INVESTIGATING THE EFFECT OF COMPUTER-ASSISTED SCIENCE INSTRUCTION ON KOREAN MIDDLE SCHOOL BOYS AND GIRLS' ACHIEVEMENT, ATTITUDES AND CAREER ASPIRATIONS

by

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ABSTRACT

This study explores the effectiveness of Computer-Assisted Instructions (CAI) in science classrooms in terms of CAI and students' achievement, achievement and Attitudes toward Science (AtoS), AtoS changes and future Career Aspirations (CA), and gender differences on these three constructs with 110 boy and 124 girl Korean middle school students. This study includes the perspectives of educational equity theorist (actualist) and information and knowledge based society: the investigation of the potential of CAI as a compensatory curriculum for low achieving students from socially disadvantageous families and enhancement of young students' computer literacy through curriculum.

Based on previous year Grade Point of Average (GPA), participants were categorized into five different achievement groups. The data of pre-test achievement scores were the previous year GPA, and post-test achievement was conducted the same style with pre-tests at the end of this study. The data of AtoS, CA and gender were collected by pre- and post-questionnaires and were quantitatively analyzed with Windows Statistical Package for the Social Sciences (SPSS) 11.5.

The research findings are: (1) achievement, AtoS, and CA were improved significantly ($p<.05$) after utilizing CAI, (2) the lowest achievement group in the pre-test showed the most significant improvement in a post-test ($p=.000$), (3) the improvement of student achievement significantly influenced AtoS ($p=.019$) and CA related to science areas ($p=.000$), and (4) gender differences were statistically significant in favor of boys on three variables ($p<.05$).

This research provides the evidence that CAI has the potential to help low achievement students as a compensatory tool in science classes, and help young students enhance ICT literacy.

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CHAPTER 1
INTRODUCTION

1.1 Introduction

Demographic, economic, social and political changes are forcing educators to rethink curriculum and instructional practices (Hargreaves, 2003; Notar, Friery & Wilson, 2002). In information and knowledge-based societies people work in technology-rich environments (Notar et al., 2002). Technology plays an important role in people's everyday lives through the Internet, e-education and e-mail. Particularly for youth, new technology is not optional. Without basic technological literacy, skills, and proficiency, students will struggle in labour market and civic participation (Hargreaves, 2003; Frantom, Green & Hoffman, 2002).

The U.S. Congress Office of Technology Assessment (1995) also emphasized the importance of technology in teaching and learning. Demands for workers to have information and technology literacy have spurred educational reform in the USA (Sheffler & Logan, 1999). The National Educational Technology Standards also focus on technology literacy in order that students become informed, responsible, and contributing citizens (NETS, n.d.).

In Korea, educational policy makers recognize the importance of adolescents' technological skills and literacy for their school work as well as for their future professional careers. Access to computers for all K-12 classrooms is a nation wide issue (University of Kyungsung, 1995). In 1995, the Korean government legislated an act to promote information and technological literacy and the basic plan for Information and Communication Technology (ICT) nation wide was executed (University of Kyungsung, 1996) (appendix 1). In particular, the plan and execution of the law (Article 2 and item 5) stipulate that education, science and

technology research, and environmental areas should receive benefits from this law (appendix 1). Schools have access to funds from government to reform and improve their ICT environments such as purchasing more computers, educational programs and expanding Internet accessibility (University of Kyungsung, 1996).

This research involves the investigation of the effectiveness of computer-assisted instruction (CAI) in the Korean classroom as well as offering opportunities for Korean students to develop literacy and proficiency with educational software. In addition, this research addresses how CAI influences different achievement levels, students' Attitudes toward Science (AtoS) and their Career Aspirations (CA).

1.2 Definition of Terms

Computer Assisted Instruction (CAI). Computer assisted instruction can be defined as including computers, and other technology resources to create learning environments for students (Rieber, 1995). As a working definition for this study, the science teacher is main designer and deliverer, and resources and computers are an auxiliary for teaching. In addition, CAI has to include at least four elements: 1) maximum of four students per computer, 2) computers are connected to the Internet, so students can use WWW resources, 3) computers capable of running simulation programs, and 4) the system provides chatting space on the web.

Traditional Class. The classrooms focus on text-type books in a lecture format (Hansen &Williams, 2003). According to Linn, Slotta and Baumgartner (2000), and Cepni, Tas, and Kose (2004), traditional science classes emphasize memorizing scientific concepts and vocabulary, and scientific practice is taught through structured laboratory experiments. Lord (1997) mentioned that traditional pedagogy permits a dissemination of facts as knowledge to be

passively absorbed by a student audience. This is the "transmission" view of learning that emphasizes teacher-centered whole-class methods and closely scripted student seatwork, and which suggests that students acquire concepts and skills through listening, copying text, and practicing sets of similar problems (Pea, 1996).

Student Achievement. Student achievement in academic areas can be defined as the degree of intellectual development which is acquired through the result of school activities (Association of Research in Educational Evaluation, 1995). Even though Rovai (2003) argues that what students learn from a course can not be measured or limited just by the score of a paper test, the foci for this study are on understanding CAI for developing students' understanding of natural scientific phenomena. Gains in content knowledge are measurable with a paper-based test, and so, students' test scores will be coded as a variable for student achievement.

Student AtoS Attitudes can be defined as personal, mental, and psychological states which affect an individual's response toward certain stimuli (Koballa, 1988; Yoo, 1994). Attitudes are built by prior experiences and maintained, until contradicted or changed. They play an important role in accepting or rejecting external information or stimuli (Kim, 2002; Koballa, 1988; Zacharia & Barton, 2004). According to researchers (Cannon & Simpson, 1985; Haladyna & Shaughnessy, 1982; Kim, 1974; Koballa, 1988; Zacharia & Barton, 2004), academic attitudes are a predictor of academic areas and are learned. Studies about students' AtoS (An & Koo, 1996; Haladyna & Shaughnessy, 1982; Kim, 1974; Koballa, 1988) show the following common criteria in measuring self concept toward a specific subject: the usefulness of the subject for everyday life and their future lives, and parents' attitudes toward the subject. As this research environment is a middle school science classroom and participants are middle school students, AtoS includes such categories as self concept toward science as a school

subject, science and scientists in society and science and everyday life.

Motivation Motivation is defined as the forces that account for the arousal, selection, direction and energization of behavior (Weiner, 1990). Weiner (1990) divided motivation into two categories: extrinsic and intrinsic. According to Ryan and Deci (2000), and Weiner (1990) extrinsic motivation refers to behavior directed to attaining external outcomes such as praise, money or a diploma, which are not directly related to the behaviors. Intrinsic motivation refers to performing an action for the inherent satisfaction that arises from the action itself. Intrinsic motivation can be prompted by the desire to accomplish challenging and meaningful goals, sensory and cognitive curiosity, and competition with others. Malone and Lepper (1987) show that when students are stimulated only by extrinsic motivators without intrinsic motivators, these extrinsic motivators can bring negative results to education: if the extrinsic rewards are removed, the expected behavior returns to its initial level and in the future, stronger extrinsic rewards are required in order to motivate students to behave in the desired way. In addition, Lepper and Hodell (1989) argue that the behavior reinforced by extrinsic motivators is rarely internalized and applied to other situations.

Therefore, this research is mainly concerned with intrinsic motivation stimulated by sensory and cognitive curiosity and the desire to accomplish challenging tasks. The class content of this research covers the revolution of the earth and the other planets as well as the phase changes of the moon. The presentation of graphic simulations of these astronomical phenomena using CAI programs and Internet resources[1] is expected to stimulate student's sensory and cognitive curiosity. In addition, CAI programs and the Internet resources can play a

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[1] http://hanol.ms.kr/~tsan/earth_moon_revolution/earth_moon_revolution1.htm
http://hanol.ms.kr/~tsan/inner_planet/inner_planet.html

scaffolding role for students' learning and enable students to be challenged to gain a deeper understanding of the astronomical phenomena.

Information Communication Technology (ICT) literacy Before defining Information and Communication Technology (ICT) literacy, reviewing computer literacy and technology literacy is a necessary procedure because these two areas are very closely related and share a lot of common factors (Oliver & Towers, 2000). Computer literacy is defined as appropriate familiarity with technology in the modern world (Scher, 1984) or the skills and knowledge required for surviving and thriving as a citizen in a city (Hargreaves, 2003). The International Technology Education Association (ITEA) states that a technologically literate person has "the ability to use, manage, assess, and understand technology" (ITEA, 2000).

In recent years, as the World Wide Web, and the comprehensive amount of internet resources have developed, a more embracing definition for the term which assumes attributes beyond computing competency is needed. But many characteristics of computer and technology literacy remained and underpinned elements for ICT literacy (Oliver & Towers, 2000).

For this research, the definition of ICT literacy should consider participants' age (13~14) and knowledge appropriateness. The ICT literacy includes the need for a basic set of computing skills such as simple word processor functions, using search engines like google or yahoo to find information and in the use of ICT as instructional media and the Internet communication tools such as e-mail and response to CAI program's questions.

1.3 Problem Statement

Schools are increasingly facing the challenge of responding to the ever- changing demands of society, such as supplying workers who are flexible, innovative and knowledgeable (Davis,

Sumara, & Luce-Kapler, 2000; Eisner, 2003; Hargreaves, 2003; Walsh, 1999). At the same time, there is an ever-widening gap between high and low achieving students (Cook-Sather, 2003; Zimmer, 2003; Eisner, 2003; Green, Preston, & Sabates, 2003; Osborne, 1999). As the result, low achieving students have difficulties in entering colleges or universities, and finding a decent job. Therefore, school is not the social gate but rather the reinforcement factor in the maintenance of the Socio-Economic Status (SES) quo (Anyon, 1988). In addition, in technology and information literacy there is a tendency for a digital divide to exist between high SES and low SES students (Becker, 2000a ; Corbett & Douglas, 2002; Fishman et al., 2001;Looker & Thiessen, 2003). Many science courses fail to engage students in the kinds of experiences they will encounter in their adult lives, such as critical interpretation of persuasive messages in advertisements, searching for information on the Internet, or finding answers to everyday science problems or problem solving (Baggott La Velle, McFarlane & Brawn, 2003; Linn et al., 2004). The consequence has been students' unwillingness to take, or lack of interest in science courses and future science-related careers (Baggott La Velle et al., 2003; Jeon, 2004; Park, Cho, Choi, Lee &Chae, 2004; Sin & Oh, 2004). Gender differences were reported in terms of the gaps of achievement and preference in science (Bendow, Arjmand, & Walberg, 1991; Dimitrov, 1999; Preece, Skinner, & Riall, 1999; Sin & Oh, 2004; Weinburgh, 1995) and technology (Braten & stromso, 2004; Bryson, Petrina, Braundy & de Castell, 2003). Boys had higher achievement and a stronger preference for science and technology than did girls.

Korean curriculum developers and science instructors face the following problems: 1) how to satisfy the demands of society, 2) how to encourage less motivated students to engage in learning activities, 3) how to increase the decreasing number of students in science areas, and 4) how to provide and realize equal educational experiences in terms of equitable distribution of

educational resources for all Korean students (Park et al., 2004; Sin & Oh, 2004). In particular, science is broadly considered a prerequisite subject for entry into most of the high status professions such as engineering, computer science, medicine and technology, thereby attracting students into science and offering a proper curriculum for the students from disadvantaged SES are a great concern (Jeon, 2004; Park et al., 2004; Yeo, 2000).

Therefore, this research was conducted to test such assumptions as CAI as an effective learning tool to enhance students' understandings in science, CAI as an alternative potential for low achieving students and CAI as an opportunity to enhance technological literacy and future professional careers. In addition, gender differences were investigated in technology enhanced science class.

1.4 Purpose

The purpose of this study is to examine the effectiveness of CAI in terms of

- Students' school achievement in science,
- A relationship between students' school achievement, AtoS and CA,
- Investigation of the probability of CAI as an extra curriculum for low achieving students and
- Improvement of ICT literacy through curriculum.

Using technology as a learning tool, the researcher examined the following relationships: CAI and students' achievement, achievement and attitude changes, attitude changes and future course or career aspirations. CAI is currently being used as a motivating factor to improve science understanding.

1.5 Significance and Foci of the Study

The significance of this study is based on the following newly defined societal and educational expectations that arose from our transition from an industrial to a knowledge economy: 1) changing society perspectives toward citizens, 2) motivating students by adjusting teaching styles to different learning styles and abilities, and 3) changing learning processes to involve: collaboration, cooperation, and integration (Cook-Sather, 2003; Hargreaves, 2003; Walsh, 1999; Zimmer, 2003). Thus, in addressing the changing perspectives toward community members, Hargreaves (2003) and Walsh (1999) noted that knowledge and information-based societies need workers who have proficiency in new technologies and capacity for lifelong learning. Societies change rapidly. Competition is globalized, and technology destroys the borders of space and culture. In order to accomplish societal goals, people must work together, respect others and consider value diversity.

A school is a place where our youngsters can learn to be future citizens and participate in democratic life (Cook-Sather, 2003; Zimmer, 2003). People get along with their neighbors and work with colleagues of different abilities harmoniously. Sharing a computer with two or a few students, the advanced students help low and normal students while working cooperatively will likely be a skill that will be useful later in life. They can practice that *Get along* is more important than *Get higher scores.*

CAI is not a perfect method or solution for students to reach societal goals but can be a useful method. Through CAI, students can be accustomed to a technology embodied environment, have the access to world wide resources with the Internet, and have open minds toward different cultures.

