reinforces development, and results in development (Chang, 2001; Johnson, Christie, & Yawkey, 1999). Based on this theoretical foundation, the cognitive theorists like Vygotsky (1978) regard play as the main sources for development in child’s life because “play creates a zone of proximal development of child. In play a child always behaves beyond his average age, above his daily behavior; in play it is as though he were a head taller than himself” (p. 102).

Especially within the last thirty years, many educators and practitioners have embraced and extended cognitive theorists’ ideas that the play behaviors of children provide fascinating clues about what they are thinking and how they are thinking. According to Johnson, Christie, and Yawkey (1999), evidences exist linking play with six important clusters of cognitive variables: conceptual development, intelligence,
operational thinking, problem-solving skills, divergent thinking, and metacognition (p. 29).

Current research provides substantial evidence supporting the value of play for children’s learning and development. Researchers divide the value of play into three groups which are: developmental values, educational values, and expressive values. By focusing on development values, they include: cognitive development, affective development, social development, physical development, attention development, and language development (Chang, 2001). Cognitive development includes creativity (Sinetar, 1991), problem-solving, perspective-taking, representational competency, imagination, and so forth. This is the reason why so many preschool or primary school educators have long emphasized the role of play in today’s early childhood education, and advocated to the application of play in various kinds of early childhood curricula (e.g., Bennett, Wood, & Rogers, 1996; Bredekamp, Copple, & National Association for the Education of Young Children., 1997; Kieff & Casbergue, 2000). Understanding the important role of play in children’s cognitive development, early childhood educators became enthusiastic at any possibilities related to play that might benefit the child’s achievement such as types of play, the design of play environments, adult involvement, play materials, or applying new technology instruction.

**Play Materials and Children**

Even centuries ago, educators had already perceived that instructional materials and students’ learning performances were related to each other, such as when Rousseau
discussed the misuse of artificial teaching aids in his “Emile” (Rousseau, 1979), Pestalozzi and his theory about “object lessons” (Pestalozzi, 1850; Wolfe, 2000), or Froebel and his idea of “gifts.” Especially, Froebel felt that the materials provided to children were “gifts” from god, and along with the gifts Froebel designed activities to help children’s development (Wolfe, 2000). From recent research in early childhood education, educators also realized that certain types of materials tend to elicit specific forms of play (Johnson, Christie, & Yawkey, 1999). These types of materials include construction materials such as blocks, Legos® which can inspire constructive play; natural play materials include sand, mud, water, play dough which can be used to teach children shapes, mathematics and science, and other imagination generating materials such as dolls, cars, space ships, which can encourage dramatic play. Furthermore, via specific forms of play, play materials can serve as learning tools for children. Piaget, whose endeavors have lain the theoretical foundation for children’s study, indicated that the “sensory-motor” format of play bridges children’s concrete experiences with symbolic connection and abstract thought (Landreth, 1991; Piaget, 1962; Shen, 1998), thereby increasing the maturity of the child’s cognitive development. For example, through play with a ball or large hollow blocks, children can develop their basic physically capacities, and they learn problem solving skills, coping/conflict resolving skills, and realize their social roles within society in dramatic play with their dolls.

Also, more and more research results support positive perspectives about play materials and children’s achievement. Geismar already investigated the influence of play materials on infant-peer interaction. With toys present, complex types of social behaviors can be seen, especially in natural settings, and the use of fine motor and social/language
toys may contribute to the development of more complex and involving social behaviors (Geismar, 1984). As Stannard’s research indicated, a significant difference exits between preschool participants’ performance with construction play materials (e.g., blocks, Legos®, and carpentry) and their success in mathematics in later school years (Stannard, 1999). Lee (1996) also found that during pretend block play in the block center, children created talk and actions in order to deal with challenges related to various aspects of play (e.g., accessory play materials, construction, plot, and enactment). Even though time changed, toy companies keep producing new, fancy play materials in response to children’s changing interests and needs. After all, play materials will still have an unbreakable connection with children’s development in the present technology era.

**Entertaining Computer and Video Games as Play Materials**

Educators perceived that a variety of materials are useful and important for promoting the development of children literacy, mathematical and spatial understanding, concepts related to nature and science, and critical thinking (Bronson, 2003). That is the reason why instructional materials are continually revised and expanded throughout the school year in response to the children's changing needs and interests. The same rationale applies to explaining why children’s interests in play materials change from time to time. Technologies rapid advance in developing electronic media have been extensively applied in contemporary play materials to enrich children’s play, such as electronic or computerized toys, electronic story books, television, personal computers, and game consoles. Not only for children have these new play materials easily caught
educators and researchers’ attention over past fifty years. Especially for computer and video games, a great debate has emerged about how these games influence children’s behaviors, and what is the role of these new media in children’s learning.

No doubt computer-based video games have come under tremendous political pressure in recent years because of an increase in violent, aggressive, and sexual content. Despite many educators’ fears that computer and video games might suppress children’s imaginations, foster violence, aggression, negative imagery of women, or social isolation (Provenzo, 1991), other educators have taken an interest in what the effects these games have on players and how some of the motivating aspects of video games might be harnessed to facilitate learning (Squire, 2003). Many research reports already corroborate that play materials are related to children’s motor, cognitive, language, social, and emotional development. Recently, studies about computer and video games in these areas have begun to appear. Some educators have a vision that these games have the potential to become powerful motivating digital environments and they study video games in order to determine how motivational components of popular video games might be integrated into instructional design (Bracey, 1992; Squire, 2003).

Physical Domain

Sitting in front of television screen or computer monitor all day may not help children to develop their gross- and fine-motor strength. However, studies showed that computer and video games can promote hand-eye coordination, navigational performance, auditory discrimination, and spatial abilities (Johnson, Christie, & Yawkey, 1999; Jordan,
Moreover, Powell (2001) found that the rapid acquisition of experience acquired through computer games reduced learning time as measured by improved anticipation and reaction time. Except for these sensory related experimental studies, researchers have just begun to investigate utilizing simulation computer and video games for improving children’s motor skills. They believe that with appropriate accessory devices, such as virtual-reality goggles or control gloves, computer and video games may stimulate children to advance their motor skills.

**Cognitive Domain**

Educators used to view computer and video games as only some kind of entertainment media. However, in the last twenty years, people began to examine whether playing computer and video games would affect children's capabilities to perform certain cognitive functions (Christinaz, 1995; O'Brien, 1996; Vaupel, 2002). For example, Pillay (Spring 2002) commenced a study investigating the influence of recreational computer games on children’s subsequent performance of instructional tasks. The study’s findings suggested cause-and-effect games tended to encourage means-end analysis strategy, whereas adventure games encouraged inferential and proactive thinking. In the United Kingdom, researchers also were interested in the development of children’s ability to make and use inferences in the context of computer games (Ko, 2002). In addition, outcomes from several research studies showed that a significant correlation exists between game playing and children’s problem solving skills and cognitive styles (Dreyfous, 1994; Gee, 2003; Lenert, 1983; Queen, 1984).
Social Domain

Computer and video games usually give people an ineradicable image: one man sits in front of a machine playing games “alone.” The image implies that computer and video games might lead the individual to be isolated from the crowd, to live in a virtual world, and to lose the ability to interact with others. Recent studies intend to revolutionize this image, to argue that game playing is actually a highly social activity. Researchers found that children like to play games with friends; they play with and against others; they discuss games in online communities, and they share their experiences with others. Kurt Squire and Henry Jenkins (2003) also specified:

Games encourage collaboration among players and thus provide a context for peer-to-peer teaching and for the emergence of learning communities. Popular digital games do this already. Look up any popular game on the Internet and you find robust communities of game players debating games, sharing game tips, or offering critiques to designers. Game theorists use the term meta-gaming to refer to the conversations about strategy which occur around the actual game play itself as players share what they know, ask questions of more expert players and put their heads together to resolve vexing challenges (p. 20).

In addition, Johnson, Christie, and Yawkey (1999) found that children’s play is intricately involved in the socialization process. Since computer and video games have become a subculture in today’s society, the likelihood is that game playing is an influence on children’s learning.

Emotional Domain

When discussing the influence of computer and video games on young children, addressing the topic of violent and aggressive behaviors is very important. The most
serious concern of parents, teachers, and educators is the negative side effects of these games. Much research examined the short- or long-term effects of current violent or aggressive video games on children who play them (Abel-Cooper, 2000; Anders, Fall 1999; Bar-on et al., Nov 2001; Meyers, 1997; Sherry, Jul 2001). However, Squire (2003) has a different perspective on this issue by stating that “… video games effect is largely unfounded, and there is very little cause for concern about their effects on players” (p. 6). To sustain his point of view, he elucidated as follows:

In an attempt to determine if there are any connections between regular video game use and violent behavior or poor school performance, researchers have conducted survey studies looking for correlations between video game play and violent behavior, or video game play and poor academic performance (Dominick 1984; Lin & Lepper 1987). None of these studies uncovered any correlations between regular video game play and violence, aggression, anti-social behavior, or poor academic performance, although Lin and Lepper did find small negative correlations around (-.30) between regular arcade play and school performance. Perhaps, not surprisingly, children who spent more than 15 hours per week in arcades did not do well in school. In summary, research on video game violence has failed to show that video games cause violent, anti-social, or aggressive behavior or poor school performance. (p. 7)

Schaefer, Gitlin-Weiner, and Sandgrund (1991) showed that the most comprehensive method of expression for children is through play. Play can relieve children’s mental distress, transfer their feelings, and reflect their inner world. Moreover, toys help children project feelings and thoughts, which they could feel too threatened to express directly. (Landreth, 1991). Based on this study, computer and video games could be a good way for children to release their stresses. A similar result showed that computer and video games elicit powerful emotional reactions in their players, such as fear, power, aggression, wonder, or joy (Squire, 2003).
Cognitive Development for Children

Children with different backgrounds or ages often think and reason differently about the situations they encounter and the phenomena they observe. Educators believe that the diversities might cause differences in their cognitive development. Then, what is cognition? McDevitt and Ormrod (2004) states that: “cognition encompasses all the mental activities in which a person engages, including perception, categorization, understanding, inference drawing, logical reasoning, problem solving, imagination, and memory” (p. 140). For children, cognitive development is not only a process of physiological maturation, but also the result of their own efforts to make sense of the world.

Perceiving the importance of children’s cognition, researchers like Jean Piaget and Lev Vygotsky conducted numerous studies of children’s cognitive processes in the early 1920s. From the observations of children in problem-solving situations, Piaget (in McDevitt & Ormrod, 2004) derived a couple of concepts and principles related to children’s cognitive development. The principles are explained as follows:

- **Children are active and motivated learners**: Children are naturally curious about their world and actively seek out information to help them understand and make sense of it (Piaget, 1974).
- **Children organize what they learn from their experiences**: Piaget depicted learning as a very constructive process. Children actively create their understandings of the world rather than just passively absorbing their experience.
- **Children adapt to their environment through the processes of assimilation and**
accommodation: Children interpret each new event within the context of their existing knowledge (assimilation) but at the same time may modify their knowledge as a result of the new event (accommodation).

- **Interaction with their physical environment is critical for cognitive development:** By exploring and manipulating various objects around them, children acquire their new experiences, and these experiences are essential for their cognitive development.

  Vygotsky (1978) also proposed some factors that can promote children’s cognitive development.

- **Children can perform more challenging tasks when assisted by more advanced and competent individuals:** To get a true sense of children’s cognitive development, Vygotsky proposed that assessing their capabilities both when performing alone and when performing with assistance (McDevitt & Ormrod, 2004).

- **Challenging tasks promote maximum cognitive growth:** Vygotsky distinguished two levels of development: “actual development” and “potential development.” Between these two levels, he proposed an idea called “zone of proximal development (ZPD).” Vygotsky defines ZPD as “…the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.” (Vygotsky & Cole, 1978, p. 86). In his analysis, children learn little from the tasks that they can already do independently.

- **Play allows children to stretch themselves cognitively:** In Vygotsky’s words: “In play a child always behaves beyond his average age, above his daily behavior; in
play it is as though he were a head taller than himself (Vygotsky & Cole, 1978, p. 102).” In play activities, children rely on their imagination as much as on real objects; in the process, they learn to use their thoughts to guide their behaviors and explore the world.

Piaget’s and Vygotsky’s theories have inspired many research studies concerning the nature of children’s cognitive development. Based on their theories, educators have a better understanding of children’s cognitive developmental processes, and they put these theories into practices to help children improve their cognitive processes. Moreover, their theories have a profound influence on contemporary theories of children’s play theory and curriculum design in computer-assisted instruction (CAI).

Computer and Video Games

Computer-Assisted Instruction: A Historical Framework

Computers have extensively changed societies and people’s living since the 1940s. Observers have acknowledged this change, especially after the impetus of computer engineers in the 1960s. The most significant breakthrough in modern computing has been miniaturization of electronic components, making it possible to reduce size and costs. In the field of education, the developments of computer technologies, especially in the past few decades, make instructional technology more practicable than ever: “The prevalence of fast, relatively inexpensive computer technology and software has made it possible for schools to use computers in ways that were inconceivable…” (Marsh II,
During the 1970's, the University of Illinois developed a computer-assisted project called PLATO (Programmed Logic for Automatic Teaching Operations), which became the first large-scale effort to develop and evaluate computerized instruction. Headed by Donald Bitzer with funding from the National Science Foundation and Control Data Corporation, PLATO was developed to create computer-assisted instruction (CAI) materials for college, secondary, and elementary levels (Coburn, 1985). At that time, from the beginning, CAI programs received significant criticism, including questions about quality and assertions that CAI are boring and are often demeaned as “drill and practice.” Besides, teachers’ attitudes, lack of training personnel, extreme expectations, and limited applications all make the materials not very effective (Murphy & Appel, 1977). However, just like miniaturization can downsize a five tons mainframe to a three pounds laptop in only sixty years, instructional technology also has the potential for tremendous development in application and research theories.

**Cognitive Theory Effects on Computer Assisted Instruction**

The appropriateness of computers in early childhood environments always creates many arguments (Armstrong & Casement, 2000). Major concerns focused on the impact of computers on children’s social and emotional development (Wright & Shade, 1994). Due to these concerns, much research has been conducted about the impact of computers on early childhood education. Research findings were encouraging. Reports are that computers facilitated cognitive development by refining creative thinking and problem-solving skills. They have also improved children’s social interaction and language skills.
These studies also suggested that computers could be utilized successfully as an option within early childhood education classrooms without interfering with engagement in more traditional early childhood activities (Clements & et al., 1993; Nastasi & Clements, 1993). The positive findings regarding the effects of CAI on children’s cognitive development respond to cognitive theorists’ ideas as follows:

- **Cognitive development is, to a considerable degree, propelled by intrinsic motivation:** Motivation can be viewed as the internal processes that give behavior its energy and direction (Deci & Ryan, 1985; Reeve, 1996). CAI programs have four important factors that can motivate challenge, curiosity, control, and fantasy in children (Tzeng, 1999). Therefore, problem-solving programs create a high level of motivation that encourage children to make choices and decisions (Clements & et al., 1993).

- **Children actively construct their own knowledge and understandings:** From the constructivists’ perspective, CAI programs were designed as a tool to assist children in generating responses and in discovering and experiencing their worlds.

- **Children benefit only from experiences in which they can relate to what they already know:** Just like a personal tutor, CAI programs can provide as much individualized instruction as possible based on individual’s experiences and knowledge, and give children necessary assistance or feedback instantly. In addition, CAI programs can supply quantities of challenging tasks that fall just within an individual child’s ZPD to promote cognitive development.

  From the research literature, quality software, such as LOGO, can provide children with microworlds where they are allowed to invent and manipulate objects,
solve problems, and organize thinking (Clements & et al., 1993; Isikoglu, 2002; Liang, 1998).

**Computer Technology in Instruction**

Results from experimental research indicate indisputable proof that computers are highly effective for instruction. Research over the last thirty years found that instructional technology can be used to achieve educational goals with higher achievement scores, shorter time to criterion, and reduced costs (Cortez, 1996; O'Brien, 1996; Powell, 2001). For example, the finding from research showed that the use of CAI as a supplement to traditional, teacher-directed instruction produces achievement effects superior to those obtained with traditional instruction alone (Braun, 1990; Cotton, 1991; Hawley & et al., 1986; J. E. Kulik & Kulik, 1987; Rupe, 1986). As summarized in Stennett's (1985) *review of reviews*, “well-designed and implemented D&P [drill and practice] or tutorial CAI, used as a supplement to traditional instruction, produces an educationally significant improvement in students' final examination achievement” (p. 7). In sum, this finding holds true for students of different ages and abilities and for learning in different curricular areas. Researchers have also found that CAI enhances students’ learning rate. Student learning rate is faster with CAI than with conventional instruction. In some research studies, the students learned the same amount of material in less time than the traditionally instructed students; in others, they learned more material in the same time (Becker, 1990; Cotton, 1991; J. E. Kulik & Kulik, 1987; Stennett, 1985). Furthermore, according to researchers who have conducted comparative studies of
learning retention, they found that students’ retention of content learned using CAI is superior to retention following traditional instruction alone (Cotton, 1991; Grimes, 1977; J. A. Kulik, Kulik, & Bangert-Drowns, 1985; Rupe, 1986).

Despite the usage of computer technologies in an increasing number of varied disciplines in education, multimedia and Internet applications bring new possibilities to instructional technology. Specifically, the multimedia applications of current computers such as the CD-ROM, Internet, and other applications that combine text, sound, image, video, and animation in various ways that provide new methods for drill, didactic instruction, interaction, simulation, and tutorials have expanded the popularity and capacity for instruction. Kumpulainen and Mutanen (1998) also indicated that computer-based multimedia, with its special characteristics, can easily create a motivating and flexible learning environment that leads learners to intensive engagement.

**Computer and Video Games as CAI Tools**

The use of computer technology and CAI software in early childhood education already significantly changed the way people teach and learn. Nowadays, teachers deliver their lectures using a variety of formats, such as print, television, computer, Internet, and even video games. And all these media have possibilities to improve children’s learning. From *Understanding Children’s Literature* of Hunt (2003), Nodelman asserted that: “We provide children with books like this [picture books] on the assumption that pictures communicate more naturally and more directly than words, and thus help young readers make sense of the texts they accompany” (p. 70). In other words,
young children are not capable of reading the texts as older children or as adults do because they lack vocabularies. This implies that those messages the teachers present through plain texts may not make sense to the children. Children may be alone in sorting out information and thoughts in this situation. Teachers have to find ways to present the information and increase the students’ understanding of their lectures. Therefore, with a little help, like sound, image, video, and animation, this gap can be fulfilled. The statement from Rosenblatt (1978) elucidated how images work with texts: “The literary work exists in a live circuit set up between reader and text; the reader infuses intellectual and emotional meanings into the pattern of verbal symbols and these symbols channel his thoughts and feelings. Out of this process emerges a more or less organised imaginative experience” (p. 25). This statement is not only apposite for images, but also explains why children thought the multimedia applications were more interesting than books. For the same reason, all forms of media, television, movies, CAI (Computer assist Instruction) software, or video games, use this characteristic of multimedia to magnetize audiences.

**Cognitive Domain: Extended to Computer and Video Games**

Previously, educators regarded computer and video games as some kind of entertainment media. But in the last twenty years, they began to examine whether playing computer and video games would affect children's capabilities to perform certain cognitive functions (Christinaz, 1995; O'Brien, 1996; Vaupel, 2002). For example, Pillay commenced a study in investigating the influence of recreational computer games on children’s subsequent performance on instructional tasks. The study’s findings suggested
that cause-and-effect games tended to encourage means-end analysis strategy, whereas adventure games encouraged inferential and proactive thinking (Pillay, Spring 2002). In the United Kingdom, researchers also were interested in the development of children’s ability to make and use inferences in the context of computer games (Ko, 2002). More specifically, games are seen as ways of addressing and reflecting many individual needs. Computer and video games provide a fantasy and imagination rich environment where children can explore new worlds and take on new challenges (McVey, 1997; Provenzo, 1991). In addition, outcomes from several research studies proved a significant correlation exists between game playing and children’s problem solving skill and cognitive style (Dreyfous, 1994; Gee, 2003; Lenert, 1983; Queen, 1984).

According to Gee (2003), computer and video games can be used to improve children’s literacy. He states,

> In the modern world, print literacy is not enough. People need to be literate in a great variety of different semiotic domains…. since there are different types or genres of video games (e.g., First-person shooter games, fantasy role-playing games, real-time strategy games, simulation games, etc.). People can be literate, or not, in one or more of these video-game semiotic domains. However, in talking about learning and literacy in regard to video games, I hope to develop, as well, a perspective on learning, literacy, and semiotic domains that applies more generally to domains beyond video games. (p. 19)

Research in cognitive development suggests that reading qualitative features implicitly displayed on the computer screen requires schemas not only for processing information explicit in the graphics but also for generating and transforming complex mental representations such as those required in problem solving (Pillay, Spring 2002).

In the "E-GEMS" (Electronic Games for Education in Math and Science) laboratory, researchers conducted studies on how upper elementary-aged children interact
with computers, and investigated curriculum, behavior and psychological issues involved in the design and use of educational computer games. Games-to-Teach, a partnership project between MIT and Microsoft, is developing conceptual prototypes for the next generation of interactive educational entertainment. In the United Kingdom, the Computer Games in Education (CGE) project was established to investigate the potential of integrating elements of game design and technology into software for education. Squire (2003) indicated that all of these trends showed one very important thing: educators have noticed the important role of computer and video games, and begun designing appropriate digital environments specifically to foster learning.

Despite the fact that none of these research projects have direct evidence showing that playing computer and video games can improve students’ academic performance, all of these researchers believe that computer and video games could be held as significant for developing thinking skills (identified as information processing, reasoning, enquiry, creative thinking, and evaluation skills). The Computer Games in Education report indicated that

If the level of challenge was appropriate for the pupils, their engagement with the game involved problem solving and critical thinking skills such as devising strategies, considering options and taking rational decisions. Success with the games involved a requirement that the pupil think logically, planning ahead and considering the interaction on outcomes of a range of factors of some complexity (Becta, 2001, p. 10).
Chapter 3

RESEARCH METHODOLOGY

This study investigates the effect of computer and video game playing on children’s learning achievement for third-grade students in Taiwan. A subsidiary purpose includes determination of the effect of prior knowledge on student’s learning performance. Hence, this chapter includes: (a) a description of participants, (b) an introduction to instructional materials, (c) an explanation of research procedures, (d) a description of treatment designs, and (e) a justification of the methodology used.

Participants

The chosen participants were from a middle/high socio-economic standard school district in Tainan City, Taiwan. The first consideration in selecting a participating school is the availability of computer laboratory facilities. The selected school laboratories should contain at least thirty well-functioning computers, with multimedia capability. The other critical prerequisite is at least half of these computers have installed a 3D graphic card accelerator with 64 MB RAM for performing the selected instructional material. Only one elementary school fulfills these conditions for participating in the study.
One hundred and thirty-six third-grade students from Chunghsueh Elementary School were recruited to participate in this study. After contacting the participants’ parents, one hundred and fifteen participants agreed to participate in the study. The learning prerequisite for participants was the ability to use basic computer tools and Internet-browsing resources. Since the computer lessons have became required courses for all third-grade elementary school students, every participant met this prerequisite.

**Instructional Materials**

The instructional topic used for this study was “fire-fighting.” In this study, instructional content covered the basic knowledge about the danger of fire and the firefighting techniques (see Appendix A). The reason for selecting “fire-fighting” was not only because fire is everpresent, but also because knowing about fire, students will gain understanding of how to protect themselves from it. As benefit for the study, the content was chosen because it covers a variety of educational objectives (facts, concepts, comprehensions), and it is not related to the participants’ courses, thus avoiding potential threats to internal validity of the study.

Two different instructional materials: computer-assisted instruction and a computer game were used in this study. “Fire Department 2: Fire Captain,” a 3D Real-Time Strategy game developed by Monte Cristo Games™ was chosen for this study (see Appendix C). This computer game has been assessed by the Pan-European Game Information (PEGI) age rating system, and has been approved for children seven years and older. A unit plain hypertext instructional material was also developed for computer-
assisted instruction in this study. The content of this computer-assisted instruction is outlined in Appendix B. Two elementary school teachers in Taiwan reviewed this instructional material in its Chinese version. Also, the listed translator has approved the translation from Chinese to English (see Appendix L).

**Independent Variables**

Two independent variables were examined in this study: (1) different types of instructional treatments and (2) students’ prior examination scores. Two groups (the computer-assisted instruction versus computer and video game playing) were identified for the variable of instructional treatment. And two levels (high score versus low score in “Nature and Technology” examination) were identified for the variable of prior knowledge of examination scores.

**Dependent Variables**

The dependent variables used in the study were the outcome of participants’ post-test scores and the results of the three sub-categories in the post-test. A post-test was designed for the study containing twenty-eight items. It has a total of one hundred points (see Appendix D). The following details the three sub-categories in the post-test:

1. Part 1: Multiple-Choice (16 items): Part 1 measures knowledge of specific facts, terms, and definitions by asking participants to answer multiple choice
questions that relate to the topic of fire-fighting. The objectives measured in this test require an understanding of factual materials and concepts.

2. Part 2: Matching (6 items): Part 2 evaluates participants’ ability to associate specific terms from a list of appropriate context. The objectives measured in this test also focus on recalling facts and identifying factual information. The difference between part 1 and part 2 is that for matching up specific terms, participants need to analyze and compare the similarities and differences in the descriptions.