1.5.1 Significance of the study.

Research on differentiated curriculum (i.e., general, vocational, or academic) has shown that the students are not evenly distributed in terms of racial or socioeconomic groups (Heck, Price & Tomas, 2004; Kim, 1998). In general and vocational courses, students from poor families and particular racial groups are over-represented, on the other hand in high level and academic courses, are students from high socioeconomic families.

The development of the computer as a learning tool has reinforced the inequality of access to learning resources among students from various socio-economic and cultural backgrounds (Corbett & Douglas, 2002; Fishman, Kupperman, Marx & Soloway, 2001; Looker & Thiessen, 2003). For instance, poor families or low educated parents are not aware of the importance of computers in their children's current school work and future lives, or even though they are aware of the importance, they cannot afford to provide the expensive computers. Thus, there is a potential disproportional access to technology, which may contribute to an achievement gap. In other words, this trend necessarily indicates that the majority of low and high achievers come from poor and well to do families respectively (Ahonen, 2000; Guiton & Oakes, 1995; Oakes, 2003). Thus, CAI in science class can provide opportunities for those students who are in disadvantageous situations to have technology and information literacy and proficiency and to enhance their understanding of scientific conceptions.

Gender differences of achievement in, attitudes toward and career aspirations in science have been reported (Bendow et al., 1991; Choi et al., 2003; Dimitrov, 1999; Preece et al., 1999; Sin & Oh, 2004; Weinburgh, 1995). The digital divide between boys and girls is identified in

the way they use computers (Canada, 2001; Fishman, Kupperman, & Soloway, 2001; Looker & Thiessen, 2003). Boys are more voluntary users than girls. Bryson et al. (2003) report that the differences are significant, but others argue that the differences are not significant (Mayer-Smith, Pedretti & Woodrow, 2000; Shaw & Marlow, 1999). Through the investigation of gender differences in my research, computers for instruction can help clarify if there is a gender difference in achievement, AtoS, or CA in Korean middle school students.

There have been many studies (Bell & Linn, 2000; Hsu & Thomas, 2002; Lajoie & Lesgold, 1992; Khan, 2002; Linn, 1992) that have demonstrated the effectiveness of CAI in student achievement. The advanced functions of CAI programs like iteration, comprehensive feedback resources, flexibility for learner's request, and visualization of abstract scientific concepts have enhanced learners' understanding. However, few studies reported holistically[2] the effectiveness of CAI in different achievement groups, AtoS and CA. This research examined how CAI affected different achievement groups in terms of achievement, AtoS, CA and gender differences. Therefore, the results of this research can be a guide for educators who try to use CAI for different achievement groups and for the enhancement of their students' AtoS.

1.5.2 Foci of the study

This study has *two* areas of focus related to the purpose and significance of this study (Figure 1-1). The first is to identify and describe the effectiveness of CAI for different achievement students. The second area of focus is to understand the thinking behind, or rationale for, the desired characteristics being recommended for computers providing resources, and included the

[2] Here, "holistically" means that the research investigation in CAI includes achievement in, attitudes toward and skills rather than investigating one construct (Sumara & Carson, 1997).

following aspects: 1) What are the factors that influence student achievement in a CAI environment, 2) Does achievement have an impact on student AtoS?, 3) How does AtoS interact with student achievement, AtoS and CA?, and 4) Can CAI be a potential tool to improve low achieving student achievement?

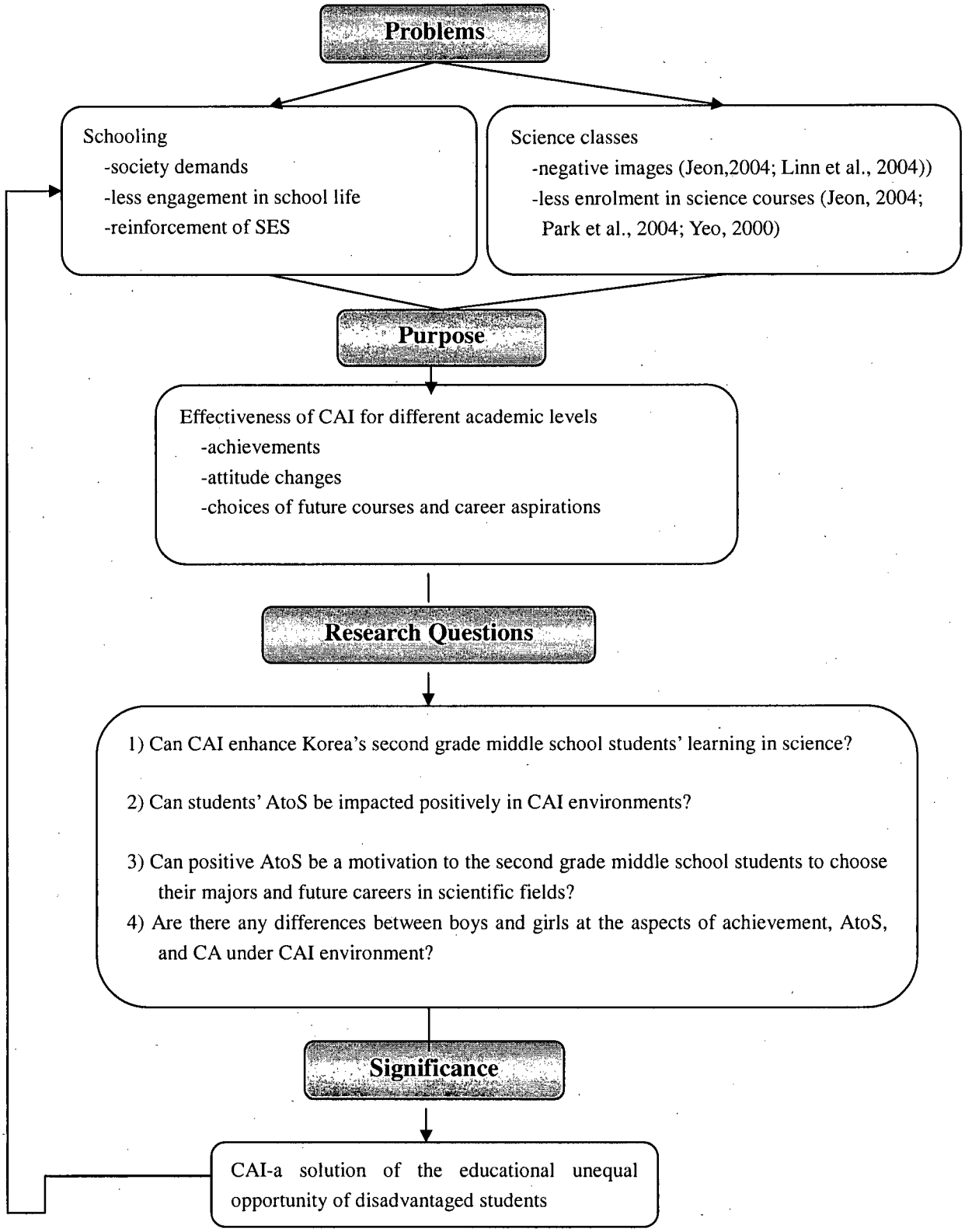

Figure 1-1 Overview of the Research

1.6 Research Questions and Hypotheses

This study has four main research questions and one or two sub-questions under each main question. In order to examine the research problem, I set a null hypothesis and an alternative hypothesis for each question. The dependent variables of the hypotheses are student achievement, AtoS and CA, which could be the driving force for students to engage in their classes and a strong motivation to carry out their tasks successfully.

Question 1) Can CAI enhance Korea's second grade middle school students' learning in science?

H_0: The null hypothesis (H_0) is that there is no significant difference in student achievement in science between the grouping mean of before and after CAI.

H_1: An alternative hypothesis (H_1) is that there is significant difference between the grouping mean before and after CAI.

H_0: $\mu_{0ach} = \mu_{1ach}$

H_1: $\mu_{0ach} \neq \mu_{1ach}$

- Are there any differences in students' improvement among different achievement groups?

  H_0: There is no significant difference in student improvement in post-test scores among five different achievement groups.

  H_1: There is significant difference of the student improvement in post-test scores among five different achievement groups

H_0: $\mu_{0achI} = \mu_{0achII} = \mu_{0achIII} = \mu_{0achIV} = \mu_{0achV}$

H_1: $\mu_{0achI} \neq \mu_{0achII} \neq \mu_{0achIII} \neq \mu_{0achIV} \neq \mu_{0achV}$

Question 2) Can students' AtoS be impacted positively in CAI environments?

H_0: CAI does not influence students' attitudes such as self-confidence, motivation and interest towards science.

H_1: CAI does influence students' attitudes toward science.

H_0: $\mu_{0att} = \mu_{1att}$

H_1: $\mu_{0att} \neq \mu_{1att}$

- Does students' improvement in their post-test achievement affect their AtoS?

H_0: There is no significant difference in attitudes toward science whether or not students improve in their post-test.

H_1: There is significant difference in attitudes toward science whether or not students improve in their post-test.

H_0: $\mu_{0att} = \mu_{1att}$

H_1: $\mu_{0att} \neq \mu_{1att}$

- What is the difference among different achievement groups and AtoS?

H_0: There is no significant difference of the student attitudes among five different achievement groups.

H_1: There is significant difference of the student attitudes among five different achievement groups

H_0: $\mu_{0attI} = \mu_{0attII} = \mu_{attIII} = \mu_{0attIV} = \mu_{0attV}$

H_1: $\mu_{0attI} \neq \mu_{0attII} \neq \mu_{attIII} \neq \mu_{0attIV} \neq \mu_{0attV}$

Question 3) Can positive AtoS be a motivation to the second grade middle school students to choose their majors and future careers in scientific fields?

H_0: There is no significant difference between CA and AtoS.

H_1: There is a significant difference between CA and AtoS.

H_0: $\mu_{0cose} = \mu_{1cose}$

H_1: $\mu_{0cose} \neq \mu_{1cose}$

- Sub hypothesis: There is no difference between the different achievement levels and CA.

H_0: There is no significant difference in CA among different achievement groups.

H_1: There is significant difference in CA among different achievement groups.

H_0: $\mu_{0cose\ I} = \mu_{0\ cose\ II} = \mu_{0\ cose\ III} = \mu_{0\ cose\ IV} = \mu_{0\ cose\ V}$

H_1: $\mu_{1\ cose\ I} \neq \mu_{1\ cose\ II} \neq \mu_{1\ cose\ III} \neq \mu_{1\ cose\ IV} \neq \mu_{1\ cose\ V}$

Question 4) Are there differences between boys' and girls' achievement, AtoS, and CA under a CAI environment?

H_0: There is no significant difference in achievement, AtoS and CA between boys and girls under CAI environment.

H_1: There is significant difference in achievement, AtoS and CA between boys and girls under CAI environment.

H_0: $\mu_{0\ boys} = \mu_{0\ girls}$

H_1: $\mu_{1\ boys} \neq \mu_{1\ girls}$

1.7 Limitations of the Study

In conducting this research there are three limitations. First, the classes were implemented by an associate, and not by the researcher. Therefore, the interpretation of the research results depends on quantitative data and previous literature or student participants' brief comments on the backside of Optical Marker Reader (OMR) cards, not on the researcher's observation and participation. Second, the researcher did not develop the educational computer programs. Ready made programs may not satisfy all components, such as allowing students to manipulate variables, providing different levels, repeating functions for some specific parts and diagnosing their understandings. Those components reflect the theoretical framework of this research, i.e., behaviorism and constructivism. Third is the research design. This research was conducted with a time series quasi-experimental design. The method can provide information about participants' growth and a reliable picture of achievement between before and after the treatment with measuring instruments (Gribbons, Barry & Herman, Joan, 1997). In consideration of adopting an experimental design with a control group in addressing evaluation questions about the effectiveness and impact of treatment (Arlin, in press; Gribbons, Barry & Herman, Joan, 1997), the researcher noted potential unfairness for the participants of the control groups. As abundant studies have reported the benefits of computer-assisted instruction, conducting an experimental treatment may benefit one group (experimental group) while depriving another (the control group), and that is not considered fair and ethical treatment for the control group. Particularly the research result (achievement) will directly influence the participants' future high school entrance evaluation; the researcher can not be free from this ethical issue. In addition, potential complaints from the participants in the control group and their parents may negatively affect the professional career of the research associate. With this

reason, the researcher decided to use a time series quasi-experimental design instead of an experimental design with control groups in order to avoid the potential disadvantages for the participants of control groups.

1.8 Assumptions

- The instrument used was appropriate for the purposes of the study
- Students received the same treatment of CAI in the experimental group.

1.9 Organization of the Thesis

The thesis consists of five chapters. The current chapter is an introduction of the thesis, i.e., the purposes, questions and significance of this research. Also, it includes the limitations and assumptions of the research and of the definitions of terms which are used in this thesis.

Chapter 2 describes the theoretical framework and literature review, which give the foundation for this study. The theoretical framework includes pertinent learning theories such as behaviorism and constructivism which have affected the instruction and design of CAI programs. Literature reviewed includes the educational accessibility, digital divide and the effectiveness of CAI in terms of achievement, encouragement students' motivation and engagement and attitude changes.