3. Part 3: Application (6 items): In part 3, participants are required to demonstrate their understanding of how to put out a fire as a firefighter in an emergency scenario. This part requires that participants thoroughly understand the danger of fire, fire safety information, and fire-fighting processes during a rescue scene. The test measures a higher-level cognitive task that shows understanding of what is being taught and its use in other circumstances.

**Instructional Treatments**

The experimental study required one hundred and fifteen third grade students to compare different types of instructional treatments by looking at their learning performance. By using similar contents, this study investigated which instructional treatment better effects students’ cognitive learning (the computer-assisted instruction versus computer or computer game playing). Different instructional treatments were
designed and selected for this study. A description of each instructional treatment and sample screenshots follows:

**Control Group**

Participants in the control group (CG) learned by interacting with computers individually. The contents of the computer-assisted instruction in this study used a plain text hypertext format. This hypertext with fire-fighting content was presented in one single Web page without hyperlinks. The content included (1) elements of fire (see Figure 3.1), (2) fire categories, (3) fire-fighting techniques (see Figure 3.3), and (4) fire safety information (see Figure 3.5). Participants determined their own reading paces by dragging the scrolling bar on the right side of the Web browser. No teacher was involved in this study and the researcher provided only technical support to the participants if it needed. Several screenshots of this treatment in Chinese version are shown in Figure 3.2, Figure 3.4, and Figure 3.6. The complete instructional treatment can be found at: http://www.personal.psu.edu/users/t/x/txc258/CGC.htm, and the translated English version instructional material can be found at:

http://www.personal.psu.edu/users/t/x/txc258/CG.htm
I. The Elements of Fire

For a fire to start, the following are required: Oxygen, Fuel, and Heat.

Very many common materials around the home and the school can act as fuels, like wood, paper, and cotton. Heat is essential to the burning process. If fresh fuel is not heated, then a fire cannot spread. The effects of the fire result from the movement of heat away from the flame and into an adjacent area, where there is fresh fuel. Take the heat away and the fire goes out.

To prevent fire, we need to eliminate or reduce the availability of these ingredients. Since oxygen can’t be easily eliminated (it is always present in the air), the focus of fire prevention is on heat and heat sources.

II. This is Fire

Fire is FAST!

There’s little time!

In less than 30 seconds a small flame can get completely out of control and turn into a major fire. It only takes minutes for thick black smoke to fill a house. In minutes, a house can be engulfed in flames.

Most fires occur in the home when people are asleep. If you wake up to a fire, you won’t have time to grab valuables because fire spreads too quickly and the smoke is too thick. There is only time to escape.

Fire is HOT!

Heat is more threatening than flames.

A fire’s heat alone can kill. Room temperatures in a fire can be 100 degrees at floor level and rise to 600 degrees at eye level. Inhalation of this super hot air will scorch your lungs. This heat can melt clothes on your skin in five minutes a room can get so hot that everything in it goes up at once. This is called flashover.

Fire is DARK!

Fire isn’t bright, it is pitch black.

Fire starts bright, but quickly produces black smoke and complete darkness. If you wake up to a fire you may be blinded, disoriented and unable to find your way around the home you’re in or exit.

Fire is DEADLY!

Smoke and toxic gases kill more people than flames do.

Fire uses up the oxygen you need and produces smoke and poisonous gases that kill. Breathing even small amounts of smoke and toxic gases can make you dizzy, disoriented and short of breath. The odorless, colorless fumes can kill you in a deep sleep before the flames reach your door. You may not wake up in time to escape.

III. Fire Categories

It is important that the type of fire is identified first:

<table>
<thead>
<tr>
<th>Categories</th>
<th>Type</th>
<th>Fires caused by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A fires</td>
<td>classic fire</td>
<td>The category of fire relates to the most ordinary combustible materials in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>standard civil buildings: wood, fabrics, rubber, etc.</td>
</tr>
<tr>
<td>Class B fires</td>
<td>liquid fires</td>
<td>These fires are often stronger than class A and mainly occur at industrial sites</td>
</tr>
<tr>
<td></td>
<td></td>
<td>by excluding the oxygen in the surrounding</td>
</tr>
</tbody>
</table>

Figure 3.1: Screenshot#1 of Control Group

Figure 3.2: Screenshot #1 of Control Group in Chinese Version
Figure 3.3: Screenshot #2 of Control Group

Figure 3.4: Screenshot #2 of Control Group in Chinese Version
Figure 3.5: Screenshot #3 of Control Group

Figure 3.6: Screenshot #3 of Control Group in Chinese Version
Experimental Group

The intention of this study is to determine whether computer games support students’ cognitive processes. With this hypothesis, one game called “Fire Captain” was chosen for this study for the experimental group (EG). This computer game utilized similar instructional content as the control group. The primary goal of this game is to master all kinds of knowledge and skills to prevent fire. Although, five single player campaigns with increasingly complex missions constitute this game, the tutorial mission is one that participants have to play first in the study (see Figure 3.7). In the tutorial mission, the participants learned everything they need to know to be a firefighter through each relevant and inclusive introductory task. Several screenshots of this game are shown in Figure 3.8 and Figure 3.9. As a Real-Time Strategy game, the players need to put out a fire at the end of tutorial mission, and their performance was graded by the game (see Figure 3.10). To avoid interference with others, no teacher was involved in this study during the experiment. As in the control group, the researcher provided only technical support to the participants if it needed.
Figure 3.7: Screenshot of Main Menu in “Fire Captain”

Figure 3.8: Screenshot of Backdraft Introduction
Figure 3.9: Screenshot of Fire Categories Introduction

Figure 3.10: Screenshot of Game Grading System
Pilot Study

One pilot study was conducted before the official study was scheduled. The purposes of the pilot study were to identify where in the instruction participants experienced difficulties and also to identify potential procedural problems that might occur in implementing the formal study.

Participants

The participants were three third-graders from the same middle/high, socio-economic standard, school districts in Taiwan. They were enrolled in three different elementary schools and have different academic levels: high, middle, and low. The pilot study goal included providing a basis for remedial improvement of original instructional materials.

Procedures

First, participants were required to play the computer game “Fire Captain” individually. Participants could ask any question or request for any help from the researcher in this period. The researcher observed and recognized players’ difficulties with the game by interacting with the participants. After playing the game, participants were required to browse the instructional Web page and then complete a short quiz. At this period, the participants could still ask questions, but the researcher provided only necessary support to the participants. The time each participant used in each stage was
measured and recorded for the pilot study. The qualitative results obtained provided several suggestions that eventually contributed to configuration of the formal study.

Results

The following observations were made from the pilot study:

1. In the beginning, all participants had trouble with mouse control which retarded the participants’ proceeding with the game.
2. Two participants complained that the captions in the game were too small to be read.
3. One participant, with a low academic level, had difficulties finishing the instructional Web page in thirty minutes. The wording in the Web page needed to be easier for third-graders to read and comprehend.
4. The directions in the quiz should be clearer making them easier for the participants to follow.

A few changes were made according to the previous observations:

1. Before the official study started, a short demonstration of game operation was presented for the experimental group.
2. The research found a patch from the “Fire Captain” game forum. After applying this patch to the game, the size of fonts in the game captions increased. Figure 3.11 and Figure 3.12 show the difference the patch made.
3. The contents in the instructional Web page and quiz were revised.
Figure 3.11: Screenshot of the Original Captions with Small Font

Figure 3.12: Screenshot of the Captions Patch Installed with Larger Font
Experimental Procedures

After obtaining approval from the Office for Regulatory Compliance at the Pennsylvania State University, the researcher contacted the principal of Chunghsueh Elementary School in order to obtain a formal agreement for conducting this study during the Spring semester of 2005. Appendix F shows the approval letter for the study, and Appendix H shows the consent form from the school principal. Two weeks prior to the formal study, Parental Consent Forms (see Appendix J) were distributed to students. The Parental Consent Forms need to be signed by the recruited students’ parents. For legitimate use of the computer game “Fire Captain” in the study, the researcher acquired the authorization for educational purposes from Genius Interactive Corporation, the agent for “Fire Captain” in Taiwan (see Appendix K). After finishing the consent procedure, the researcher could officially initiate collecting data for the study.

Sampling for Preliminary Study

The target population of one hundred fifteen third-graders from Taiwan wasdivided into two groups (high prior knowledge: \(n=58\), and low prior knowledge: \(n=57\)) based on their previous scores in “Nature and Technology.” Then, the two groups were randomly assigned to one control group and one experimental group (see Table 3.1).
Randomization, according to Cook and Campbell (1979), is a sampling procedure that ensures that each person in a defined population has an equal chance of being selected to participate in a study. When conducting an experiment, randomization can also overcome most of the potential threats to internal validity of experimental research design—for example, history, maturation, and differential selection.

The reason for selecting “Nature and Technology” scores as the criterion of prior knowledge is due to its use in curriculum for developing children’s cognitive processes, such as, facts, concepts, problem-solving strategies, and higher-order thinking skills.

According to the Ministry of Education (1999) in Taiwan, in “The New 1-9 Curriculum,” traditional subjects were replaced by seven major domains of learning: (1) language and literature, (2) health and physical education, (3) social studies, (4) arts and humanities, (5) mathematics, (6) nature and technology, and (7) integrated activities. In those domains, “Nature and Technology” is the curriculum focusing on developing students’ abilities in independent thinking and perceiving the relationships between people, nature, and science through everyday life. In addition, through exploring and observing, students develop methods of coordinating science to their lives. Based on the above reasons,

Table 3.1: Summary of Participants

<table>
<thead>
<tr>
<th>Prior Knowledge</th>
<th>N</th>
<th>Treatment Groups</th>
<th>N</th>
<th>Gender</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>58</td>
<td>CG</td>
<td>58</td>
<td>Male</td>
<td>61</td>
</tr>
<tr>
<td>Low</td>
<td>57</td>
<td>EG</td>
<td>57</td>
<td>Female</td>
<td>54</td>
</tr>
</tbody>
</table>

Total n=115
“Nature and Technology” is the best available source for prior knowledge for this study to in order to measure participant’s learning level and cognitive capability.

**Procedures**

Participants were asked to participate in two instructional sessions. Estimates were that each session would take 40 minutes (the length of a regular class period in elementary schools in Taiwan), for a total of 80 minutes. In the first session, the control group received a unit of computer-assisted instruction about fire-fighting. The experimental group was asked to play the computer game “Fire Captain.” In the next session, all participants were required to take a quiz to allow assessing their learning achievements.

**Treatments**

One day before conducting experiment, the researcher checked that all computers in the computer laboratory had access to the Internet, and made the final confirmation that half of them (twenty computers) had “Fire Captain” and a 3D graphic card accelerator installed. For the computers operated by the experimental group, headphones were also available. With the headphones, the participants could hear the audio directions during instruction.

On the day when the experiment was conducted, participants were asked to go to computer laboratory five minutes early before the class began. In the computer
laboratory, the researcher assigned each participant a seat according to treatment groups. At this time, all computer monitors were off, but the computers were running. Before the class began, the researcher double-checked that all participants had the correct instructional materials.

As the experiment began, the researcher asked the participants to turn on their monitors. For the participants in the control group, their monitors showed a plain text Web page immediately. The researcher informed the participants that they would have 35 minutes to read through the instructions. The participants could browse the contents at their own pace. As soon as they finished the text-based instruction, they can raise their hands to report to the researcher the completion of the task. However, anyone who finished early had to remain seated and wait for the other children to finish until the time was up.

For the experimental group at the beginning of the class, the researcher used five minutes to demonstrate the skills of mouse control for the computer game. After the demonstration, the experimental group turned on their monitors, put on headphones, and began playing the computer game. The main menu of “Fire Captain” appeared in their monitors. Participants also had 35 minutes to explore this game freely. However, they had to finish the tutorial mission as soon as possible. How fast they completed the tutorial mission was a significant factor for evaluating their ranking at the end of the mission. Participants had permission to raise their hands at anytime to ask for any technical support during this session.
Assessment

After receiving various instructional treatments, each participant was required to take a quiz during the second session. The quiz was designed and developed to assess participants’ learning achievements after finishing their instruction. From three categories of questions—Fact/Recall, Analysis/Comparison, and Understanding/Problem-solving, different types of learning outcomes were determined. The researcher was graded and recorded all the post-tests. The post-test is shown in Appendix E.