Chapter 3 describes the methodology: participants, implementation, validity of the instruments, procedures, data collection, and data analysis tools. I also provide a short rationale of alpha level and statistical tools.

Chapter 4 presents the results of this research with the data analyses and hypotheses. This chapter is the basis for addressing the research problem. Pre- and post-survey items were

categorized and then analyzed with appropriate statistical techniques. The research hypotheses were tested at the significance level .05.

Chapter 5 includes the limitation of interpreting the data, interpretation of the results, discussions and recommendation for further research.

CHAPTER 2

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

This chapter presents the theoretical background and literature review of the research (Figure 2-1). The main theoretical framework is delivered from behaviorism and constructivism, which have influenced science education (Duit & Treagust, 1998) and the design of CAI programs (Bates & Poole, 2003; Lin & Hsieh, 2001). Additionally, in regards to the aspects of the fairness in educational opportunity, the perspectives of actualist theory (Burbules, Lord, & Sherman, 1982) were considered. This chapter addresses the effectiveness of CAI in terms of achievement, how achievement groups are affected differently, AtoS, and difficulties utilizing CAI in a classroom.

2.2 Learning Theories

2.2.1. Rationale Including the Learning Theories in This Research

This study is grounded in behaviorist and constructivist perspectives as theoretical frameworks for two reasons. First, in order to investigate how students' learning occurs in an environment supported by CAI programs and web resources, it is important to find out how CAI programs are designed. Many CAI programs and web resources including those in Korea are designed on the basis of the behaviorist and constructivist learning theories (Bates & Poole, 2003; Koh, 1992; Kwun, 1993; Na & Jeong, 1990; Lin & Hsieh, 2001). Second, since 2000, the 7th Korean educational reformation focused on learner-centred instruction. Even though the paradigm

shifted from behaviorism to constructivism, behaviorist's perspectives such as measurable and objective learning goals, and tests of student achievement still remain influential (Seoul Educational Administration, 2000). Therefore, constructivism is the main theoretical framework, and behaviorism is auxiliary. These learning theories are the foundation for designing CAI programs and the class activities, and also guide the interpretation of the research results.

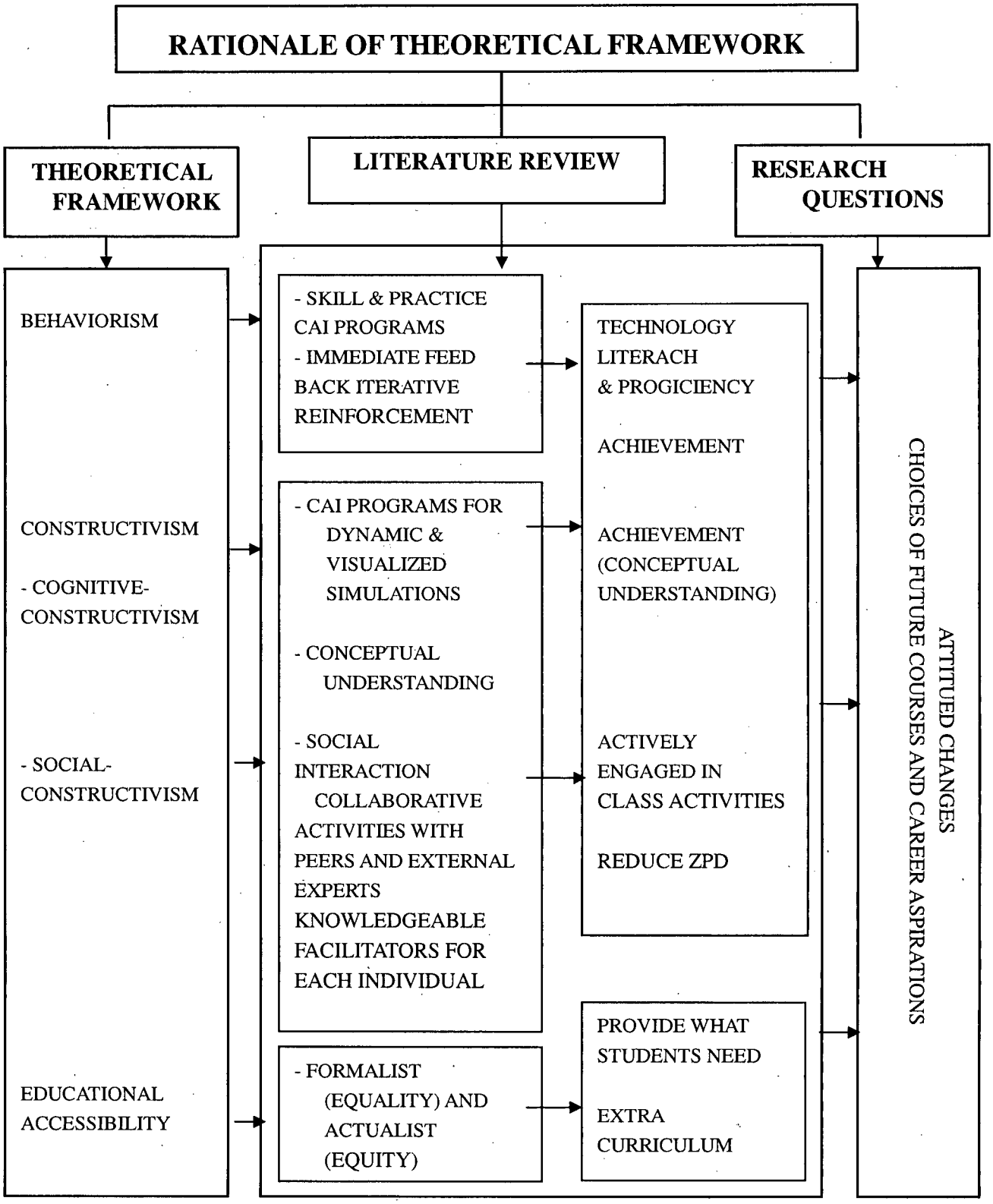

Figure 2-1 Rationale of the Framework

2.2.2. Behaviorism

Behaviorism may be traced from the 1920s and 1930s from an attempt to model the study of human behavior on the methods of the physical sciences (Bates & Poole, 2003). Based on Ivan Pavlov's theory, behaviorism holds that humans react to stimuli and learn in much the same way as animals. Central to behaviorism is the notion that contiguity between stimulus and response determines the likelihood of learning occurring (Bates & Poole, 2003; Davis, Sumara & Luce-Kapler, 2000). A certain stimulus will generate a particular physiological response like a lemon causing salivation. Thus it concentrates the attention on aspects of behavior that can be directly observable and measurable.

In the learning process, Skinner's (Skinner, 1961, cited in Resnick, 1963) operant conditioning theory assumes that the nature of the learning process emphasizes that the observable response of the learner is based on the external "reinforcements" subsequent to the response. Furthermore, inappropriate behavior could be extinguished by withdrawing reinforcement. Behaviorists do not deny individual differences, but they do not consider the differences in learning procedures because the theory applies equally to all, regardless of ability or interests or any other factors (Resnick, 1963). The mechanism of "operant conditioning theory" is 1) reinforcement, 2) stimulus discrimination training, and 3) the shaping of new behaviors by training of both stimuli and reinforcement (Davis et al., 2000; Resnick, 1963). The behaviorists' assumptions are (Davis et al., 2000):

- Human behavior is based on causes and effects
- Researchers are limited to what can be observed as opposed to inferred

The first assumption is that all behavior is logical and determined, leading to a focus on

straightforward causes and effects. Specifically, the cause and effect framework seeks to identify and to train associations between particular events and particular behaviors. Long chains of complicated and counter-instinctive behaviors can be taught through careful administration of rewards, promises of rewards, punishments, and threats of punishment. The second assumption is that thinking is invisible and not directly accessible to the researcher or the educator. Hence, behaviorists argue that the attention of researchers and teachers should be focused on observable and recordable gross behaviors. Physical behaviors are obvious, measurable, and can be influenced through direct intervention. It follows that this category of behavior is the more appropriate location for scientific analysis. Thus, behaviorists regard that even though learning is a complicated process[1], educators can predict learning outcomes (Davis et al., 2000).

Behaviorism has been the primary theoretical foundation for the development of computer assisted instructions in combining skill and drill required in areas like trouble shooting and medical training (Bates & Poole, 2003). Computers provide the means for stimulus-response learning on which behaviorists focus. Stimuli become inputs; responses become outputs, and what occurs in between inputs and outputs is information processing (Bates, 1999). The basic idea in designing CAI programs is that technology can give immediate feedback and provide various reinforcement resources through a comprehensive database (Baggott la Velle et al., 2003; Lin & Hsieh, 2001; Smeets, 2005). After learners have experienced computer programs, teachers can monitor learning activities, for instance, how reinforcement occurs and whether feedback is effective or not. However, Fraser (1996) complained the behaviorist learning

[1] The complicated systems are made by human beings, for example, clocks, computers, and robots. Even though the operating mechanisms are complicated and not easy to understand, people can predict and understandable the behaviors or the outcomes of the systems (Davis et al., 2000).

models offered by computers were flawed, since the emphasis is on an instructional process that does not consider dynamic and flexible learning resources. Becker (2000) reported his findings that most cases of using CAI programs focused on behaviorism were learning technology itself and acquiring or improving simple skills like typing speed. Becker noted that students were bored with the programs, but could not access the integrated context knowledge and could not reach higher cognitive achievement. Thus some educators were reluctant to use the CAI programs (Backer, 2000).

The main factors of behaviorism's decline were that it overlooks mental activity: complexity[2] of the unobservable learning processes contained in the mind, and the difficulty explaining higher order learning such as problem-solving and hypothesizing (Bates & Poole, 2003; Davis et al., 2000). Moreover, the behaviorist's stimuli and response mechanism had been challenged by humanists who emphasized the understanding of a human being as a holistic, self -fulfilling being (Gilbert & Watts, 1983). According to Fontana (1981), learning abilities should be reorganized as human beings' psychological fields (i.e., inner world of concepts, memories, etc.), with responses as an experience. He places stress not only on the environment, but upon the way in which the individual interprets and tries to make sense of the environment. Cognitive constructivists insist that there are mental processes in learning which are essential for human learning (Davis et al., 2000).

2.2.3. Constructivism

A key point for constructivism is that knowledge is not transmitted directly from a knower or a teacher to learners, but is actively built and created by each learner (Cobb, 1994a; Driver,

[2] Complex systems are more spontaneous, unpredictable, and volatile than complicated systems, for example, the brain, weather and ecosystems. Human beings do not produce these systems and they are self-organizing, self-maintaining, dynamic and adaptive (Davis et al., 2000)

Asoko, Leach, Mortimer & Scott, 1994; Lin & Hsieh, 2001). Constructivism shifts educators' attention from teaching to learning where students are to "construct their own understandings and capabilities in carrying out challenging tasks" (Collins, 1991, p. 29). Thus, constructivist instruction calls for a learner-centered model, assuming that individuals learn better when they are enabled and encouraged to discover things for themselves (Lin & Hsieh, 2001). Erickson (2001) noted that the "constructivist research programme introduced a number of important conceptual and methodological advances, the most notable being the recognition that all learners, even very young children, are capable of constructing plausible conceptions while engaging with their physical and social worlds." (p. 7) Learners learn by fitting new information together with what they already know and this happens best when they can actively construct their own understanding. So, from a constructivist perspective, learners are encouraged to engage in a knowledge constructing process and a social communicating process and to try out ideas and hypotheses and invent their own solutions.

There are two views of how individuals construct knowledge (Cobb, 1994b; Choi, 1997; Driver et al., 1994). One is that learning is an individualized, individual cognitive activity, what Cobb (1994 b) has called cognitive constructivism. The other view is that knowledge is socially conditioned or determined, and learners co-construct this knowledge. This has been called social constructivism (Cobb, 1994 b; Davis et al., 2000).

First, for the cognitive constructivists, learning is an individual cognitive internalizing activity. "Mind" is located in the learners' head or in an "individual-in-social-action" (Cobb, 1994 b). From this viewpoint, learning is characterized as a process of self-organization in which the subject reorganizes his or her activity to eliminate cognitive conflicts (perturbations)

(von Glasersfeld, 1989). The cognitive constructivist perspective regards formal learning as a process of interpreting and re-interpreting one's understanding of his/her experiences. Through these procedures the students can construct knowledge.

The cognitive constructivists' emphasis is on conceptual changes, thus, their learning activities are heavily weighed on figuring out individual's prior experience and conceptualizing facts (Confrey, 1990; Driver & Leach, 1993; Posner, Strike, Hewson, & Gertzog, 1982; Strike & Posner, 1992). They argue that learning activities should be individualized because each learner is different and prefers a different learning style. Before or during learning activities, articulating each individual's characteristics (differences) is important. If an instructor ignores the fact that different students have different learning styles, then instruction may only have a fleeting impact. If students could not have the opportunity to compare their previous experiences and preconceptions with the normative ones presented in class, they would soon return to their much more established view (Linn et al., 2000). Here, the teachers' job is "to provide opportunities for students to see the weakness or the inaccuracies in their current conceptions through demonstrations or activities designed to instill cognitive dissonance" (Girod & Wong, 2002, p. 201). Therefore, for the cognitive constructivist each learner is not a passive accepter of knowledge but an active knowledge constructor who connects previous experiences, preconceptions and novel knowledge. Individualized learning activities which consider the differences of each learner are effective in acquiring the conceptual understanding which cognitive constructivists emphasize.

For cognitive constructivists, learning is an individual procedure of implementing conceptual changes, without denying the importance of the individual's interaction with others

in the community (von Glaserfeld, 1989). The cognitive constructivist stresses that knowledge is essentially subjective in nature and constructed from an individual's perceptions, while the social constructivist views knowledge construction as an active process of interpretation within a social and cultural setting (Duit & Treagust, 1998).

The second perspective on how learners construct knowledge, which has been called social constructivism, or situated cognition, posits that learning is largely mediated by social and cultural processes (Cobb, 1994a; Davis et al, 2000; Salomon, 1987). Individuals construct their own meaning of a new idea, and the process of constructing meaning is embedded in a particular social setting to which the individual belongs (Duit & Treagust, 1998). Vygotsky, the 20th century Russian educational theorist, provided a foundation for socio-cultural theories of learning that have become part of the constructivist tradition (Choi, 1997; Davis, et al, 2000; Yang, 2003). His theories focus on the relationship between social interaction and the individual's cognitive development as well as on the idea that one's biological development and social development are not isolated from one another.

For social constructivists, an effective learning activity is one where the activity occurs within a community and in a classroom where teacher-learner and peer learner collaboration occurs within small groups. In the classroom, pedagogical strategies can include questioning, rephrasing, defending, hypothesizing, critiquing, theorizing and imagining (Girod & Wong, 2002). The emphasis is placed on the social nature of learning, i.e., individual mental processing is better understood as a complex system involving the individual and the whole inter personal environment (Becker, 2000; Hewitt & Scardamalia, 1998; Winn, 2003). Interpersonal social interaction of a learner with his or her peers and with the teacher is

considered a key pedagogical strategy to facilitate learning. Lave (1988) also stresses the importance of interpersonal interaction in learning that the relationship between human thought, human action, and the environment is so tightly interwoven that the mind cannot be studied independently of the culturally organized settings in which people function.

According to Vygotsky (1978) learning takes place in one's "Zone of Proximal Development (ZPD)" (1978, p. 14) The ZPD "is the distance between the actual development levels 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, 1978, p. 14). In other words, the ZPD is the gap between what a learner can accomplish independently and what a learner cannot do without assistance. That which a learner can do currently by himself or herself and what he or she can do with a more capable peer or knowledgeable teacher, may help a learner to accomplish tasks. According to Hewitt and Scardamalia (1998) the "zone of proximal development" is the area in which the teacher and student collaboratively work on activities in the zone, with the teacher gradually transferring responsibility for activities to the students as competence develops. Since a teacher is the 'more knowledgeable and experienced other' and the goal of education is to improve the experience levels of the students, the mediation provided by the 'more experienced other' is gradually removed, as the learner gains facilities. He/She is then in a position to serve as a 'more experienced other' to and for others who are novice learners. Yang (2003) stresses that in order to succeed in learning an instructor should identify each learner's ZPD, and give enough opportunities for each learner to work without the help of more knowledgeable others.

These two perspectives offered here on how individual learners construct new knowledge

are different in terms of how learning is viewed, whether an individual process or a social/cultural activity. Cognitive constructivists argue that the most important source in the development of cognition or knowledge is the students themselves, but social constructivist stresses that the social environment is important in assisting the student's cognitive development, i.e., human mental activity is the result of social learning. However, in many cases the strengths of one theory complement the weakness of the other. Cobb (1994 a) argues that learning as an individual's concept re-construction and as social interaction are complementary. Salomon (1993) proposes two varieties of interaction: individual conceptualization and socially distributed learning, which interact in a spiral-like fashion, with distributed cognition informing individual ones, and individual cognitions affecting distributed learning practices.

The strengths of computer assisted environment are in overcoming the disjuncture between school and students' lives, and to allow students to become the creators of knowledge rather than the consumers of knowledge created by others because students can manipulate their own study agendas (Collins, 1993). In other words recreating learning environments with technology enables students to promote collaboration with the experts of certain areas and to enter into a discourse with a community of learners (Butler& MacGregor, 2003; Colella, 2000). CAI programs tap into the socialization needs of students, as well as provide a social context for their learning. In addition a variety of different examples enable students to identify the similarities and differences and to hypothesize rules and patterns (Khan, 2003), so they can be encouraged to create and construct their knowledge. Garcia (1998) stresses the advantages of technology in learning:1) make observable what in nature is unobservable, 2) enables learning

to take place over a long period of time, 3) take place quickly to be grasped in real time, 4) magnify what is microscopic, 5) reduce what is macroscopic, 6) simplify and visualize complex mechanisms (p. 249).

2.2.4 Summary of Learning Theories

Since learning is a complex process (Davis et al. 2000), one theory can not explain the whole process of learning. I reviewed behaviorism and constructivism, which have heavily influenced the ways which a teacher approaches teaching or facilitating his or her students in the classroom (Erickson, 2001) and the design of CAI programs (Bates, 1999; Bates & Poole, 2003; Hannafin, 2004; Matusevich, 1995; Winn, 2003). Behaviorism explains the observable and measurable changes in learning, and has been the foundation of skill and drill focused programs like learning technology, practicing calculation, and in medical areas. Constructivism has changed the view of learners from passive knowledge acceptors to active knowledge constructors. Engaged in cognitive processing such as hypothesizing, analyzing and generalizing, CAI programs try to offer dynamic and diverse learning opportunities to enhance student conceptual understanding, to offset each student's zone of proximal development, and help them develop into autonomous learners.

The hypotheses are postulated that CAI programs grounded on behaviorism and constructivism foster the enhancement of understanding, and achievement. The positive changes of AtoS are assumed to follow up the enhancement of achievement, as well as CA. too.

Table 2-1 Theoretical Framework Rationale and Research Questions

Learning theories	Reasons	Connection with research questions
Behaviorism	- Influenced the skill and practice CAI programs - Operant conditioning particularly for lower achieving students (Becker, 2000)	-Technology literacy and proficiency - Achievement influences students' AtoS - Achievement influences students' CA - AtoS influences students' CA
Constructivism	- Influenced designing CAI programs. - Learner-centered: encouring students' engagement in class activities 1) conceptual understanding, 2) social interaction	

The following section reviews literature that supports my research questions and purposes. Schools can not sufficiently assist disadvantaged students, so in a way schooling reinforces social economic status. Research addresses whether CAI is effective in improving achievement, changing attitudes positively and helping low achieving students develop in their learning.

2.3. Literature Review

2.3.1 Introduction of the Literature Review

Educational literature since the late 1980s' has shown the possibility of using technology as a bridge for the gaps between schools and society (Bulter & MacGregor, 2003), and between higher and lower achievement (Kozma & Wanger, 2003; Linn, 1992; Smeets, 2005; White & Frederiksen, 1998). CAI enabled students to enhance their achievement and generally supports

a change of the teachers' role in classroom from teacher to facilitator as well as students from passive acceptors of knowledge to active knowledge constructors. In addition CAI is a compensatory opportunity for low achieving students who are mostly from low SES families.

In the literature on the educational accessibility, I reviewed: 1) the meaning of educational accessibility, 2) two different philosophies related to educational equal opportunity i.e., the formalists' and the actualists', 3) unevenly distributed proportion in learning achievement within different ethnic and social economic groups, and 4) digital divide. This literature review also focuses on CAI: 1) the results of CAI, in terms of achievement including the correction of misconceptions in regards to visualized conceptions or principles, 2) attitude changes toward technology, science or self confidence, 3) teachers' pedagogical philosophy and the effectiveness of CAI and, 4) difficulties in utilizing CAI in a classroom.

2.3.2. Educational Accessibility

2.3.2.1 The Meaning of Educational Accessibility.

When we consider "equal educational opportunity" there are four different meanings: equality of access, equality of treatment, and equality of outcomes, and systemic reform (Ennis, 1976; Lessard, 1995; Varpalotai, 1995). Firstly, equality of access means that theoretically the school doors are open to all. According to Lessard (1995) it is that "all individuals, regardless of sex, race, religion, or social class, should have equal opportunity of access to education" (p. 178). It rests on the assumption that education is a gateway to social mobility (Varpalotai, 1995). This category can include ease of access to school, courses offering, and the scope and depth of school curricula (Report of the Royal Commission on Education, 1988). Secondly, equality of treatment is generally equated with uniformity of treatment for the initial stages in the

curriculum (Lessard, 1995). In other words, equal treatment is beyond simple access to education. After students enter the school door, school systems and educators should not discriminate against them because of their gender, races, social status and so on (Varpalotai, 1995). Thirdly, equality of outcomes means that "school systems should compensate for the physical, intellectual, and sociocultural handicaps that individuals may bring to their schooling" (Lessard, 1995, p. 178). Husen (1979) argues the importance of equality of outcomes in terms of compensatory education. The practical implication of this is that it is not enough to give equal access and equal treatment to disadvantaged students. Emphasis should also be placed on extra resources and opportunities, i.e., "positive discrimination" (Husen, 1979, p. 75). Systemic reform suggests that inequities are designed and built into the curriculum and instructional strategies. Only systemic change can fully address equity.

2.3.2.2 Two Different Philosophies Related to Educational Equal Opportunity i.e., the Formalists' and Actualists'

These four different meanings, equality of access, equality of treatment, equality of outcomes, and systemic reform, can be interpreted and applied utilizing different philosophical conceptions: the conservative or formalist and the actualists (Burbules, Lord, & Sherman, 1982; Lessard, 1995; Renner & Moore, 2004). In most industrialized countries throughout the nineteenth and early twentieth centuries, educators and education administrators focused on equality, which was based on a formalist (Lessard, 1995; Burbules et al., 1982) philosophy. On the other hand, from the 1960s, the philosophical conception of the liberal (Lessard, 1995) and actualist theory (Burbules et al., 1982) focused on educational equity and the fairness of social justice in educational opportunity.

First, the conservative and formalist conception of educational equal opportunity is the *School door is open for all* and "Opportunities should be equal, i.e., the same for all." (Burbules et al., 1982. p. 181). School systems should give the same opportunities for all individuals regardless of sex, race, religion, or social class and if there were students who did not participate in schooling, it was their problem not that of the school system or the society (Varpalotai, 1995). After students enter the doors of the school, they should receive uniform treatment, with the same resources, and the equally qualified teachers for all. According to the formalist's perspective, a student's learning ability is determined innately and they do not consider the influence of social status, gender, or race. For the formalists, success or failure is the student's responsibility, so the less gifted have the shorter school career and it is natural-efficiency as a justification (Lessard, 1995. p. 179). They apply the rule of the survival of the fittest, and do not have much concern about compensatory education.

Secondly, the actualist conception in approaching equal educational opportunity is the fairness of social justice. They consider individual student's disadvantages in regards to economic, cultural, and racial differences. Therefore, helping those who have these disadvantages to overcome them is a matter of justice to be addressed by the school system and society (Burbules et al, 1982; Lessard, 1995; Varpalotai, 1995). However, research results (Anyon, 1988; Heck et al., 2004; Lessard 1995; Oakes, 2003; Zimmer, 2003) showed that the democratic school system did not reach the goal of equality for all students. When school systems tracked students according to their achievement the racial and economic status distribution in high, middle and low levels was not proportional. Lower groups were primarily made up of black and poor children. This means that a student's achievement is affected not

only by one's innate aptitude but also by one's socio economic status and race. For the actualists conception, the school system should provide different students different things. The term "Positive discrimination" means offering a variety of compensatory programs, and providing extra resources for disadvantaged or exceptional students. Thus, the responsibility of an individual's success or failure in academic achievement shifts from the individual and lays responsibility on the educational system.

2.3.2.3 Unevenly Distributed Proportion in Learning Achievement

Since the 1920s in the US, most elementary and secondary schools have tracked their students into separate groups, higher, average, and slow learners, according to student "ability" (Heck et al., 2004; Oakes, 2003). Recently even in the absence of formal curricula tracking, it is still likely that students' course-tracking patterns will vary widely in high school due to curriculum differentiation (Heck et al., 2004). This tracking seems to be reasonable and fair. For society, tracking provides an array of opportunities for the students so that they can have the best fit for their educational opportunities, and additionally, the teachers have tailored classes. The research reports, however, inform that the distribution in different academic ability groups is not proportional (Anyon, 1988; Heck et al., 2004; Oakes, 2003, Zimmer, 2003). In the higher courses such as math II, or science II, the White and Asian students from middle or upper SES families are dominant. In the lower courses, Hispanic, Black and poor family students are disproportionately represented (Oakes, 2003; Tieso, 2003). Heck et al. (2004) studied several class levels that students placed themselves in. They reported that most free lunch program accepters and particular ethnic group students were heavily distributed in the lower level courses, while high SES families' students were overrepresented in the honor and above

average group. In addition, among those lower level course taking students, 29% did not graduate and 76% of the lower group wanted to go to a community college and not into a four year university. Their findings are that even though there was not formal tracking, different social stratifications were revealed as course differentiation (i.e., the lower level course takers) was marginalized in society. Thus Anyon (1988) argues that school is not a gate for social movements any longer; on the contrary, it reinforces and reproduces social economic status. Furthermore, some viewed the public schools as the twentieth century's economic and social "sorting machines" (Heck et al., 2004, p. 324).