Research Design

This study investigated the effect of varied types of instructional treatments (computer-assisted instruction versus computer and video game playing) and prior knowledge (previous “Nature and Technology” score: high versus low) on individual learning achievement for third-grade students. This is a typical two-factor experiment. Gall, Borg, and Gall (1996) explain that a factorial experiment is “an experiment in which the researcher determines the effect of two or more independent variables (i.e., factors)—both singly and interaction with each other—on a dependent variable” (p.508). Therefore, this study is a 2 X 2 factorial design (see Figure 3.13) because it contains two variables of treatment (CG, EG) of one independent factor (different instructional treatments), and two variables (levels) (high versus low) of the other independent factor (prior knowledge). The dependent variables were the outcome of participants’ post-test scores and the results of the three sub-categories in the post-test.
Since the dependent variables are typically related statistically and conceptually (Yoder, 2002), and the statistical correlation should be in the range of a low to moderate level (Tabachnick & Fidell, 2001). A Multivariate Analysis of Variance (MANOVA) was performed to analyze the results. Furthermore, the real value of using MANOVA is in controlling Type I error (also known as false positive error) while analyzing multiple dependent variables simultaneously.

![Study Framework](image)

Figure 3.13: Study Framework
Chapter 4

RESULTS

Introduction

The purpose of this study was to assess, compare, and analyze the effects of different instructional treatments and varied prior knowledge on children’s learning achievements for elementary school students in Taiwan. In this chapter reports the results of the statistical analyses which examine the effects of the treatments.

Data Description

The data for this research were collected from a random sample of third-grade students enrolled in the Chunghsueh Elementary School in Tainan City, Taiwan. One hundred and thirty-six third graders were expected to participate in this study. After contacting the participants’ parents, one hundred fifteen participants agreed to participate. After instructional treatments and concluding the post-test, a total of 108 participants had completed the experiment. The drop-out rate for the study was 6.1%.

The data used for statistical analysis were collected from three sources: (1) “Nature and Technology” scores of each participant, which was provided by the school, (2) the results of the post-test scores, and (3) the results of the three sub-categories in the post-test. The reliability analysis of the post-test showed internal consistency of the test scores. By using Cronbach’s Coefficient Alpha, an overall reliability of .88 was reported.
for this study. Specific reliability for sixteen items in Part 1: Multiple-Choices was .86, and .71 for the six items in Part 2: Matching.

**Statistical Analysis**

To test significant differences in learning achievement among the treatments (computer-assisted instruction versus computer and video game playing), a two-way multivariate analysis of variance (MANOVA) was performed. Multiple analysis of variance in Statistical Package for the Social Sciences (SPSS) was used to examine main and potential interaction effects of categorical variables on multiple interval/ratio dependent variables. That is, MANOVA tests for population group differences on several dependent variables simultaneously by creating vectors of the multiple dependent variables (Garson; Yoder, 2002). Thus, in conducting a two-way MANOVA for this study, varied types of instructional treatments and different levels of students’ prior knowledge were used as independent variables (i.e., nominal scale); the outcome of students’ multiple measure scores of the post-test were the dependent variables (i.e., interval/ratio scale). An alpha level of .05 was set for analysis the significant difference of testing hypotheses. Prior to using MANOVA, the researcher examined the test score results and found the test score distribution to be fairly normal with no extreme outliers. All the statistical analyses were conducted by using Microsoft Excel XP and SPSS Release 13.0 for Windows.
Descriptive Profile of “Nature and Technology” Scores

The “Nature and Technology” scores were used to group students into two levels of prior knowledge, high prior knowledge and low prior knowledge. According to the “Nature and Technology” score median (Web CAI group: Mdn=93.2, Video Game group: Mdn=93.3), participants were evenly divided into high and low level of prior knowledge. From the results of the “Nature and Technology,” Web CAI group (M=91.68), and Video Game group (M=91.28) showed similar means (see Table 4.1). Thus, each group contained subjects with almost the same quality (level of prior knowledge test scores) and number of subjects (Web CAI group: n=58, Video Game group: n=57).

Table 4.1: Prior Knowledge Score

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web CAI</td>
<td>58</td>
<td>91.68</td>
<td>5.68</td>
<td>93.20</td>
</tr>
<tr>
<td>Video Game</td>
<td>57</td>
<td>91.28</td>
<td>6.68</td>
<td>93.30</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>91.49</td>
<td>6.17</td>
<td>93.30</td>
</tr>
</tbody>
</table>

Scores could range from 0 to 100

Results of the subgroup analysis reveal (see Table 4.2), group means showed fairly large differences between the Web CAI group (M=70.05) and the Video Game group (M=76.18). Post-test mean scores of low prior knowledge participants in the Web CAI group (M=63.07), and Video Game group (M=70.96) showed differences approaching eight points. Also, similar findings for high prior knowledge level participants existed (Web CAI group: M=76.33, Video Game group: M=81.60).
Table 4.2: Descriptive Statistics Results of Subgroup Analysis

<table>
<thead>
<tr>
<th>Test</th>
<th>Prior Knowledge</th>
<th>Treatment Groups</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Web CAI</td>
<td>52.1333</td>
<td>5.70380</td>
<td>30</td>
</tr>
<tr>
<td>Part 1 (0-64 points)</td>
<td></td>
<td>Video Game</td>
<td>55.6800</td>
<td>4.60724</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>53.7455</td>
<td>5.48472</td>
<td>55</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>Web CAI</td>
<td>45.1852</td>
<td>9.20300</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Video Game</td>
<td>48.9231</td>
<td>7.18289</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>47.0189</td>
<td>8.40899</td>
<td>53</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>Web CAI</td>
<td>48.8421</td>
<td>8.27170</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Video Game</td>
<td>52.2353</td>
<td>6.90098</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>50.4444</td>
<td>7.80766</td>
<td>108</td>
</tr>
<tr>
<td></td>
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<td>Web CAI</td>
<td>12.5000</td>
<td>4.10004</td>
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</tr>
<tr>
<td>Part 2 (0-18 points)</td>
<td></td>
<td>Video Game</td>
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<td>4.24264</td>
<td>25</td>
</tr>
<tr>
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<td></td>
<td>Total</td>
<td>12.5455</td>
<td>4.12678</td>
<td>55</td>
</tr>
<tr>
<td>Low</td>
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<td>Web CAI</td>
<td>8.7778</td>
<td>4.62712</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Video Game</td>
<td>10.8462</td>
<td>3.80202</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>9.7925</td>
<td>4.32950</td>
<td>53</td>
</tr>
<tr>
<td>Total</td>
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<td>Web CAI</td>
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<td>4.70762</td>
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<tr>
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<td></td>
<td>Video Game</td>
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<td></td>
<td>Total</td>
<td>11.1944</td>
<td>4.42900</td>
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<tr>
<td>Post-Test Total Score</td>
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<td>Web CAI</td>
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<td>3.37486</td>
<td>30</td>
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<tr>
<td>(0-100 points)</td>
<td></td>
<td>Video Game</td>
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<td>2.60960</td>
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<tr>
<td></td>
<td></td>
<td>Total</td>
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<td>3.13146</td>
<td>55</td>
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<tr>
<td>Low</td>
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<td>Web CAI</td>
<td>9.1111</td>
<td>3.94514</td>
<td>27</td>
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<tr>
<td></td>
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<td>Video Game</td>
<td>11.1923</td>
<td>4.53448</td>
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<td>4.33251</td>
<td>53</td>
</tr>
<tr>
<td>Total</td>
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<td>Web CAI</td>
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<td>3.85035</td>
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<tr>
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<td></td>
<td>Video Game</td>
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<td>3.83452</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>11.3056</td>
<td>3.92561</td>
<td>108</td>
</tr>
<tr>
<td></td>
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<td>Web CAI</td>
<td>76.3333</td>
<td>8.55543</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Video Game</td>
<td>81.6000</td>
<td>7.47774</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>78.7273</td>
<td>8.43593</td>
<td>55</td>
</tr>
<tr>
<td>Low</td>
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<td>Web CAI</td>
<td>63.0741</td>
<td>13.56729</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Video Game</td>
<td>70.9615</td>
<td>10.98173</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>66.9434</td>
<td>12.87875</td>
<td>53</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>Web CAI</td>
<td>70.0526</td>
<td>12.96068</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Video Game</td>
<td>76.1765</td>
<td>10.76978</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>72.9444</td>
<td>12.31049</td>
<td>108</td>
</tr>
</tbody>
</table>
Correlations between Multiple Dependent Variables

MANOVA assumes that multiple dependent variables relate statistically and conceptually (Yoder, 2002). According to this assumption, correlations between multiple dependent variables should be checked before conducting MANOVA. As Table 4.3 indicates, most of the dependent variables have statistically significant correlations with one another (p<.01) in the range considered appropriate by Tabachnick and Fidell (2001).

Table 4.3: Correlations between Multiple Dependent Variables

<table>
<thead>
<tr>
<th></th>
<th>Part 1</th>
<th>Part 2</th>
<th>Part 3</th>
<th>Post-Test Total Score</th>
<th>Prior Knowledge Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>1</td>
<td>.349**</td>
<td>.341**</td>
<td>.869**</td>
<td>.534**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>108</td>
<td>108</td>
<td>108</td>
<td>108</td>
<td>108</td>
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<tr>
<td>Part 2</td>
<td>Pearson Correlation</td>
<td>.349**</td>
<td>1</td>
<td>.301**</td>
<td>.677**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.002</td>
<td>.000</td>
<td>.013</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>108</td>
<td>108</td>
<td>108</td>
<td>108</td>
<td>108</td>
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<tr>
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<td>.301**</td>
<td>1</td>
<td>.644**</td>
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<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.002</td>
<td>.000</td>
<td>.001</td>
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</tr>
<tr>
<td>N</td>
<td>108</td>
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<td>108</td>
<td>108</td>
<td>108</td>
</tr>
<tr>
<td>Post-Test Total Score</td>
<td>Pearson Correlation</td>
<td>.869**</td>
<td>.677**</td>
<td>.644**</td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
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<tr>
<td>N</td>
<td>108</td>
<td>108</td>
<td>108</td>
<td>108</td>
<td>108</td>
</tr>
<tr>
<td>Prior Knowledge Score</td>
<td>Pearson Correlation</td>
<td>.534**</td>
<td>.239*</td>
<td>.324**</td>
<td>.528**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.013</td>
<td>.001</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>108</td>
<td>108</td>
<td>108</td>
<td>108</td>
<td>115</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
By examining the Levene’s test of equality of error variances, the results showed that most of the dependent variables had equal variances (p>.05). Based on the above results, a two-way MANOVA was conducted.

**Results of Multivariate Analysis of Variance (MANOVA)**

Table 4.4 reports MANOVA results for the effect of each independent variable and the interaction between treatment and prior knowledge on the dependent variable. Interaction between prior knowledge and different treatment groups was not significant at the p-value of .05 and the value of Pillai’s Trace was .014. However, significant omnibus effects for prior knowledge and treatment group were found (p<.05).

**Table 4.4: Multivariate Tests**

<table>
<thead>
<tr>
<th>Effect</th>
<th>Pillai’s Trace</th>
<th>F (b)</th>
<th>Hypothesis df</th>
<th>Error df</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
<th>Observed Power(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>.983</td>
<td>2001.302</td>
<td>3.000</td>
<td>102.00</td>
<td>.000</td>
<td>.983</td>
<td>1.000</td>
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<tr>
<td>Treatment Group</td>
<td>.104</td>
<td>3.950</td>
<td>3.000</td>
<td>102.00</td>
<td>.010</td>
<td>.104</td>
<td>.819</td>
</tr>
<tr>
<td>Prior Knowledge</td>
<td>.255</td>
<td>11.660</td>
<td>3.000</td>
<td>102.00</td>
<td>.000</td>
<td>.255</td>
<td>.999</td>
</tr>
<tr>
<td>Prior Knowledge * Treatment Group</td>
<td>.014</td>
<td>.500</td>
<td>3.000</td>
<td>102.00</td>
<td>.683</td>
<td>.014</td>
<td>.149</td>
</tr>
</tbody>
</table>

a  Computed using alpha = .05  
b  Exact statistic  
c  Design: Intercept+Prior Knowledge+Treatment Group+Prior Knowledge * Treatment Group
Univariate analyses (Tabachnick & Fidell, 2001) results (Table 4.5) reveal that the independent variables had significant main effects on the dependent variables in all the tests except for the Part 2 test.

Table 4.5: Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Dependent Variable</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Groups</td>
<td>Part 1</td>
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<td>1</td>
<td>356.542</td>
<td>7.499</td>
<td>.007</td>
<td>.067</td>
</tr>
<tr>
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<td>Part 2</td>
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<td>31.592</td>
<td>1.788</td>
<td>.184</td>
<td>.017</td>
</tr>
<tr>
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<td>Part 3</td>
<td>92.042</td>
<td>1</td>
<td>92.042</td>
<td>6.777</td>
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<td>.061</td>
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<td>Post-Test</td>
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<td>1162.595</td>
<td>10.733</td>
<td>.001</td>
<td>.094</td>
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<tr>
<td></td>
<td>Total Score</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Prior Knowledge</td>
<td>Part 1</td>
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<td>26.543</td>
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<tr>
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<td>11.403</td>
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<td></td>
</tr>
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<td>Prior Knowledge *</td>
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<td>Error</td>
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<td>108.322</td>
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<td></td>
</tr>
<tr>
<td>Total</td>
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</table>
Research Questions

The following research questions were addressed using data from this study:

1. Are computer games effective in facilitating third-grade students’ cognitive processes?
2. Do students with different prior knowledge levels (high and low) achieve differently?
3. Does interaction exist between different instructional procedures and learner’s level of prior knowledge on student scores?