The situation in Korea also shows the unequal distribution of students' achievement in social status (Bang & Kim, 2002; Kim, Kang, Yang, & Paek, 1994). Kim et al., (1994) researched the relationship between parents' educational levels and elementary school students' achievement with total 9 classes of grades 4, 5 and 6. The students' whose fathers only graduated from elementary school had an achievement level of only 50.92%, while students with a father who had been educated beyond the university level had an achievement level of 70.42% on the same test. He also investigated the relationship between students' achievement and parents' jobs. The result showed that students' achievement from unemployed families or from families employed in manual labor was 52.09%, but the high level workers' (doctors, lawyers, engineers, university professors etc.) family students were 67.40%.

The ratio of students who passed the entrance examination for the prestigious universities in Korea is even worse in its unequal distribution among SES; 49.8 % of students were from highly educated and high income families. According to a professor in Kangwon University, the composition of families from this level is about 9.1 % for the total population in

2001 (The Kookmin Ilbo, 2001). Therefore, this group is over represented in universities.

As this research has demonstrated, from the beginning of one's school life inequality exists and continues to university, and may even continue throughout life. A school is a place where children can prepare for their future, learn how to be future citizens and participate in democratic life (Cook-Sather, 2003; Eisner, 2003; Zimmer 2003). Literature shows that the formalist argument of "innate aptitude" and the responsibility of individuals' success or failure in school lives is not always accurate. Those students who fail in their school lives are, in many cases, from socially disadvantaged groups. To give access to equal educational opportunities to all will not result in all students reaching what our society expects of our children. Schooling should give different students different things, i.e., school systems should offer extra learning resources and opportunities for the relatively disadvantaged students to compensate for their less advantageous situation in terms of social justice.

2.3.2.4 Digital Divide

As information and technology develops, the problem of the digital divide also deepens among regions, educational and economic levels (Corbett & Douglas, 2002; Looker & Thiessen, 2003; Yang, Song & Kim, 2004). Since the digital divide is closely related to the socio-economic leveling, digital equality should be realized (Davivongse, 1998; Yang et al., 2004). Young ages, highly educated and higher economic groups quickly adjust to the digital environment. However, the elderly, low-income earners, and the lower educated are excluded from the benefits of information and technology development (Corbett & Douglas, 2002; Davivongse, 1998; Looker & Thiessen, 2003; Yang et al., 2004)

In the USA and Canada, statistical data shows an unequal distribution of computers, and access to Internet resources (Canada, 2001; Corbett & Douglas, 2002; Fishman et al., 2001; Looker & Thiessen, 2003). The students from lower educated parents, economically poor families, single-parent families, or some ethnic groups have relatively fewer opportunities than students from highly educated parents and rich families (Corbett & Douglas, 2002; Looker & Thiessen, 2003). Frantom, Green and Hoffman (2002) showed that students who had a computer at home scored higher on "interest/aptitude" than those who did not own a computer (t (570) = 2.46, p=.014).

Whether a household owns a computer or not could be a substantial issue, but a more important phenomenon in the digital divide is how computers are used differently between high and low educated families, between the boys and the girls, and between urban and rural areas (Canada, 2001; Fishman et al., 2001; Looker & Thiessen, 2003). The highly educated, boys, or people living in urban areas use computers more actively and for following their own interests, while on the contrary, the lower educated, girls, or rural area people use them as passively, i.e., they use computers when they should do work with computers.

In Korea, educational level is the most significant factor in a digital divide (Oh, Kim, Hwang & Cho, 2000; Yang et al, 2004).Oh et al. (2000) studied with 2600 Koreans aged from 20 to 60 and found that technology usage was different form one's educational level, gender, age and income. The rates of using computers for middle school graduates was only half that for university graduates. Men had about 12% more opportunities to access computers and the Internet than women. Those in their twenties used the Internet the most, and the elderly used it

the least (61.5% of people in their twenties were users). High income families[3] used the Internet more frequently than low income families[4] (67.1% of high income families'). However, there was not a digital divide between rural and urban areas.

As research literature shows, achievement in school and the digital divide are not randomly distributed but depend considerably on one's SES and education levels of the students' parents. Few can deny the fact that information technology will greatly decide what children can do in their school life and in their future. With respect to equal access to educational opportunities, CAI is not only improving academic performance but is also a turning point i.e. "From Digital Divide to Digital Opportunity" (Clinton, 2000) for those students who are in a disadvantageous situation.

Therefore, in the next section my literature review will be examined the effectiveness of CAI in terms of an approach targeted at enhancing students' conceptual understanding and engagement in school activities.

2.3.3. The Effectiveness of CAI

Learning with CAI means that learning activities include exploratory or scientific discovery processes utilizing technology (de Jong et al., 1993). This is because educational computer programs usually provide diverse resources enabling learners to practice the learning processes of postulating hypothesis using a deductive method of theoretical approach and collecting data and finding patterns through an inductive approach.

In this section, the literature review will be divided into four categories: achievement, the effect of CAI on low achieving students, attitude toward science and some difficulties

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[3] more than $50,000 a year
[4] less than $12,000 a year

practicing CAI in a classroom will be considered.

2.3.3.1 Achievement

Research informed the effectiveness of CAI in improving students' achievement in terms of 1) iterative and diverse stimuli, and effective reinforcement (Baggott la Velle et al., 2003; de Jong et al., 1993; Lajoie & Lesgold, 1992; Lin & Hsieh, 2001; Smeets, 2005), 2) flexibility of contents (Hannafin, 2004; Lin & Hsieh, 2001; Smeets, 2005), 3) visualization of abstract concept and the bringing of conceptual changes (Khan, 2003, Bell & Linn, 2000; Davis & Linn, 2000; Linn, 1992; Hsu &Thomas; 2002; Noh, Cha, Kim & Choi, 1998) and, 4) encouragement of collaborative and corporative learning activities (Linn, 1992; Noh et al, 1998).

Iterative, Diverse Stimuli and Effective Reinforcement. Several researchers (Lajoie, & Lesgold, 1992; Lin & Hsieh, 2001; Linn, 1992; Noh et al, 1998; Smeets, 2005) have shown the benefit of CAI programs in providing iterative and diverse stimuli and immediate feedbacks (response to a stimulus). The project, Computer as Learning Partner (Linn, 1992) and MtnSim (Lin & Hsieh, 2001) reported that feedback could promote knowledge integration with reflection and familiar language. Comprehensive resources also served as stimuli, and reinforcement occurred effectively. Reinforcement helps learners retain newly gained knowledge, enabling it to be used when needed. Thus, diverse reinforcement should be offered to satisfy the learners' different aptitudes, prior experiences, and learning preferences as well as to prevent the students from becoming bored. With iterative, diverse stimuli and effective reinforcement computer programs can contribute to scaffolding in learning, so students can develop higher-order thinking skills (Davis, 2000; Lajoie, & Lesgold, 1992; Linn et al, 2004; Smeets, 2005). For example, in the troubleshooting practices in US Air Forces, the program SHERLOCK (Lajoie, 1993; Lajoie &

Lesgold, 1992) provided the trainees with diverse problems. Each trainee could practice skills targeted to his or her shortcomings, and mastering one step enables the learner to complete succeeding steps.

Flexibility of Contents. The flexible application of CAI programs can also be used as a scaffolding of learning (Hannafin, 2004; Lin & Hsieh, 2001; Smeets, 2005). Under the CAI learning environment, it is no longer necessary to establish a fixed learning sequence for everyone; individual learners can make their own decisions to meet their own needs at their own pace and in accordance with their existing knowledge and learning goals, in other words "learner control" (Lin & Hsieh, 2001, p. 382). CAI gives opportunities for adjusting learning contents to the needs and learning abilities of each individual student and offers tailored feedback. Learners can ask for help at any point through the materials that would have been provided by the instructors in accordance with their own perceived needs and desires. When learners need more help, CAI can provide enough opportunities to repeat the same content by just clicking buttons. For these reason, CAI makes higher achievement possible (Hannafin, 2004).

Visualization of Abstract Concepts. According to the cognitive constructivists, learning is a process of conceptual change (Cobb, 1994b; Choe, 1997; Driver et al, 1994; von Glasersfeld, 1989). One of the important aims in science education is to teach science concepts meaningfully, and make students become aware of how these concepts can be used in their everyday lives (Driver et al, 1994, Girod & Wong, 2002; Winn, 2003).

When students face theoretical principles, laws, and abstract concepts, they have difficulties in understanding and applying them to a real situation, particularly theoretical

principles and abstract concepts which can not be observed (Bell & Linn, 2000; Davis & Linn, 2000; Linn, 1992; Hsu &Thomas; 2002; Noh et al., 1998). Therefore, many CAI programs created models which enabled what was unobservable in nature to be observable. As Nashon (2003) argued that the concrete objects enable students to accustom to unfamiliar situation to familiar situations, the visualized models supported conceptual reorganization by providing a context or example that connects the abstract concepts to familiar concrete objects (Bell & Linn, 2000; Clark & Jorde, 2004; Davis & Linn, 2000 Garcia, 1998; Hsu & Thomas, 2002).

Linn (1992) says that educational computer programs are bridges to connect students' prior experiences to their newly gained knowledge. In the project, Computer as Learning Partner (Linn, 1992), students had misconceptions about heat and temperature, and heat conduction of wool sweaters and aluminum foil before they engaged in the project. Students studied and practiced with computer simulations and their understanding of thermodynamics dramatically increased from 3% to 50%. Olson's (1992) studies show how CAI led to conceptual changes on the topic of combustion with a group of 10 to 12-year-old students. The students brought preconceptions which were combined with everyday language and surface phenomena. He conducted parallel experiments, i.e., direct experiments and computer simulations. The computer simulation made it relatively easy to find patterns, because the students could gather data quickly without having to reset the experiment, and without encountering errors that could occur in actual experiments. At the end of the study the students could articulate their preconceptions and develop explicit ideas while they were working with computer simulations. Clark and Jorde (2004) reported that the experimental group's students' understanding of heat flow and thermal equilibrium was significantly higher than the control group's, $F(1,99)=9.7$,

p=.002; furthermore, the delayed post test demonstrated that the experimental students' memory lasted longer than the control group. While they generate hypotheses, and investigate the data with CAI programs, they correct their misconceptions and regenerate hypotheses. Through these processes, the students could correct their misconceptions and learn problem-solving procedures.

To learn effectively and for knowledge to be useful, Edelson (2001) emphasizes the importance of the learners' desire to learn. The goal of Learning-for-Use was that knowledge should be active and retrievable, not inert. The most impressive strategy was at the motivation step. The instructor made a situation using visualized computer simulation which confronted the limitations of students' current understanding. This internal conflict situation stimulated students' desire and curiosity to know more and engage in learning activities. While the students engaged in learning activities such as analyzing data and postulating fictitious models, computers helped them to trace where they were. The students engaged in learning activities and acquired a deeper understanding of scientific phenomena and were satisfied with their learning.

Encouragement of Collaborative and Corporative Learning Activities. Collaborative and cooperative learning activities usually take place in a computer mediated environment due to a lack of computers (Linn, 1992), and the researchers' intention to examine learners' conceptual changes by discussions mediated computers (Hewitt & Scardamalia, 1998; Tao & Gunstone, 1999). The social constructivists argue that deep and robust conceptual understandings can be constructed from communication experiences with collaborative and cooperative learning (Davis, et al., 2000; Vygotsky, 1978; Winn, 2003). In Computer-Supported International

Learning Environment (*CSILE*) project (Scardamalia & Bereiter, 1999), a group of students studied a specific area of mutual interest over an extended period of weeks and months and created a shared knowledge building by the products of their intellectual efforts for common purpose. At the *GLOBE* project (Bulter & MacGregor, 2003) students and external scientists collaboratively engaged in a project with a computer mediated environment. The students could imitate what the scientist did and could actively engage in learning activities.

Other researchers examined the collaborative communication activities in a computer mediated environment (Bell, 2001; de Jong et al., 1993; Wishart, Oades and Morris, in press). Computer Mediated Communication (CMC) plays an advantageous role in offering a rich, problem-solving atmosphere for the learner through 'creating environments that encourage conversation and collaboration'. Smeets (2005) found that 81% (N=328) teachers agreed that computer provided chatting tools stimulated students to discuss the learning content together. However, Wishart, Oades and Morris (in press) reported the inconvenient aspect of CMC activity, which was the long gap in between responses to inquiries and messages.

In using technology in classes, some approaches were endeavoring to assist students to communicate with computers (Hannafin, 2004; Means & Coleman, 2000; Williams, Chen & Seaton, 2003). By manipulating variables, learners are encouraged to work collaboratively with CAI programs or peers to formulate a hypothesis and to discover evidence. While students were engaged in these processes their higher order of thinking like problem solving or generating hypothesis improved.

2.3.3.2 CAI for Low Achieving Students

Many teachers use computers to give their students opportunities to practice for themselves

and to adapt the curriculum to the individual students' needs and abilities (Dexter, Anderson & Becker, 1998; Smeets, 2005). Kozma and Wagner (2003) inform the potential of ICT for the disadvantaged learners, who can not continue their learning due to academic disengagement from learning or social disengagement from family or school.