Three hypotheses were developed to examine above research questions.

**Hypothesis 1: Instructional Treatments**

**Hypothesis 1:** No statistically significant differences exist in students’ achievement when they receive different instructional treatments.

Hypothesis 1 intends to investigate the effect of different instructional treatments on student’s achievement. As Table 4.5 reports, univariate analysis was conducted for the post-test and each of the three sub-categories.

**Part 1: Multiple-Choice Test Results**

Univariate analysis results for Part 1 show that significant differences between treatment groups exist (F=7.50, p<.05). Therefore, for Part 1, the null hypothesis was rejected. Compared to the Web CAI control group (Mean=48.84; Standard Deviation=8.27), the Video Game experimental group on average had a significantly higher score (Mean=52.24; Standard Deviation=6.90) (Figure 4.1).
Part 2: Matching Test Results

Univariate analysis results for Part 2 show no significant differences between treatment groups (F=1.79, p>.05). Therefore, for Part 2, the null hypothesis is retained. However, according to Table 4.2, the experimental group (Mean=11.71; Standard Deviation=4.08) on average still had a slightly higher score than the control group (Mean=10.74; Standard Deviation=4.71; Figure 4.2).

Figure 4.1: Estimated Marginal Means of Part 1
Part 3: Application Test Results

Univariate analysis results for Part 3 show that significant differences between treatment groups exist ($F=6.78$, $p<.05$). Therefore, for Part 3, the null hypothesis was rejected. Compared to the Web CAI control group (Mean=10.47; Standard Deviation=3.85), the Video Game experimental group on average had a significantly higher score (Mean=12.24; Standard Deviation=3.83) (Figure 4.3).

Figure 4.2: Estimated Marginal Means of Part 2
Univariate analysis results for post-test score show that significant differences between treatment groups exist ($F=10.73, p<.05$). Therefore, for the post-test, the null hypothesis was rejected. Analysis of the results shows that the Video Game experimental group (Mean=76.18; Standard Deviation=10.77), on average, had a significantly higher post-test score when compared with the control group (Mean=70.05; Standard Deviation=12.96) (Figure 4.4).
Hypothesis 2: Difference Due to Prior Knowledge

Hypothesis 2: No statistically significant differences exist in students’ achievement between the students identified as having high prior knowledge and the students identified as having low prior knowledge in “Nature and Technology” scores.

Figure 4.4: Estimated Marginal Means of Post-Test Total Score
Hypothesis 2 intends to examine the effect of different prior knowledge levels of “Nature and Technology” on students’ achievement. As Table 4.5 reports, univariate analysis was conducted for post-test and each of the three sub-categories of the post test.

**Part 1: Multiple-Choices**

Univariate analysis results for Part 1 show that significant differences between the groups with high- and low-prior knowledge exist ($F=26.54$, $p<.05$). Therefore, for Part 1, this null hypothesis was rejected. For Part 1 test, high-prior knowledge students (Mean=$53.75$; Standard Deviation=$5.48$) performed significantly better than the low-prior knowledge students (Mean=$47.02$; Standard Deviation=$8.41$).

**Part 2: Matching**

Univariate analysis results for Part 2 show that significant differences between the groups with high- and low-prior knowledge exist ($F=11.04$, $p<.05$). Therefore, for Part 2, this null hypothesis was rejected. As the results show, high-prior knowledge students (Mean=$12.55$; Standard Deviation=$4.13$) on average had a higher score when compared to the low-prior knowledge students (Mean=$9.79$; Standard Deviation=$4.33$).

**Part 3: Application**

Univariate analysis results for Part 3 show that significant differences between the groups with high- and low-prior knowledge exist ($F=11.00$, $p<.05$). Therefore, for Part 3,
this null hypothesis was rejected. Compared to the low-prior knowledge students (Mean=10.13; Standard Deviation=4.33), the high-prior knowledge students (Mean=12.44; Standard Deviation=3.13), on average, had significantly higher scores.

**Post-Test Total Score**

Univariate analysis results for post-test total score show that significant differences between the groups with high- and low-prior knowledge exist (F=35.42, p<.05). Therefore, for post-test, this null hypothesis was rejected at the .05 level. For post-test total score, high-prior knowledge students (Mean=78.73; Standard Deviation=8.44) performed better than the low-prior knowledge students (Mean=66.94; Standard Deviation=12.88).

**Hypothesis 3:**

**Hypothesis 3:** No statistically significant interaction exists in students’ achievement of different instructional treatments (computer-assisted instruction versus computer and video game playing) and students’ prior knowledge (previous exam score: high and low).
Chapter 5

FINDINGS, CONCLUSIONS, RECOMMENDATIONS, AND IMPLICATIONS FOR FUTURE RESEARCH

In Chapter Four, the results show the impact of different instructional treatments and prior knowledge on students’ achievement. Learner achievement was measured through a post-test that assessed facts, understanding, and problem-solving strategies for interpreting participants’ cognitive structures under different instructional treatments. The interaction between the instructional treatments and prior knowledge is also explored.

This chapter discusses findings and limitations, interprets results, and makes conclusions and recommendations for future instructional design and research.

Findings

The findings of this study are presented, based upon the three null hypotheses.

Finding 1

Hypothesis 1: No statistically significant differences exist in students’ achievement when they receive different instructional treatments.

The statistical results clearly show a significant difference between computer-assisted instruction and computer and video game playing in students’ learning achievements (See Figure 5.1). Based on this finding, playing computer and video games...
was determined to be more effective in facilitating third-graders’ average learning outcome than plain text computer-assisted instruction. Therefore, it may be concluded that this null hypothesis should be rejected.

To discuss the significant differences between different instructional treatments precisely, the results of this study were subdivided into four sections: multiple-choice, matching, application, and the post-test total scores. Table 5.1 summarizes the results of the statistical differences in hypothesis 1.

Table 5.1: Summary of Statistical Difference of Hypothesis 1

<table>
<thead>
<tr>
<th>Part</th>
<th>Treatment Groups</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 1: Multiple-Choices (0-64 points)</td>
<td>Web CAI</td>
<td>48.8421</td>
<td>8.27170</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Video Game</td>
<td>52.2353</td>
<td>6.90098</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50.4444</td>
<td>7.80766</td>
<td>108</td>
</tr>
<tr>
<td>Part 2: Matching (0-18 points)</td>
<td>Web CAI</td>
<td>10.7368</td>
<td>4.70762</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Video Game</td>
<td>11.7059</td>
<td>4.08066</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>11.1944</td>
<td>4.42900</td>
<td>108</td>
</tr>
<tr>
<td>Part 3: Application (0-18 points)</td>
<td>Web CAI</td>
<td>10.4737</td>
<td>3.85035</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Video Game</td>
<td>12.2353</td>
<td>3.83452</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>11.3056</td>
<td>3.92561</td>
<td>108</td>
</tr>
<tr>
<td>Post-Test Total Score (0-100 points)</td>
<td>Web CAI</td>
<td>70.0526</td>
<td>12.96068</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Video Game</td>
<td>76.1765</td>
<td>10.76978</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>72.9444</td>
<td>12.31049</td>
<td>108</td>
</tr>
</tbody>
</table>
Discussion of Instructional Treatments

According to the results of post-test scores, clearly computer and video games can facilitate students’ learning performance. This finding indicated that computer and video game playing not only can improve participants’ fact/recall processes, but also promotes problem-solving skills by recognizing multiple solutions for problems.

Figure 5.1: The Box and Whiskers Plots Graphically Display the Test Scores Difference with Different Treatment Groups
Additionally, more precise effects were detected by breaking the post-test scores into three sub-categories. When the researcher developed the items in Part 1, the objectives were to make the participants recall key facts, definitions, and concepts. As the results of Part 1 indicate, the participants in the experimental group have a better understanding of factual materials and concepts. Consequently, for finishing their mission, the participants in the experimental group know they have to memorize the key facts or concepts even if they were just playing a game.

The design of Part 2 is to measure the participants’ ability to associate and analyze similarities and differences. Unfortunately, the results in this part are not as impressive as expected. According to the results, there is no statistically significant difference in Part 2, and the scores of the experimental group only slightly better than the scores of the control group. Consequently, computer and video game playing did not much improve participants’ judgment. Two explanations are possible for this consequence: (1) insufficient descriptions or explanations of each key concept in the computer game, thus the participants in the experimental group do not have enough information to analyze and compare the differences, (2) the depictions of each item in Part 2 is not simple and easy enough for third graders to understand. Therefore, they are confused in making the right choice.

The results in Part 3 are the most remarkable finding in this study. Apparently computer and video game playing is effective for improving critical thinking and higher-level cognition. Part 3 was designed to identify the participants’ comprehension, problem-solving, and strategy skills. The results indicate that participants’ achievement of learning comprehension knowledge was enhanced. A number of research studies have
been developed and explore better approaches to prompt student’s higher-order thinking. With this finding, it may be concluded that computer and video games can be considered an instructional approach to improve students’ higher-order thinking.

From the above discussion of Finding 1, computer and video games might improve students’ achievement in learning factual knowledge, problem-solving strategies, and higher level cognition thinking processes.

Finding 2

Hypothesis 2: No statistically significant differences exist in students’ achievement between the students identified as having high prior knowledge and the students identified as having low prior knowledge in “Nature and Technology” scores.

Two-way MANOVA shows that statistically significant differences between low prior knowledge and high prior knowledge students exist (see Figure 5.2). Based on this finding, regardless of instructional treatments, high prior knowledge students performed significantly better than low prior knowledge students in the post-test and the three sub-categories in the post-test. Therefore, it may be concluded that this null hypothesis should be rejected.
Discussion of Prior Knowledge

This study tests the general hypothesis that with higher prior knowledge of “Nature and Technology,” students will score higher in the post-test results. Hypothesis 2 explores the influence of prior knowledge on different instructional treatments. Based on the results, prior knowledge appears to be a significant predictor of students’ learning achievement in this study. This means that high prior knowledge students always show

Figure 5.2: The Box and Whiskers Plots Graphically Display the Test Scores Difference with Different Prior Knowledge Levels
higher mean scores than low prior knowledge students, regardless of instructional
treatment groups they participated.

This result also supports Ausubel’s (1968) contention that the most important
single factor influencing learning is what the learner already knows, and the learner
should be taught accordingly. From the aspect of learning, prior knowledge and
experience in numerous investigations have revealed a solid basis in research on learning:
prior knowledge is an important variable affecting study results, and it plays a major role
in educational performance (Dochy, 1992; Jonassen & Grabowski, 1993; Pressley &
McCormick, 1995). Widespread agreement exists that prior knowledge influences
learning, and that learners construct concepts from prior knowledge (Glasersfeld, 1995;
Roschelle, 1995). The results of this study reinforce that prior knowledge could facilitate
the effects of the learning process, and lead to better study results.

Moreover, Thompson and Zamboanga’s (2003) study finds that prior knowledge
contributes to course achievement even though, relative to their subsequent achievement.
Their findings suggest that the knowledge that students bring with them to the first day of
class is positively and significantly predictive of their academic achievement, and
students from the high prior knowledge group with more relevant domain-specific
knowledge have several advantages over those with low prior knowledge. These findings
are consistent with a broader spectrum of literature in psychology and education
documenting the importance of preexisting understanding to new learning and the value
of incorporating prior knowledge into instructional strategies.

In addition, several theories employ prior knowledge as learning factors. For
example, the restructuring theory and the accessibility theory state that information is
structured in a different way in long-term memory, and that prior knowledge increases the accessibility of knowledge and reduces the load on the working memory, so that more information can be processed (Dochy, 1995). New instruction built on students’ prior knowledge is also supported by research in cognitive psychology, especially from constructivist theory, which emphasizes the importance of enlisting prior understanding into the construction of new understanding (Bransford, National Research Council (U.S.). Committee on Developments in the Science of Learning., & National Research Council (U.S.). Committee on Learning Research and Educational Practice., 2000). Since numerous research studies found positive influence of prior knowledge, educators should take those findings into account and employ them, either in educational settings or as an instructional support. Thus, the different entry levels of students may require providing individual learning materials so that appropriate learning methods may be employed.

**Finding 3**

**Hypothesis 3:** No statistically significant interaction exists in students’ achievement of different instructional treatments (computer-assisted instruction versus computer and video game playing) and students’ prior knowledge (previous exam score: high and low).

According to the results of the two-way MANOVA, no significant interactions appeared between the two studied independent variables: different instructional treatments and students’ prior knowledge. The absence of this interaction implies that the difference in students’ achievement of different instructional treatments is the same for
different levels of prior knowledge. Thus, it may conclude that this null hypothesis should be retained.

**Limitations**

Five limitations to this study became apparent when conducting the play theory based computer and video game research and after reviewing the results.

First, even all third-grade students have attended computer lessons and their ability to use basic computer tools and Internet-browsing resources are a prerequisite for participating in this study. One issue needs to be considered to ensure the validity of research design: for some students, “Fire Captain” is their first experience playing a computer game. Playing computer games is different from using an Internet-browser, and that could cause a problem for some students. Whether a student can successfully operate the game in forty minutes becomes critical for the willingness and ability of a student to finish this game.

Second, a forty-minute class for developing complex higher-order thinking and a post-test in twenty-four hours for measuring participants’ outcomes may be inadequate. The amount of time for instruction should be taken into consideration for children’s play in play theory. Especially, how much time a student spent on play or practice could be a major factor influencing children’s motivation for learning and achievement. After all, human motivation is a function of human cognition-involving (McDevitt & Ormrod, 2004, p. 462). However, this study did no intend to address this question, although it is an important consideration for future studies.
Third, the contents of instructional treatments for this study could have been more objective. “Fire Captain” is not a game designed for instructional purposes. Also, the possibility of designing a web site that could perfectly match all contents with a computer game is likely to be impossible. In particular, different hypertexts developed by different designers may result in different formats. To ensure that the design of the hypertext format and the contents were consistent with the game, the instrument’s validity needs to be examined further.

Fourth, from the results of this study, apparently computer and video games could function as powerful tools in assisting children’s cognitive processes. However, an unanswered question is what could be the improved major cognition factor arising from playing computer and video games—for example, short-term memory, or long-term memory—needs further investigation.

Fifth, one methodological weakness of this experiment is that a sufficiently larger number of participants would be better so that the statistical test of effect size would have a higher partial Eta squared value. However, the sample size was limited by the number of computers in a computer laboratory and the consent of students’ parents. In Taiwan, the fact that some parents keep their children away from computer and video games is well known. Without parents’ understanding and support, difficulty arises for having to have a sufficiently large number of participants for similar future studies.
Conclusions

Different from previous studies that examined computer or video games, this study was developed to investigate the play effects of computer and video games on the subject of cognition of elementary level students. Based on the aforementioned findings and the limitations of this study, the following conclusions may be drawn.

First, computer and video games were applied to cognitive improvement. The results from this study provided experimental evidence to support that the use of computer and video games can facilitate students’ cognitive learning process. Prior research dealing with computer and video games did not explore the idea of learning. In fact, computer and video games have often been criticized for reproducing violent action or behavioral aberration in most previous research reports. As this new form of technology has been treated as an entertainment device with negative influences on children, this study was attempted to restore computer and video games to its original value: multifunction interactive media. In addition, given this approach, a different character emerges by suggesting multimedia is functionality and instructional capability should be considered equally with CAI programs.

Second, of great theoretical and practical importance, play could benefit children’s development and learning. Even without the emphatic educational intention such as CAI programs, children still can improve their cognition through playing computer and video games. Kids’ play with computer games exemplifies forms of knowing and being in the world that are irreducibly and simultaneously social, technical, material, and symbolic (Ito, 1997). Disregard of establishing specific instructional goals,
play can work to effect children’s motivation for competency and achievement in learning. When playing games, academic success or achievement no longer would be a pressure for students. For children, they are just enjoying the fun.

Third, prior knowledge plays a significant role in students’ learning achievements. The participants with high-level states of prior knowledge obtained higher scores in the post-test. This study verified the general hypothesis that students possess greater relevant prior knowledge, they tend to establish their own knowledge base by self learning more easily than others. Skills of encoding information, processing cognitive systems, and retrieving information extended and benefited the higher prior knowledge students’ learning outcomes.

Fourth, although no significant interaction between different instructional treatments and prior knowledge appeared in this study, an interesting tendency that was found is that low-prior knowledge students benefit more from playing computer and video games than do high-prior knowledge students. Since lower-level students need particular consideration in a regular classroom setting, this instructional treatment could be an auxiliary method for their cognitive development.

**Implications and Recommendations for Future Research**

As this study is exploratory for instructional purposes and addresses a specific experimental design, several implications for parents, teachers, and educators, can be derived from its conclusions.
Parents

An imperative question for most parents of the current generation of students is whether they should allow their child to play computer or video games. From the results of this study, the answer could be simply a “Yes.” The truth is that restraining children from playing computer and video games is difficult. However, the real world is different from the experimental environment. In the experimental study, time control is not a problem for researchers, and the researchers do not need to worry that game playing will displace children’s homework time as parents must.

After taking these possibilities and questions into consideration, the most important recommendation for parents is to participate in children’s game playing. Engagement in children’s computer or video game playing can give the parents a better understanding of the consequences of these games. For instance, parents can become aware of the computer and video game ratings systems, involved in children’s game purchases or rentals, and monitor the content of the computer and video games that their children play. Then, adults must consider the character of each child, provide the appropriate games and arrange play time. Finally, this study concurs with the advice from McVey (1997): “I would encourage parents to consider limits on when video game play is allowed and what behaviors are acceptable during game play… overall, I would recommend that parents take a proactive, involved approach to their children’s video game play.”
School

The instructional design employed in this study provides teachers with alternative options for applying various interactive media to the curriculum. After all, the most important task for educators is to design instruction that learners really enjoy and actually learn from, and to investigate what kinds of interactive tools can improve learner achievement (Lai, 2001). Even today, facilitating the learning process for the wide variety of learning experiences for each student stands as a challenge for many course designers. Traditional approaches are still effective for learning, but could prove interesting investigating the effect that new technology may have on individuals’ performance. Consequently, through technology’s diversity and compatibility to each individual, deficiencies can be overcome to help students ultimately achieve self-actualization (to fulfill one’s potentialities) (Celce-Murcia, 2001). Contemporary research trends show one important thing: educators have noticed the important role of computer and video games, and have begun to investigate curriculum, behavior, and psychological issues involved in the design and use of educational computer games, specifically, to foster learning.

However, computer and video games are not intended to replace any other approach. They provide teachers with alternatives and provide students the opportunity to engage actively in learning. Therefore, further investigation of the reasoning behind inferences and results from serious studies are indispensable for determining the value of computer and video games in education. While both traditional and computer-based
delivery systems have valuable roles in supporting instruction, they are of greatest value when complementing one another.

**Future Research**

Based on the findings of this study, and the discussion of its limitations, several recommendations for future research may be drawn:

1. The positive outcome of this study may not result principally from computer and video game playing, but also from well-organized instruction and research design. Follow-up studies should consider the effects of various game types (e.g. action, adventure, role-playing, or simulation games) and different hypertext learning materials. By examining every variety, researchers could confirm the factors that improve learning achievement.

2. Replication of this study should consider the participants’ capabilities for manipulating computer or video games. Conducting a survey to acquire the participants’ general background information and prior experiences about computer and video games could reduce the encountered shortcoming.

3. Time is an essential component of students’ learning pattern. It relates to participants’ motivation and affects the results of their assessment directly. Consideration should be given to the amount of time the participants engage their task enthusiastically. Further research should record the sequence and duration during the experiment.
4. Investigation of participants’ behaviors while they are playing computer and video games will help model their learning styles. Through studying participants’ covert cognitive strategies from playing games, researchers can identify how they process information. This could be an important procedure if educators intend to integrate computer and video games into curriculum or instruction.

5. This study only addressed players’ cognitive performance in a single player computer game. With the expansion of multiplayer online games, the researchers should examine the implications of game players’ interactions and social relationships in an online environment. Developing various studies of the effects of the online environment, the game playing experience, and group activities, would reveal a more holistic understanding.
REFERENCES


Sutton-Smith, B. (1972). The folkgames of children. Austin, TX: Published for the American Folklore Society by the University of Texas Press.


Appendix A

Outline of Computer-Assisted Instrument Content in English
BASIC KNOWLEDGE OF FIRE

I. The Elements of Fire

II. This is Fire

III. Fire Categories

   Class A fires
   Class B fires
   Class C fires
   Class D fires

IV. How do we put fires out?

   Cooling:
   Smothering:
   Starvation:
   Stop chain reaction:

FIRE PREVENTION

I. Firefighting Equipments

   Portable Fire Extinguishers

      Water filled extinguishers:
      Foam filled extinguishers:
Dry powder:

CO2 extinguishers:

Wet chemical:

**Fire Hydrant Systems**

Hydrant:

Standpipe Systems:

Pumping Facilities:

Booster Tank:

Hose:

Drafting:

Nozzles:

Portable Radios:

**Fire Alarm Systems**

Smoke and thermal detectors:

Fire Alarms:

Box Alarm:

**Fire Alarm Protection**

Fire Sprinkler Systems:

Water Mist:

**II. Fire Apparatus**

Rescue ladder:

Pumper:

Foam Pumper:
Tanker and foam tanker:

Water ladder:

Fireboat:

Helicopter:

**III. The Tactical Objective of Fire Suppression**

Rescue:

Exposure:

Confinement:

Extinguishment:

Ventilation:

Property Conservation:

**FIRE HAZARD: RAPID FIRE PROGRESS**

I. **Flashover**

Can a 'flashover' be induced?

Warning signs of flashover:

Defensive search procedures:

II. **Backdraft**

Signs of backdraft are:

Vertical Ventilation:
FIRE SAFETY INFORMATION

I. Fire Safety Tips

II. High-Rise Safety

Ways to Keep your Apartment Safe

If the Fire is in Your Apartment

If the Fire is NOT in Your Apartment

Planning Ahead Can Save Your Life

Evacuation Procedures

III. Fire Safety in the Home

Inspection Hints and fixes

Home Safety Tips:
Appendix B

Outline of Computer-Assisted Instrument Content in Mandarin
火災背景知識

一、 引發火災的原因

二、 火災對人的危害

三、 火災的種類與撲滅方法

火災依燃燒物質之不同可區分為四大類。

A 類火災

B 類火災

C 類火災

D 類火災

滅火的基本方法：

拆除法

窒息法

冷卻法

抑制法

消防知識

一 、 消防安全設備之種類
減火設備:

1. 滅火器、消防沙：
2. 室內／外消防栓設備：
3. 自動灑水設備：
4. 水霧滅火設備：
5. 泡沫滅火設備：
6. 二氧化碳滅火設備：
7. 乾粉滅火設備：

警報設備:

1. 火警自動警報器：
2. 手動報警設備：
3. 緊急廣播設備：
4. 瓦斯漏氣火警自動報警設備：

避難設備:

1. 標示設備：
2. 避難器具：
3. 緊急照明設備：

消防搶救上之必要設備:

1. 連結送水管：
2. 消防專用蓄水池：
3. 排煙設備(緊急昇降機間特別安全梯間室內排煙設備):
4. 緊急電源插座:
5. 無線電通訊輔助設備:

二、消防安全設備性能簡介

消防車輛簡介
1. 水箱消防車
2. 水庫消防車
3. 直線雲梯消防車
4. 化學消防車

火場危險

一、閃燃

閃燃是什麼？
預防閃燃方式：

二、回燃，搶火，又稱「煙爆」

回燃是什麼？
預防回燃方式：
消防隊處理回燃方式：
預防火災的方法

一、 基本常識
二、 養成良好的生活習慣
三、 在公共場所與大樓
四、 居家生活方面

遇上火災該怎麼辦？

一、 滅火
二、 報警
Appendix C

Screenshots of Computer Game Instrument: “Fire Captain”
FIRE CAPTAIN

Fire Captain is one of the most intense real-time strategy games around. You command a professional crew of firefighters equipped with highly effective vehicles and equipment to bring the most extreme situations under control. Fire Captain delivers an incredible level of realism, enhanced by superb graphics, where the game fire and smoke propagation systems lend a terrific and thrilling urgency to the missions. Control dozens of units and vehicles in a relentless fight against the inferno for an unforgettable gaming experience!

EXPLOSIVE INNOVATIONS

More than 40 firefighters and vehicles under your command, superb graphics, an ultra-realistic fire and smoke propagation system, numerous specialist firefighters and state-of-the-art vehicles; an optimized AI system, vast maps and multiplayer modes: game longevity assured!