According to Dexter et al. (1998), teachers' view computers as a tool for their lower readiness students to make lessons simpler and more focused or instituting an accountability system. Smeets (2005) found that 76.3% (N=308) of the primary school teachers regarded ICT as a differentiation tool or ICT for the students who preferred to study independently. Besides, teachers (56%) answered they used ICT for presenting remediation learning materials or tasks to slower learners. Ruthven, Hennessy and Deaney (2005) interviewed secondary school English teachers about their opinions and usage of computers in their classrooms, and the teachers agree that the Internet resources were a complementary material, "relevant and motivational to range of students with different preferred learning styles" (p. 13). They reported that in their research, there were several different groups of students such as from different schools, grades and subjects, but most of the teachers and students agreed that computers support independent student learning activities. Furthermore, one of the teachers, who taught the academically disadvantaged students, mentioned his reluctance to conduct his class using ICT.

> To start with, there was a great reluctance.... 'I can't do this. It never works. It always goes wrong. I never finish anything' And as soon as they've started having successful lessons, then the reluctance has gone but I think it's a reluctance to do a lot of things which relates to all kinds of failures in some of their lives. (p. 27)

However, as the classes were going on the students showed enthusiasm for the classes. They claimed that CAI connected with the Internet was a potential means of success for the

disadvantaged students through offering a fresh arena, distinct from the traditional classroom.

Kozma and Wanger (2003) report that the potential of ICT for the disadvantaged learners, who are out-of-school learners. Advanced ICT which has the Artificial Intelligence (AI) technology provides the most disadvantaged learners with tailored supports of a new set of literacy skills. When integrated into a comprehensive program designed to meet the academic and social needs of disadvantaged learners, ICT can build and provide an appropriate learning communities and compensate for their academic ability.

Some studies proved that low achievement students using CAI showed improvement (White & Frederiksen, 1998). White and Frederiksen (1998) report the effectiveness of CAI in physics class. Academically low achieving students improved at a significantly higher rate than high achieving students. Baggott la Velle et al., (2003) interviewed lower achieving students after they finished the class which was about electric circuits and was taught with CAI. Even though the interviewee could not understand the characteristics of a series and parallel circuit, and the measure of current and voltage, they enjoyed manipulating computers and did the class task well. One of the students responded that she could have strong confidence in doing class tasks with a computer. On the other hand the high achievement boy's and girl's response to the question of the preferred learning strategies was doing things their own way and carrying out practical work.

Among many teachers CAI is used as remedial and compensatory medium for low achieving or slow learners, because it can provide tailored supports, learning communities and complementary opportunities (Kozma & Wanger, 2003), diverse types of materials for different learning style students (Baggott la Velle et al., 2003; Ruthven et al., 2005) and an independent

learning tool (Smeets, 2005).

2.3.3.3 AtoS Changes

Many studies have developed and defined constructs around students' attitudes toward science (AtoS) when computers were introduced to the science classroom. For instance, the constructs are achievement in science (Ma, 1997; Ma & Xu, 2004), confidence oneself toward science (Hannafin, 2004; Smeets, 2005), teaching styles (Barton, 2000; Ruthven et al., 2005; Smeets, 2005), motivation (Elson, 2001; Jeong, 1994), engagement in science activities (Bulter, MacGregor, 2003; Bazler, Spokane, Ballard & Fugate, 1993; Williams et al., 2003). The literature reviewed for this study focuses on such constructs as achievement in science, confidence in oneself towards science, and teaching styles.

Achievement in a subject is the most important factor in one's attitudes toward the subject (Ma, 1997; Ma & Xu, 2004). In this section will overlap with the previous section as it was also examine how CAI has affected students' achievement in science. Following the constructivist perspectives, some programs focus on conceptual understanding, so they provide specific domain knowledge (Hsu & Thomas, 2002; Linn, 1992; White & Fredrikson, 1998), and visualization of abstract concepts or principles (Khan, 2003, Clark & Jorde, 2004; Noh et al., 1998; Win, 2003). Visualization and animations provided by CAI programs and the Internet resources led to the enhancement of students' conceptual understanding, and they were more effective than text or diagrams in promoting knowledge integration and enhancing students' attitudes and interests (Bell & Linn, 2000; Davis & Linn, 2000; Clark & Jorde, 2004; Sadler, Gould, Brecher & Hoffman, 2000). Clark and Jorde (2004) designed the thermodynamics class with visual discrepant events to reach the conceptual reorganization of students. During the

post-interview all students of the experimental group demonstrated the positive impact of the visualized tactile model.

The flexibility of CAI programs also brought self confidence in science and it plays an important role in changing attitudes (Hannafin, 2004; Smeets, 2005). CAI programs easily provide additional materials for the learners, which may be accessed by both required lower and higher achievement students. The students can receive feedback as to performance and appropriate paths to follow as well as choosing a particular degree of difficulty and choosing the amount of problem practice required. In the learner controlled learning environment (Hannafin, 2004), learners have more responsibility for their learning than in instructor controlled environments. In addition, positive self concept was led toward science; therefore, students' learning attitudes change positively.

When an instructor changed his/her teaching styles from lecture-based to collaborative grouping using delivered teaching resources and discussion mediated with ICT, students responded positively to the classes (Barton, 2000; Ruthven et al., 2005; Smeets, 2005). Teachers reconstructed class activities and focused on what students would do in the classes utilizing ICT rather than what the teachers would teach. Teachers as facilitators provided diverse learning activities and resources through the use of ICT (Barton, 2000), and encouraged collaborative activities with others and computer programs (Ruthven et al., 2005). Smeets (2005) investigated the relation between teaching style and student attitude changes from the teachers' perspective. He conducted a survey with teachers (N=328) who used CAI programs in their classes and the reported results demonstrated that 98% (N=328) of teachers answered that CAI programs stimulated their students to work autonomously and to encourage engagement in

class. The strength of learning activities with technology was seen as helping to stimulate students' interest, engagement in and positive attitudes toward the lessons.

The public schools' classroom setting in Korea is usually that of 30-40 students with one teacher, and the teacher's activities are basically text-based and teaching tools are mainly the textbook, pieces of chalk, and a blackboard. The teacher sometimes presents learning content using a projector for the whole class, and it is difficult to adjust to individual students' understanding levels. The science teacher of this study attempts to change her instructional methods from lecture-based and teacher-centred to learner-centred instructions. Therefore she is interested focusing on encouraging students to engage in class activities and acting as a facilitator who provides class materials and encouraging students' engagement in class activities and responses to students' toward the lessons.

Changing instructional styles from lecture-based to discourse- and activity-based, and motivating students with dynamic simulation encouraged them to engage in learning activities more actively, and as consequence students attitudes were changed positively.

2.3.3.4 Gender Difference in Science

Gender differences in science, such as achievement in, attitudes toward, and eventually professional career areas exist (Benbow et al., 1991; Choi et al., 2003; Dimitrov, 1999; Preece et al., 1999; Sin & Oh, 2004; Weinburgh, 1995). Dimitrov (1999) notes that gender differences in science class have existed, such as achievement, attitudes, interest, and performance. Preece et al. (1999) identified gender differences in favor of boys and attempted to find the causes of these systematic aspects. They recommended to avoid using gender biased questions or items in science. Their assumption is that biased contexts can unwillingly influence student attitudes

toward science. Choi et al. (2003) investigated why the number of girls taking science courses in high school had gradually declined since 1997. According to their interpretation of this phenomenon, when economic situations in Korean society had gotten difficult in 1997[5], women had fewer chances to get a job in scientific areas than men. The systematic inequality reinforced gender differences in science.

The literature demonstrates the need for research regarding gender differences in science and achievement, AtoS and CA.

2.3.3.5 Difficulties with Utilizing CAI in a Classroom

Universal evidence for the effectiveness of using computers in classes does not exist. Some researchers argue that the CAI method is less effective than traditional teaching in terms of the flaws of CAI programs (Ruthven et al., 2005), the difference of learning activities (Cepni et al., 2004), and the difference of learning styles (Hart, 1995; Shaw & Marlow, 2000). Some researchers complained of difficulties in using computers with younger students, because it requires self-control (Hannafin 1984 cited in Lin & Hsieh, 2001; Looker & Thiessen, 2003) and because it lacks the reliability of web resources (November, 2002).

Ruthven et al. (2005) reported the case of badly designed web-resources. For the academically disadvantaged students, several hyperlinks were too much of a challenge for them and they got lost. Another challenge was banners. The students were easily distracted by the pop up banners. When learning activities were focused on factual knowledge, CAI classes were less effective than the traditional lecture-based classes (Cepni et al., 2004). In their experimental research, the traditional lecture-based class students' scores were much higher

[5] In 1997, Korea was in one of the worst economic situations since the Korean War. The Korean government asked the IMF to loan the country some money.

than the scores for the CAI class students in a factual knowledge test. However, in their research, when they evaluated the comprehension and application level, the students who took CAI had much higher scores than students who had not experienced CAI. Hart (1995) and Shaw and Marlow (2000) conducted CAI with four different learning style groups. CAI was not effective for the theoretical style learners.

Furthermore, teachers and parents should be aware of concerns regarding management and efficiency when utilizing CAI programs in a classroom or in one's house (Lin & Hsieh, 2001; Looker & Thiessen, 2003). The flexibility of CAI and the learner controlled learning environment are effective, but on the other hand for young children self control is not easy, and after a review of relevant research, Hannafin (1984 cited in Lin & Hsieh, 2001) and Looker and Thiessen (2003) concluded that learner control is likely to be successful if applied when the learners were older and more able. Another risk in CAI is the temptation of non-educational web resources like Internet games, chatting additions, and pornography sites. To focus on educational programs on the Internet, teachers and parents should continuously supervise the youngsters' use of computers.

It is widely known that many of the Internet resources are generated anonymously and their origin as well as their validity is not known. As a result, the significant problem is the reliability of Internet resources (November, 2002). November found that "too many young people believe that if they see some information on the Internet, it must be true" (p. 2). In his example a fourteen-year-old high school student believed that the Holocaust never happened and the death camps were in fact "Concentration camps to help Jews fight typhus carried by lice" (p. 2). The reason the student believed this was because he found the information on the

Internet site (http://pubweb.acns.nwu.edu/~abutz/index.html). In order to give students the ability to discern valuable information from a large body of resources, information literacy is a very important prerequisite factor.

In short, the possibility or ability of CAI with respect of learners' activities includes: enabling diverse experiences with alternative reality, encouraging students to broaden the scope of their intellectual investigations, practicing scientific learning procedures (hypothesizing, generalizing concepts, and analyzing data), and connecting classrooms with the outside world. Furthermore with CAI classes, students can develop computer proficiency and technology literacy. However, there are some risks in using CAI. It is a challenge to discern appropriate information on the Internet. The reliability of information is also a problem. Therefore, CAI in classes should be accompanied with lessons on information literacy.

2.4. Summary

Literature articulates the connections of the major variables of this study, i.e., achievement, AtoS and CA, and their constructs (See Figure 2-2). The possible constructs which affect these major variables are explored and can validate the interpretation of the results. Most constructs are overlapped due to major variables which are interrelated..

The constructs which affect student achievement in science are attitudes toward science (Ma, 1997; Ma & Xu, 2004), teaching styles (Baggott La Vella, 2003; Bates & Poole, 2003; Becker, 2000 b; Noh, et al., 1998), motivation (Edelson, 2001; Jeong, 1994), parents' SES (Heck et al., 2004, Zimmer, 2003), gender differences (Benbow, Arjmand, & Walberg, 1991; Weinburgh, 1995) and ICT literacy (Bryson et al., 2003; Kim, 2003).

AtoS includes the meaning of learnable and favorable. Particularly important for a student are school works, including achievement in science (Ma & Xu, 2004) and science instructional methods (Barton, 2000; Ruthven et al., 2005; Smeets, 2005). Students are motivated when science is related to everyday lives (An & Koo, 1996; Bazler, Spokane, Ballard & Fugate, 1993; Bulter & MacGregor, 2003), and science and scientists contribute to society (Strike & Posner, 1992, Moore & Foy, 1997). Family background affects students' AtoS, as well (Haladyan & Shaughnessy, 1982). Whether or not a student has confidence in science, or is aware of one's ability in science is one construct in AtoS (Simpsone & Oliver, 1990; Strike & Posner, 1992). Boys are generally motivated for science than girls (Braten & Stromso, 2004; Bryson et al., 2003; Kim 2003). When adolescents are considering their future courses or professional careers, achievement in that area (Ma, 1997; Ma & Xu, 2004; Sin & Oh, 2004), usefulness (Haladyan & Shaughnessy, 1982; Sin & Oh, 2004), family background (Haladyan & Shaughnessy, 1982), attitudes (Choi et al., 2003; Sin & Oh, 2004), and gender differences (Choi et al., 2003; Sin & Oh, 2004) are important factors.