FEATURES

- 4 solo campaigns
- 3 game modes (arcade, realistic, extreme)
- Select the nationality of your firehouse (USA, England, France or Germany)
- Various units: basic firefighters, specialists, dog handlers, technical officers...
- Numerous vehicles: ladders, fireboats, Canadians, helicopters, tankers, pumpers...
- Ultra-realism: improved AI, fire and smoke propagation and reactions of combustible and hazardous substances
- Game designed in collaboration with specialist professional firefighters
- Up to 4 players in multiplayer mode (LAN and via Internet)

MINIMUM CONFIGURATION:

- Windows® 98SE/2000/XP/ME
- Pentium 1 GHz (or superior)
- 256 MB RAM
- 3D graphic card accelerator with 64 MB RAM and compatible with DirectX® 9.0c (GeForce 2 or equivalent)
- Sound card compatible with DirectX® 9.0c
- Direct X 9.0c • 4x CD-ROM
- 1,5 GB free hard disc

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Appendix D

Post-test in English
Part I: Multiple-Choice (4 Points)

1. The mission of a firefighter is: ①To protect lives ②Carry out fire fighting work ③All of the above ④None of the above

2. Which of the following is NOT a fire fighting equipment? ①Dry powder ②Hydrogen cylinder ③Foam filled extinguishers ④CO2 extinguishers

3. Which of the following is not a fire engine? ①Water tanker ②Water ladder ③Bus ④Foam Pumper

4. The fire engine is used to:
   ①Transport firefighters and supply water for the initial attack on a fire ②Attract everybody to pay attention to ③Let the firefighters look cool ④Make noises

5. Which of the following is an ideal fire apparatus for high-rise fires? ①Pumper ②Water ladder ③Bus ④Tanker

6. Fire hydrant is: ①A warning sign ②A potty for dogs ③A rest room for firefighters ④To deliver water for fire fighting

7. In a fire scene, blaze and smoke will threaten lives. Which of the following can help firefighters to defend fires from a safe distance? ①Fire hose and nozzles ②Water polo ③Toy squirt ④Bamboo pole

8. Which of the following is NOT a cause of class A fires (classic fire)? ①Wood ②Fabrics ③Gasoline ④Rubber

9. Which of the following is NOT a cause of class B fires (liquid fires)? ①Gasoline ②Natural gas ③Diesel fuel ④Paper

10. The first step of preventing a class C fire (electrical fire) is to: ①Shut down the power supply ②Fire fighting with water ③Rescue your property ④Turn on the light

11. What is the most critical situation for firefighters when they are inside a burning room? ①Not have enough sleep ②Flashover and backdraft ③All of the above ④None of the above

12. When a fire burn in a confined environment for a period of time, then the combustion process reaches a point where the heat and unburned gases are at a certain level, and when the fire has burned up the available oxygen in the confined environment, the rapid introduction of air, such as opening a door, will result in an explosion. This phenomenon is called: ①Flashover ②Out of control ③Blast ④Backdraft

13. Firefighters always fight with the fires alone, and never consider teamwork. ①True ②False
14. When a smoky gas layer in a room becomes hotter and hotter, it radiates more and more heat to the rest of the room. Finally, the whole room catches fire. This is called flashover. To avoid flashovers, firefighters have to vent windows of a burning room to release the heat in the room. ①True ②False

15. In the event of a fire, the first thing to do is to call a fire department. ①True ②False

16. There are different types of fires, and all of which can be extinguished with the same extinguisher. ①True ②False

Part II: Matching (3 Points)

A. Backdraft  
   1. This is the rarest type of fire and relates to combustible metal substances that generate intense heat

B. Class B fires (liquid fires)  
   2. This is an ideal vehicle for intervening in force on fires on upper floors.

C. Class C fire (electrical fire)  
   3. It is dangerous if attacked with a conductive extinguishing agent (e.g. water).

D. Class D fire (metal fires)  
   4. Can not be put out with water. Foam filled extinguishers will be a better choice for this type of fire.

E. Foam Pumper  
   5. Break the door is the most common tactic used by firefighters to ventilate. This allows the heat and smoke to escape without igniting explosively.

F. Water ladder  
   6. It can fire fires foam jets. Foam is a concentrate mixed with water or air and applied to any material that is on fire or could potentially catch fire.
Part III: Application (3 Points)
Scenario: Your fire department just receives an emergency call about a fire has taking place in one residential area and tend to spread into a major fire. The firefighters have to be set out immediately!

As a commanding officer, you have to plan an effective fire fighting tactic with the following options to your team. Sequence the following options with your knowledge and experiences to assist firefighters in extinguishing the fire. Good luck! Hope you can control the situation and put out the fire in a short time.

①. Rescue every body from the fire, and put out flames.
②. Verify whether there is any live endangered by the fire.
③. Firefighters begin to connect hosts to hydrants and fire engines. Ask the firefighters to enter the firing building for rescue.
④. Check fire fighting equipments. Make fire engines and ambulances ready to use.
⑤. Confirm the type of the fire. Get rid of any possibility that may cause gas explosion or electric shock.
⑥. Warn each firefighter the phenomenon of flashover and backdraft before they go into rooms or building. They have to make a decision when getting in or keeping out of the way.

ANSWER:
Appendix E

Post-test in Mandarin
第一部份：是非選擇題

17. 消防員的主要職責是：①保護人民生命安全 ②有效地執行滅火工作 ③以上皆是 ④以上皆非

18. 下列哪一種物品不屬於消防滅火器材？①消防沙 ②氦氣筒 ③泡沫滅火器 ④滅火器

19. 下列哪一樣不屬於消防車輛？①水箱車 ②雲梯車 ③公共汽車 ④化學消防車

20. 消防車的用途？①為迅速運載消防員與裝載儲備物品為消防員進行物資補充 ②吸引大家注意 ③讓消防員看起來很酷 ④製造噪音

21. 因應大樓愈建愈高，當發生火災時下列哪一種車輛會是有效高樓救火設備？①水箱車 ②雲梯車 ③公共汽車 ④照明車

22. 消防栓的用途：①當成地標 ②給狗狗上廁所 ③讓消防員休息 ④供應充足消防用水，保持滅火活動所必要之水壓與水量

23. 在火場內救火時，烈焰與濃煙會威脅到救災人員性命，下列哪一個選項能讓消防員在安全距離控制火勢？①幫浦與水箱車的噴槍 ②水球 ③玩具水槍 ④竹竿

24. 下列哪一項不屬於 A 類火災（普通火災）？①木製品 ②布料 ③汽油 ④橡膠

25. 下列哪一項不屬於 B 類火災（油類火災）？①石油 ②天然氣 ③柴油 ④紙纖維

26. 處理 C 類火災（電氣火災，像是通電中之電氣設備，如電器、變壓器、電線、配電盤等引起之火災）時，首要步驟是什麼？①截斷電源 ②用水救火 ③搶救財物 ④打開電燈

27. 在火場內救火時，消防人員最大的危機是什麼？①睡眠不足 ②『閃燃』及『回燃』 ③以上皆是 ④以上皆非

28. 在密閉空間內，由於空氣不流通可燃性氣體便會積聚。這些氣體不一定會著火，特別是在氧氣不足的情況下。然而，當有足夠的空氣引入火場內時，如開門時，空氣進入，即引發激烈的爆炸，這種特別現象稱之為：①閃燃 ②失控 ③激爆 ④回燃

29. 消防員常常無懼高溫煎熬，經常獨自一人與大火單打獨鬥，從不講求團隊合作 ①對 ②錯
30. 當易燃氣體累積到危險的臨界點，閃燃現象便會發生。製造通風口有助於將這些氣體和煙霧排出，以降低發生閃燃的機率。而最簡單的方法就是打破窗戶。①對 ②錯

31. 灭火最重時效，能於火源初萌時，立即予以撲滅，即能迅速遏止火災發生或蔓延。 ①對 ②錯

32. 火災雖然可以區分為數種不同類型，但是都是可以利用完全相同的方法來撲滅 ①對 ②錯

第二部份：連連看

<table>
<thead>
<tr>
<th>甲、回燃</th>
<th>1. 燃燒時溫度非常高，極為罕見</th>
</tr>
</thead>
<tbody>
<tr>
<td>乙、B 類火災 （油類火災）</td>
<td>2. 具有廣泛垂直移動範圍，在某些區域或許無法藉由樓梯進入時非常有用</td>
</tr>
<tr>
<td>丙、C 類火災 （電氣火災）</td>
<td>3. 如果試圖用水之類的滅火劑來撲滅的話，將造成觸電的危險</td>
</tr>
<tr>
<td>丁、D 類火災 （金屬火災）</td>
<td>4. 無法用水撲滅，必須用泡沫滅火劑來滅火</td>
</tr>
<tr>
<td>戊、化學消防車</td>
<td>5. 必須製造通風口，讓火在不會爆炸的情況下繼續燃燒，所以要破壞門窗。</td>
</tr>
<tr>
<td>己、雲梯消防車</td>
<td>6. 附有泡沫及乾粉，車內的自動混合系統能以最精確的比例混合滅火藥劑與水，並將之泡沫化噴出</td>
</tr>
</tbody>
</table>
第三部份：排列順序

緊急狀況：一場在住宅區內發生的火災有擴大蔓延的傾向，在接到民眾的報案後，消防人員即將緊急出動…

小朋友，接下來要請身為現場指揮官的你把下列的救火步驟按照你認爲最有效的順序來排列一下，希望能在最短的時間裡把火撲滅！

(1) 救出受困民眾，撲滅所有火苗

(2) 確認是否有任何民眾受困火場

(3) 消防車開始噴水灌救，命令消防人員開始進入火場救援

(4) 檢查所有救難設備是否準備齊全，各式消防、救護車輛使用是否已經準備待命

(5) 確認火災類型，排除任何可能引發油氣爆炸或是觸電的可能

(6) 進入每個房間前要留意閃燃或回燃現象，判斷應否強行進入內部或暫時退避

答案：
Appendix F

Approval Letter for the Study
Date: May 6, 2005

From: Jodi L. Mathieu, IRB Administrator

To: Tsung-Yen Chuang

Subject: Results of Review of Proposal - Expedited (IRB #20307)

Approval Expiration Date: February 13, 2006

"The Effects of Computer/Video Gaming as Play Effects on Elementary Students' Cognitive Processes and Learning Achievements in Taiwan."

The Social Science Institutional Review Board (IRB) has reviewed and approved your proposal for use of human participants in your research. By accepting this decision, you agree to obtain prior approval from the IRB for any changes to your study. Unanticipated participant events that are encountered during the conduct of this research must be reported in a timely fashion.

Enclosed is/are the dated, IRB-approved informed consent(s) to be used when recruiting participants for this research. Participants must receive a copy of the approved informed consent form to keep for their records.

If signed consent is obtained, the principal investigator is expected to maintain the original signed consent forms along with the IRB research records for this research at least three (3) years after termination of IRB approval. For projects that involve protected health information (PHI) and are regulated by HIPAA, records must be maintained for six (6) years.

The principal investigator must determine and adhere to additional requirements established by the FDA and any outside sponsors.

If this study will extend beyond the above noted approval expiration date, the principal investigator must submit a completed Continuing Progress Report to the Office for Research Protections (ORP) to request renewed approval for this research.

On behalf of the IRB and the University, thank you for your efforts to conduct your research in compliance with the federal regulations that have been established for the protection of human participants.

JLM/slk
Enclosure
cc: Thomas D. Yawkey

Please Note: The ORP encourages you to subscribe to the ORP listserv for protocol and research-related information. Send a blank email to: L-ORP-Research-L-subscribe-request@lists.psu.edu
Appendix G

Consent Form
INFORMED CONSENT FORM FOR SOCIAL SCIENCE RESEARCH
The Pennsylvania State University

Title of Project: The Effects of Computer/Video Gaming as Play Effects on Elementary Students' Cognitive Processes and Learning Achievements in Taiwan

Principal Investigator: Tsung-Yen Chuang
Department of Curriculum and Instruction
740 Teal Lane, State College, PA 16803
chuangyen@psu.edu; (814) 238-7567

Advisor: Thomas D. Yawkey
Department of Curriculum and Instruction
165 Chambers Building, University Park, PA 16802
tdy1@psu.edu; (814) 863-2937

1. **Purpose of the Study:** The purpose of this study is to determine if computer and video games facilitate students’ cognitive learning process.

2. **Procedures to be followed:** All the students will be divided into two groups based on their previous scores in their course. Then the two groups are randomly assigned to one control group and one experiment group.

   **Control Group:**
   1. In the first session, students will be given an instruction on how to use all the web resources that will be used during the course.
   2. Students do not have guidelines for leading their study, but they are allowed to ask any question just as in a regular class.

   **Experiment Group:**
   a. In the first session, students will be given an instruction on how to play a computer game that will be used during the course.
   b. Just as control group, students do not have guidelines for leading their exploration in this game, but they are allowed to ask any question.

   After receiving the various instructional treatments, each student will be required to take a quiz in the second session. The context in this quiz is related to the web resources and computer game. The score of the quiz will have no impact on the student’s class standing or grade.

3. **Discomforts and Risks:** There are no risks in participating in this research activity beyond those experienced in everyday life.

4. **Benefits:** This study could further extend instructional technologists, educators, and curriculum designers’ understanding in this field, which is previously received little attention.
For participants, they will be able to explore a new way to learn art appreciation through technology.