CONNECTIONS OF THE MAJOR VARIABLES AND THEIR CONSTRUCTS

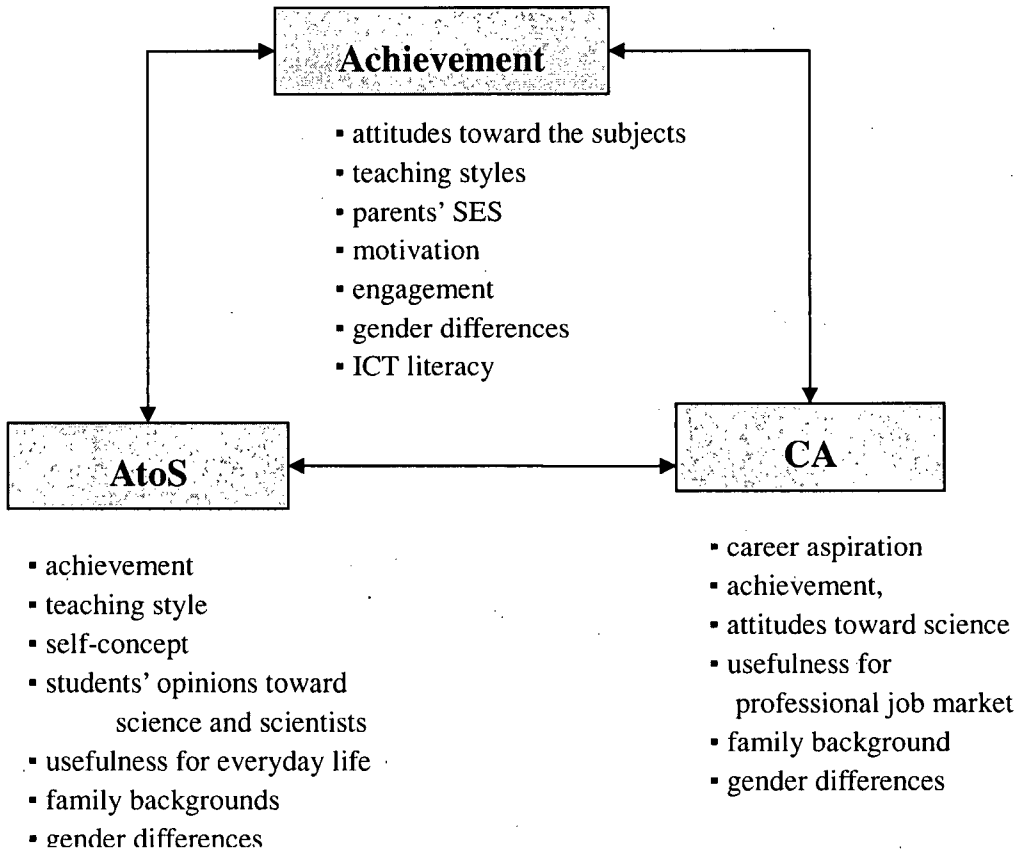

Figure 2-2 Connections of Variables and Their Constructs

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter I present the overview of this study, description of participants and their environment, the context of the participants' access to CAI, and procedures. The measuring instrument for this research is explained, i.e., the procedures of development, its contents and the proofs of validity. Data collection and the statistical techniques of data analysis are described. This chapter also includes the rationale of choosing Tukey's Honestly Significant Difference (HSD) as a post-hoc test and significance level (α level).

3.2 Research Overview

This research is a quasi-experimental design with 234 second year middle school students in Korea. The variables measured were psychometric entities: achievement in science, Attitudes toward Science (AtoS), and Career Aspiration (CA) in science areas. When a study attempts to examine the effects of treatment, a quasi-experimental design is appropriate particularly when it is impossible to manipulate the independent variables (Spatz, 2004). Since the post-test scores of participants were an important factor for their entrance into high schools, the achievement differences which may be caused by different instructional methods, i.e., some groups with CAI others with lecture-based, could raise a potential ethical problem. Also, the teacher would not take the risk to be blamed by participants and parents, so instructor would not want to volunteer.

Achievement in science, AtoS, and CA were the major variables. In this research these variables were treated as latent variables. Test scores of science were facilitated as achievement

in science, and four constructs were used to represent AtoS: self-concept in science, science as school curriculum, science and scientists for society, and science and everyday life. CA was measured by the choice of future courses and majors, and professional careers. Participants responded to these constructs on a five-point Likert scale. Pre-and post-survey questionnaires were not parallel tests, because the post-questionnaire included a few more questions about using CAI programs and reasons of post-test results. However, the major variables (AtoS, and CA) were the same categories; therefore the comparison to pre- and post-surveys were valid.

Research hypotheses were tested by statistical techniques: a paired T-test, factorial Analysis of Variance (ANOVA) and Tukey's Honestly Statistical Difference (HSD). The hypotheses were tested at the significance level (α) .05.

3.3 Choice of Location and Participants

3.3.1 Location and school conditions

For this study, I selected Mora Middle School in Pusan Korea (Pusan is the second largest city in Korea). About 98.3% of the students had access to a computer in their houses (The exact data were from the pre-survey question No. 1). Two laboratories were available for this study (Figure 3-1 and Figure 3-2). One was science experiment laboratory. There were ten computers[8] for thirty four students in each class, which enabled access to high speed Internet. On the other corner there were nine tables where students could do an experiment. The other was a computer lab which had eighteen computers. All were able to access to high speed Internet. For the teacher, there was another desk top computer, and it was also connected with the high speed Internet and a projector, in the case of the projector, the teacher wanted to hold the attention of the class as

[8] One for the science teacher and the others are for the students. Each four student shares one computer.

whole.

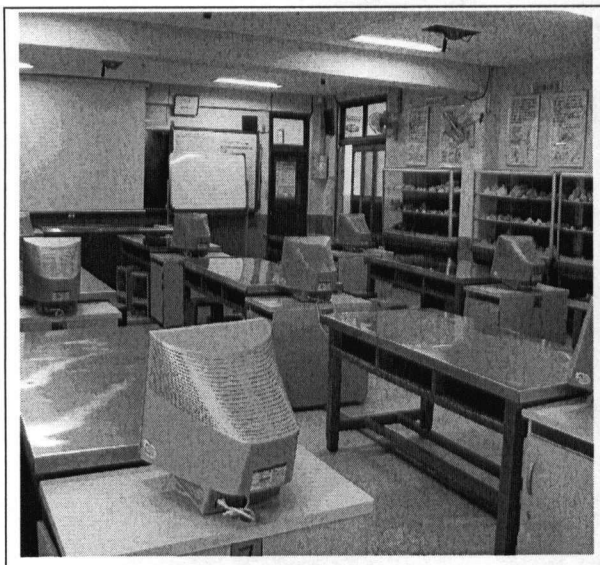

Figure 3-1 Science Lab

Figure 3-2 Computer Lab

3.3.2 Participants

Participants included two hundred and thirty four (110 boys and 124 girls) students of grade 2 of middle school[9], and consisted of 7 classes and each class consisted of 33~34 students. Since in the first grade of middle school, the students learned how to use a computer, operating systems, word processing, search the Internet and use spread sheets, the science teacher needed not to teach them how to do these basic things. In addition, they learned science with one or two teachers who studied science areas like physics, chemistry, geo-earth, or biology in university. They had been adjusted to the middle school system which was different from elementary schools[10]. Furthermore, for the researcher, the teacher (researcher's associate) and participants, this study would involve fewer burdens than with the third year middle school students, since

[9] Grade 2 of middle school in Korea is grade 8 in Canada and most of the students' ages are 13~14. Also, most Korean schools are organized by age cohort, ranging from 13~14.

[10] Children in Korea start their formal school life at six years old. In elementary school one teacher covers most of the subjects like Korean, Math, Science, Social study, Music, Drawing and etc. From middle school students learn different subjects from different teachers who majored in specific areas.

tests in the third year were weighted heavily on high school entrance exams. The classes were heterogeneous, and the achievement in the previous year Grade Point of Average (GPA) ranged from 25% to 100%. They have not had the experience of streamed classes.

3.4 Contents and CAI Programs

3.4.1 Contents

The contents included the movement of the earth, the moon, the solar system, and galaxy which were the official curriculum. Students used pre-selected web sites and programs which their science teacher provided.

3.4.2 Conditions in Choosing CAI Programs or Web Resources

Class materials can impact on the student learning (Jonassen, 1999). Many educational computer programs have simulations, questions, and options of manipulating variables, but in most cases the programs which focus on answering questions are not good enough to encourage students to engage in classes (An & Koo, 1996). The selection of the educational computer programs and the Internet resources should be sufficient for the following conditions:

- They should be appropriate for the middle school grade two student intelligent capacities.
- They should provide appropriate materials i.e., match for the curriculum content.
- They should be authentic and relevant, which means that the content should be meaningful for the students.
- The software will be open-ended constructivist software rather than skill-based transmission software. Open-ended software may serve as a tool for helping learners

build knowledge (Jonassen, 1999).

- They should provide authentic learning activities, which enable the students to manipulate the variables, to testify their hypotheses, and to demonstrate the cognitive conflict phenomena.
- They should provide the diverse opportunities to enhance conceptual changes (development) of the science conceptions.
- The program should be easy to manipulate even though the students do not know much about computer.
- They should include immediate feedback.

At the beginning of each class, participants were provided with the Internet resources pre-selected by the science teacher and the researcher, and the end of the class participants could search freely the related content areas. The reasons of pre-selections are to prevent participants from consuming class time and getting frustrated, and to give relevant and authentic information. A few classes (five classes e.g. the change of the moon phases, and calculating the brightness of a star) were presented with the PowerPoint, which were done by the science teacher (the school home page http://www.mora.ms.kr/).

Table 3-1 Contents and Class Resources

Blocks	Contents	Class Resources
1	Pre-survey	Questionnaire and explanation about the study
2-3	The Shape of the Earth	http://cyber.busanedu.net http://scienceall.com http://my.dreamwiz.com/sunghundai/Themepark/earth/earth_quantity.htm
4-5	The Size of the Earth	http://scienceall.com http://cyber.busanedu.net
6	Telescope and Spacecrafts	http://scienceall.com http://cyber.busanedu.net Middle School Science for Grade 2 produced by Korean Textbook Co.
7-9	The Sun and the Moon	http://cyber.busanedu.net http://scienceall.com PowerPoint materials made by the science teacher
10-13	Solar System	http://skywheel.kangwon.ac.kr/~ahnhi/solar.htm http://cyberlab.honam.ac.kr/javap/java.html http://www1.nasa.gov/centers/goddard/solarsystem/index.html http://scienceall.com
14-15	Constellation	http://scienceall.com http://www.science.go.kr http://cont111.edunet4u.net/2002/sangin1/earth/index1.htm
16-17	Classify the brightness of stars	http://cyber.busanedu.net http://scienceall.com PowerPoint materials made by the science teacher
18	A Cluster of Stars and Nebula	http://cyberlab.honam.ac.kr/javap/java.html http://scienceall.com
19-20	The Galaxy	http://myhome.hanafos.com/~cools4/index00.html http://scienceall.com http://cyber.busanedu.net
21	Post-test	Paper-based test
22	Post-survey	Post-questionnaire

Table 3-2 Used Computer Programs and Web Address

Web Site Name	Address
Cyber edunet	http://cyber.busanedu.net
Science All	http://scienceall.com
Lee DongJoon's JAVA Experimental Laboratory	http://scienceall.com
Ko JongHow's Cyber Science Experimental Laboratory	http://cyberlab.honam.ac.kr/javap/java.html
Teens46club	http://sciencenote.com/
Edunet4u.net	http://cont111.edunet4u.net/2002/sangin1/earth/index1.htm
Movement of the Earth	http://myhome.hanafos.com/~cools4/index00.html
Hwang Science home	http://my.dreamwiz.com/chemt/

3.4.3. CAI in the Classroom

According to the definition of CAI used in this study, the teacher is the main resource and facilitator for the class. Table 3-3 and table 3-4 provide clear information in terms of how classroom activities with CAI were different from those without CAI. Table 3-3 shows usual class activities before the research associate employed CAI, and Table 3-4 shows the class activities while she was using CAI as a teaching tool. The major difference between the two is that the teacher's explanation time was reduced. This means that students' passive roles such as observers of the teacher's lecture and copying the teacher's notes from the blackboard, were reduced in CAI environments.

The CAI class activities included introduction, explanation, interaction with computers, and reflection and discussion. The introduction is the same as the research associate's previous class instructional activities, which included the learning objectives, content and students activities. After that she devoted about 10 minutes to provide key content knowledge, but not with as much detail as that used in the lecture-based instruction. The next stage of the class was

to announce the website addresses, demonstrate how to manipulate the variables, and distribute handouts (Appendix II is an example of the handouts). She guided what the students should focus on and what the students should do while they were working with computers. The tasks for every class were to find answers to the questions on their handouts. This took about 20 minutes. The remaining time (10 minutes) was assigned checking whether the students' answers on handouts were correct or not and some students would ask questions that arose while they were interacting with CAI. The time dispositions varied depending on the content (See Table 3-4). As the handout (Appendix II) shows, the questions are focused not only on factual knowledge but also stimulating the students to postulate hypotheses and to connect scientific concepts with phenomena found in everyday life.