5. **Duration:** Total duration of the project that participants will be involved is one week with two sessions. Each session is estimated to take 40 minutes (the length of a regular class period in elementary schools in Taiwan). For a total of 80 minutes.

6. **Statement of Confidentiality:** Only the principal investigator, the principal investigator’s advisor, and your child’s teacher will know who participated. The Office for Research Protections and the Social Science IRB may review records related to this project. You and your child’s decision to participate will have no impact on the child’s grade or class standing. Furthermore, all students will be notified their classmates’ decisions about who did and did not participate in the study. If your child does not wish to participate in this study, they can stay in the classroom when the study occurs and the teacher in charge will use class time as English reading class and play English video CD for them. If this research is published, no personal identifiable information will be disclosed.

7. **Right to Ask Questions:** You can ask questions about this research. The person in charge will answer your questions. Contact Tsung-Yen Chuang at chuangyen@psu.edu or at (814) 238-7567 with questions. If you have questions about your rights as a research participant, contact Penn State’s Office for Research Protections at (814) 865-1775.

8. **Compensation:** No compensation will be provides for the participants of this research study.

9. **Voluntary Participation:** You and your child do not have to participate in this research. You and your child can end participation at any time by telling the person in charge. Your child does not have to answer any questions she/he does not want to answer.

In addition to your consent, your child will be orally informed of this study.

You must be 18 years of age or older and you must be the child’s parent or legal guardian to consent to your child’s participation in this research study. If you consent to your child’s participation in this research study and to the terms above, please sign your name and indicate the date below.

Please keep a copy of this consent form for your records.

I give permission for my child, ______________________, to participate in this research project.

Parent/ Guardian Signature ______________________  _____________________

Date

The informed consent procedure has been followed.
Appendix H

Agreement Form to the Principal
Agreement Form to the Principal

I am aware that all the students and teachers of my institute have agreed to be involved in a research study conducted by a Ph.D. candidate, Tsung-Yen Chuang, of The Pennsylvania State University. In this study, the students will agree to use the computer-assisted instruction, which was designed by the researcher. This use will occur in their regular class period.

I consent to the participation of our institution in this study and give my support to the project.

________________________________________
Name/Signature

________________________________________
Title

________________________________________
Institution

________________________________________
Date
校長同意書

我明白本校全體學生、級任老師及電腦老師，願意參與此項研究—「融合遊戲理論的電腦電視遊戲對中華民國台灣國小學生認知發展及學習成效的影響」；此研究由美國賓州州立大學博士候選人莊宗嚴所主持，學生們將被要求使用由研究者提供之電腦電視遊戲為教材以測驗其與學習成效的關聯；此實驗將在一般課程中完成。實驗結果將作爲博士論文學術研討專用。

我同意本校相關人員參與此項研究計劃，並給予全力支持。

姓名/簽名

職稱

校名
Appendix I

Agreement Form to the Teachers
Agreement Form to the Teachers

I am aware that all the students of my class have agreed to be involved in a research study conducted by a Ph.D. candidate, Tsung-Yen Chuang, of The Pennsylvania State University. In this study, the students will agree to use the computer-assisted instruction, which was designed by the researcher. This use will occur in their regular class period.

I consent to the participation of my class in this study and give my support to the project.

________________________________________________________________________
Name/Signature

________________________________________________________________________
Title

________________________________________________________________________
Institution

________________________________________________________________________
Date
教師同意書

我明白本班全體學生，願意參與此項研究—「融合遊戲理論的電腦電視遊戲對中華民國台灣國小學生認知發展及學習成效的影響」；此研究由美國賓州州立大學博士候選人莊宗嚴所主持，學生們將被要求使用由研究者提供之電腦電視遊戲為教材以測驗其與學習成效的關聯；此實驗將在一般課程中完成。實驗結果將作爲博士論文學術研討專用。

我同意本班參與此項研究計劃，並給予全力支持配合。

姓名/簽名

職稱

校名

日期
同意書

本人同意提供本班全體學生於三年級的學業成績做為美國賓州州立大學博士候選人莊宗嚴所主持之「融合遊戲理論的電腦電視遊戲對中華民國台灣國小學生認知發展及學習成效的影響」實驗數據分析之用。本人明白所有提供的資訊都將受到嚴密保護，只有計劃主持人可以接觸處理這些機密數據，而且所有數據只作爲博士論文學術研討專用。就算本實驗結果將來用於學術論文發表也不會有暴露或危害學生隱私的任何可能。

本人已詳細閱讀這份同意書，並同意給予全力支持配合。

三年五班  李麗香老師

簽名

日期

三年六班  許慧玲老師

簽名

日期

三年十三班  楊孟儒老師

簽名

日期

三年十四班  郭碧華老師

簽名

日期

崇學國小校長  吕岳霖校長

簽名

日期
Appendix J

Parental Consent Form
PARENTAL CONSENT FORM

The Pennsylvania State University

Title of Project: The Effects of Computer/ Video Gaming as Play Effects on Elementary Students' Cognitive Processes and Learning Achievements in Taiwan

Person in charge: Tsung-Yen Chuang

Dear Parent,

Thank you for considering assisting in this study for Tsung-Yen Chuang’s doctoral dissertation concerning the use of computer/ video gaming as play effects in instruction for your child. Mr. Chuang is currently a doctoral candidate in the Curriculum and Instruction program at The Pennsylvania State University. He is conducting this research to investigate the effects between computer/ video games and learning achievements for elementary students.

Your agreement of your child’s participation in this study will provide valuable information to prepare future curriculum and instruction design for elementary school students.

What students will be asked to do?

Before your child receives one unit of computer-based instruction that is designed by the researcher, they will be explained a description of the instruction, and asked if they would like to participate in this study. It will take approximately 30-40 minutes to complete this instruction in regular class base. After receiving this instruction, children will be asked to take a quiz for the teachers to assess their learning outcomes.

Assurance of confidentiality

Your child’s answers will remain confidential. To make sure the participation is confidential, only a code number appears on the answer sheet for students’ reports. Only the researchers can match names with code numbers. Because your child’s participation in this study is strictly voluntary, she/he is free to discontinue her/his participation in this project at any time or to decline to answer any specific questions if she/he desires. Her/his completion of the report will be considered consent.
Consent form

I have read this consent form and understand the content of this form. I understand my child’s participation is voluntary so that she/he can stop participating in this study at any time. I also understand the participation in this research is confidential. Only the person in charge will have access to my child’s identity. Moreover, I understand that my child will receive no compensation for participation, and will receive a signed copy of this consent form.

I hereby agree my child to participate in this study.

_________________________________________  ________________
Parent’s Signature                      Date

Thank you for taking the time to help and participate in this study. If you have any questions, please feel free to contact the following persons:

Tsung-Yen Chuang (Person in charge)
Doctoral Candidate, Curriculum and Instruction, The Pennsylvania State University
E-mail: chuangyen@psu.edu
Phone: 0021-814-238-7567 (USA)
       011-886-6-2673351 (Taiwan)
Address: 740 Teal Lane, State College, PA 16803

Dr. Thomas Yawkey (Academic adviser)
Professor, Curriculum and Instruction, The Pennsylvania State University
E-mail: tdy1@psu.edu
Phone: 0021-814-863-2937 (USA)
Address: 165 Chambers Building, University Park, PA 16802
家長同意書

研究案主題: 融合遊戲理論的電腦電視遊戲對中華民國台灣國小學生認知發展及學習成效的影響
計劃主持人: 莊宗嚴

親愛的家長:

感謝您考慮讓您的孩子參與此項研究計劃，此計劃由美國賓州州立大學博士候選人莊宗嚴所主持，研究主旨為探討電腦電視遊戲對台灣國小學生認知發展及學習成效的影響之可能性。學生們將被要求使用由研究員提供之電腦遊戲為教材以測驗其與學習成效的關聯性；實驗結果將主要將作爲博士論文學術研討專用。

您孩子的參與將為此研究提供非常寶貴的資訊，同時也對未來進一步研究電腦電視遊戲在兒童認知發展的應用上的可能性提供了最初的基礎；並在兒童遊戲理論上奠定重要的里程碑。

學生將參與的部分

在正式實驗進行之前，研究員將會詳述計劃內容給您的孩子；並徵得他/她的口頭同意。之後您的孩子將被要求使用由研究員提供之網路資訊或電腦遊戲軟體做爲教材進行實驗，實驗進行時間大約需要兩節課；合計約八十分鐘。學生完成學習步驟之後，將被要求參加一個小測驗，作爲研究測量評分之用。本實驗成績絕不會列入學生任何一門學科的計分；也絕不會影響其在課堂上的評比。所有實驗將在一般課程中完成。

機密保證

您的孩子任何作答都將被視為機密，爲了確保實驗之機密性，學生的試卷將只出現號碼，只有計劃主持人能比對姓名及號碼。美國賓州州立大學 The Social Science IRB 辦公室將保有審查有關此實驗紀錄的權力。

由於您的孩子是自願參與此實驗，他/她有權利在任何時間停止參與本計劃，或拒答任何不願回答的問題。所有他/她提供的資訊都將保密，就算本實驗結果將來會用於學術論文發表也不會有暴露您孩子身份或危害您孩子人身安全的任何可能。

《續下頁》
同意書
我已詳細閱讀這份同意書，也已充分了解這份同意書的相關內容：我了解我的孩子是自願參與此實驗，他/她有權利在任何時間停止參與。同時我也明白所有提供的資訊都將保密，只有計劃主持人可以處理我的孩子所透露的個人訊息。除此之外，我了解我的孩子將不會因參與此實驗而得到任何獎勵。在實驗結束後我將收到一份同意書副本作存檔保留。

我據此宣稱同意我的孩子__________________參與本研究計劃。

__________________________     ________________
家長簽名     日期

再次感謝您對此研究計劃的支持！研究員保證在任何時候對任何疑問竭力提供您滿意的答覆。如果您有任何問題，請與下方人員聯絡：

莊宗嚴 (計劃主持人)
美國賓州州立大學，課程與教學系博士候選人
電子郵件：chuangyen@psu.edu
電話：0021-814-238-7567（美國）
       011-886-6-2673351（台灣）
地址：740 Teal Lane, State College, PA16803, USA

Dr. Thomas Yawkey (論文指導教授)
美國賓州州立大學，課程與教學系教授
電子郵件：tdy1@psu.edu
電話：0021-814-863-2937（美國）
Appendix K

Agreement Form to Genius Interactive Corporation
廠商同意書

主題: 融合遊戲理論的電腦電視遊戲對中華民國台灣國小學生認知發展及學習成效的影響
The Effects of Computer/Video Gaming as Play Effects on Elementary Students' Cognitive Processes and Learning Achievements in Taiwan

對象: 105名台南市崇學國小三年級學生

敬致 淇倫互動股份有限公司:

感謝您同意讓本研究計劃使用貴公司的產品「消防第六分隊 國際中文版」為主要實驗研究教材，此計劃由美國賓州州立大學博士候選人莊宗嚴所主持，研究主旨為探討電腦電視遊戲對台灣國小學生認知發展及學習成效的影響之可能性。本研究計劃將使用貴公司所提供之電腦遊戲為教材以測驗其與學習成效的關聯性；實驗結果主要將作爲博士論文學術研討專用。

經由貴公司之協助將為此研究提供非常寶貴的資訊，同時也對未來進一步研究電腦電視遊戲在兒童認知發展的應用上的可能性提供了最初的基礎；並在兒童遊

戲理論上奠定一重要的里程碑。

實驗設計內容:

A. 隨機選出數班共約 100 名三年級學生。
B. 兩堂彈性課或電腦課時間 (共約 80 分鐘) 進行受測 (每回一班 20-30 名學生進行測試)。
C. 學生將被要求使用研究者提供之「消防第六分隊 國際中文版」為教材，單次學習時間應不超過 40 分鐘。
D. 學習之後，學生將被測試其學習成果。

《續下頁》
同意書

本公司同意提供「消防第六分隊 國際中文版」作爲“The Effects of Computer/Video Gaming as Play Effects on Elementary Students' Cognitive Processes and Learning Achievements in Taiwan”之研究及論文發表使用。

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日期

再次感謝貴公司對此研究計劃的支持！研究人員保證在任何時候對任何疑問竭力提供您滿意的答覆。如果您有任何問題，請與下方人員聯絡：

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Appendix L

Translator’s Approval
January 1, 2005

To whom it may concern,

This is to certify that the Chinese translation of the dissertation proposal, “The Effects of Computer/Video Gaming as Play Effects on Elementary Students' Cognitive Processes and Learning Achievements in Taiwan,” by Mr. Tsung-Yen Chuang has been found corresponding to the English version both in content and meaning.

Sincerely,

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AWARDS

2005         Alumni Society Research Initiation Grant Award 2005-2006
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