Table 3-3 Time table without CAI

Time (minutes)	Class Activities	Teachers role	Students Activities	Types of Classroom Activities
About 5	Introducing the topic, objectives and content	Main designer and source of information	Students see and listen to what the teacher present to them. (acceptors of information)	Close to traditional classroom (lecture based) Most class activities occurred in the classroom not in a science lab or computer lab. Each classroom has one computer for only the teachers. Therefore, students cannot use the computer during the class. The research associate usually posted the content using the blackboard, but sometimes also using the computer.
About 25	Explanation of the key points			
About 7	Dictation of what she wrote on the blackboard or posted on the computer screen	Facilitator	Copiers of the note on the blackboard and the students who have questions could ask questions individually.	Lecture based
About 7~8	Reflection of the content and question from students	Provider of questions	Students answer the teacher's questions	Lecture based

Table 3-4 Time table with CAI

Time (minutes)	Class Activities	Teachers role	Students Activities	Types of Classroom Activities
About 5	Introducing the topic, objectives and content	Main designer and source of information	Students observer and listen (acceptor of information)	Close to traditional classroom (lecture based) except she posted the content using her computer.
About 10	Explanation of the key points			
About 20	Helping students who have difficulties using computers or answering to individual students' questions	Facilitator	Interactions with computers in pair or four students	CAI programs or WWW resources (Refer to table 3-2)
About 10	Reflection of the activities with CAI and conformation of the answers, questioning and discussion	Leader and facilitator of discussion	Discussants and constructors of knowledge and actors	Learner centred

The interaction with CAI programs or www resources was that most students used the same resources pre-selected by the teacher. The first CAI activities were to diagnose (self-check) students' prior knowledge and the last CAI activities were to test how much they understand the contents at a developmental (intermediate) or an advanced level. (http://cyber.busanedu.net/jspbusan/student/exam/self_test.jsp) (See Figure 3-3). How the students interacted with the programs is shown in Figure 3-4. There are several functions such as self-diagnosis, repeat, audio supported multi lecture and simulation. Students can choose whichever they prefer to. While the students worked with computers they had to complete their handouts. If they did not know an answer they could discuss it with their peers or ask the teacher for help. After finishing their task, each group could search freely for the related information by

using keywords (The popular search engines in Korea are yahoo: http://www.yahoo.co.kr or naver: http://www.naver.com). Some students who could not understand the concept would revisit the websites and listen to the explanation from the programs, or refer to the glossary whenever the students need to clarify the meaning of a term (Figure 3-5).

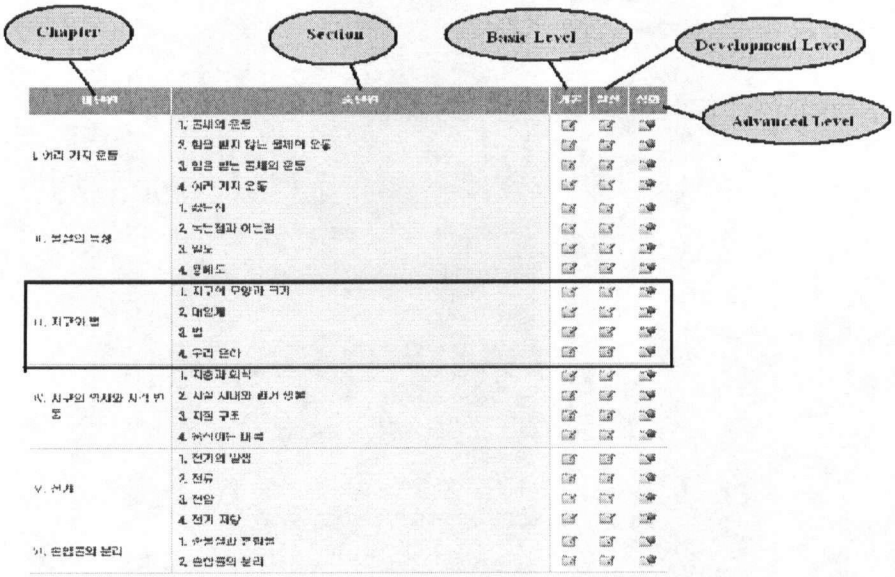

Figure 3-3 Questions of Different Difficult Levels

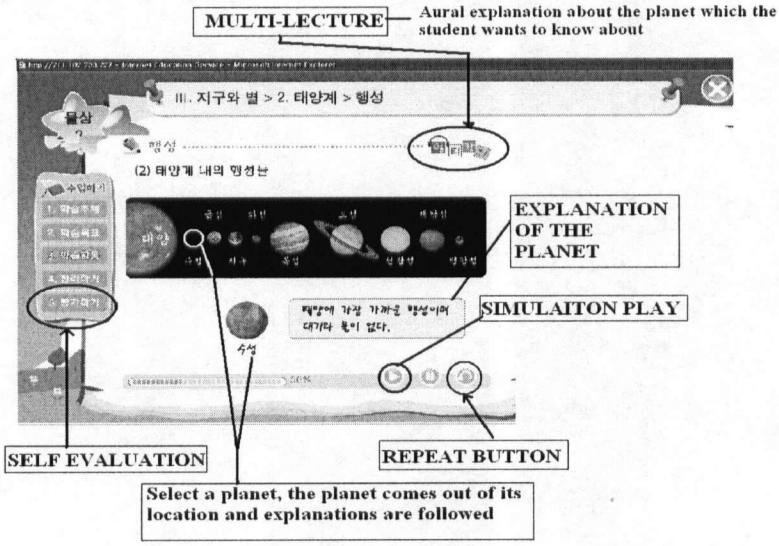

Figure 3-4 Students' Interaction with Computers

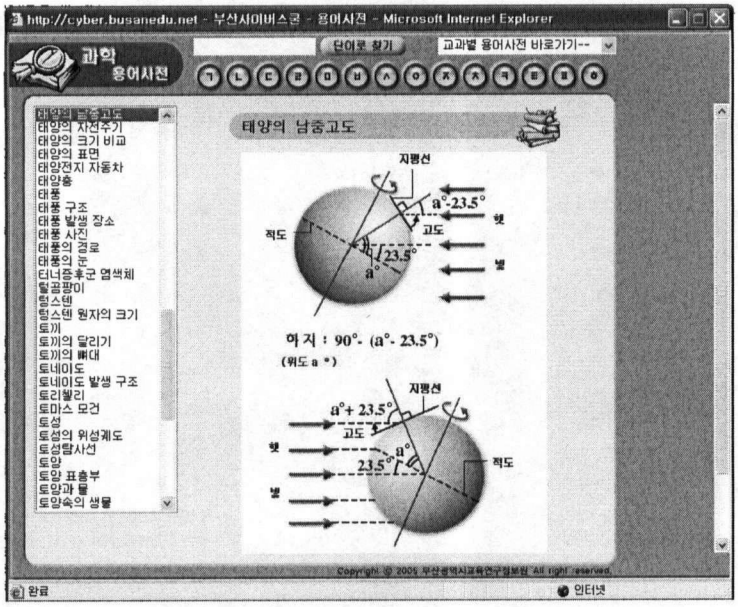

Figure 3-5 An Example of Glossary (the culmination of the sun)

3.5 Instrument Description

3.5.1 Instrument Description (see appendices III (pre-questionnaire) and IV (post-questionnaire))

Measurement instruments constitute primary tools for the collection of data sources. How well the measurement instruments match research purposes, and the properties of such instruments, are critical aspects of the validity of inferences from the research. Developing pre- and post-questionnaires, I referred to several previous studies (An & Koo, 1996; Cannon & Simpson, 1985; Koballa, 1988; Haladyna & Shaughnessy, 1892; Kim, 1974; Moore & Foy, 1997; the Relevance of Science Education Project (ROSE), n.d; Simpson & Oliver, 1990; Strike & Posner, 1992) which focus on the attitudes toward science. Item selection and question types required the consideration of the content appropriateness and age level appropriateness. After reviewing these studies, I selected attitude items and corresponding questions from following four studies.

Firstly, I consulted the "learning attitudes (of science)" (p. 163) which were developed by Strike and Posner (1992) to find an empirical support in their conceptual change theory. Secondly, I consulted the questionnaire which An and Koo (1996) developed for Korean middle school students in order to test the attitudes toward science. Thirdly, I consulted the Scientific Attitude Inventory Revision (SAI II) (Moore & Foy, 1997) for science and a scientist to a society. Lastly I referred to ROSE for science and a scientist to a society, and scientific areas for future professional careers. Ten questions were selected for measuring AtoS and 2 questions were for CA.

Pre- and post-questionnaires were carried out to probe following sub-domains: demographics, student achievement, AtoS and CA. The demographics and preference of subject were answered by direct choices. The other sub-domains consisted of Likert scales as 5 levels: strongly agree (SA), agree (A), are neutral (N), disagree (D), or strongly disagree (SD). Each response was associated with a point value, and an individual's score was determined by summing the point values of each statement (Positive statement SA=5, A=4, N=3, D=2, SD=1). For negative statements, the point values would be reversed-that is, SA=1, A=2, N=3, D=4, SD=5[11]. A high total score across all items on the scale would be indicative of an overall positive attitude. The pre-questionnaire was designed to help the researcher describe the participants' demographics like gender, household computers, and prior achievement and

	Positive Questions	Negative Questions
Strongly agree	5	1
Agree	4	2
Neutral	3	3
Disagree	2	4
Strongly disagree	1	5

opinions toward science more thoroughly. The post-questionnaire did not include the participants' demographics and rather added questions about the impression of CAI and technological difficulties while they were using CAI programs.

Pre-questionnaire. The objectives of the pre-survey are to determine participants' 1) demographics, 2) previous year GPA, 3) AtoS, and 4) CA. The pre-questionnaire consisted of 18 questions. The demographics included gender, household computers and connection with the Internet. One question was the previous year achievement in science and two questions addressed the favorable subject and the reasons. The achievement levels were divided into five groups: I) lower than 59, II) between 60 and 69, III) between 70 and 79, IV) between 80 and 89, and V) above 90[12]. The remaining twelve questions were AtoS and CA. The categories of AtoS were self-concept in science, science as a school subject, science and scientists for a society, and science and everyday life.

Post-questionnaire. The post-questionnaire appraised similar sub-domains of pre-questionnaire, some questions were added such as the reason why they could improve or drop down in post-test, difficulties or ease in using computers, positive or negative points of computer programs, and questions about opinions of using computers in science classes.

Three questions were about achievement information: the previous year GPA and post-test scores (after taking computer assisted classes) with the same scale of pre-questionnaire and five improvement ranges: 1) more than -7 points, 2) -3~ -6, 3) nearly the same (+2 ~ -2), 4) +3~+6, and 5) more than +7 points. Six questions probed the convenience and inconvenience of using computers. Twelve further questions were similar to those from the pre-questionnaire on

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[12] The grading system in Korea is 5 levels:
A is 90 or above, B is between 80 and 89, C is between 70 and 79, D is between 60 and 69, and F is lower 59 points. This research also follows the official grading system.

AtoS and CA. Demographic data would be gathered only on the pre-survey.

3.5.2 Validity of the Instrument

According to the *Standards* (American Educational Research Association (AERA), American Psychological Association, and National Council on Measurement in Education (NCME), 1999), validity "refers to the degree to which evidence and theory support the interpretations of test scores entailed by proposed uses of test" (p. 9). In other words validity means that the information from a test result is appropriate and meaningful for decision making. Thus, the question, "Is this test valid?", arises from a misunderstanding of validity. Validity is not a concern of an instrument per se but with decisions based on scores yielded by an appraisal activity (Ercikan, & Roth, 2006; Osterlind, 2006). Providing the evidence of validity is required to probe what the research is attempting to measure, how the results are to be interpreted, and what the consequences are.

The first task of probing validity, therefore, was to articulate the meaning of AtoS that was used in this research. The next step was devoted to developing and refining the measuring instrument. The third was the validation process of the instrument particularly in terms of research purposes. Finally the reliability was tested utilizing a Cronbach alpha.

3.5.2.1 Identify AtoS in This Research

The properties of a measuring instrument and how well it matches the purposes of the research are critical aspects necessary to formulate valid inferences (Ercikan & Roth, 2006). An appropriate questionnaire should include the constructs[13] of AtoS which are highlighted in this

[13] Constructs are entities that cannot be observed directly by the researcher or the teacher (Ercikan, & Roth, 2006). Cronbach and Meehl (1995, cited from Benson (1998)) defined a construct as an "attribute of people, assumed to be reflected in test performance (p. 283).

research. Thus, a review of literature provides the information to articulate what the focal constructs which belong to theoretical domain[14] and other constructs which belong to empirical domain in AtoS (An & Koo, 1996; Cannon & Simpson, 1985; Haladyna & Shaughnessy, 1892; Kim, 1974; Koballa, 1988; Moore & Foy, 1997; ROSE, (n.d[15]); Simpson & Oliver, 1990; Strike & Posner, 1992). The studies I reviewed investigated AtoS from different angles, examining attitudes toward achievement, school curriculum, and instructional environment. In order to measure the constructs, the first and the most important task of this research was to establish and define AtoS.

When researchers mentioned AtoS, what did they really mean and what kinds of AtoS did they utilize to measure from the participants? Haladyan & Shaughnessy (1982) conducted meta-analysis with 49 previous research studies in this area, and attempted to define AtoS with the 49 individual studies. They categorized the two most common constructs of AtoS from each individual research as well as several others. One common construct was that attitudes were learned from prior experiences and the other was preference toward the objects. The different constructs were scientific attitudes (a student's approach to thinking about science or cognitive attitude), attitudes toward scientists, attitudes toward a method of teaching science, scientific interests and attitudes toward parts of the curriculum. In Simpsone & Oliver's (1990) study, the constructs of AtoS were focused on the relationship between attitudes and achievement (this relationship is also the focus of my research). Their three major categories of the constructs were self (individual characteristics), school (learning environment, instructional methods,

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[14] According to Benson (1998) theoretical domain can be evolved from related literature or the scientific theory surround the traits and it is reflected by empirical domain. The constructs in empirical domain, have the potential observables.

[15] http://www.ils.uio.no/forskning/rose

textbook, etc.), and home (parents' attitudes and educational levels). Strike and Posner (1992) used the attitude questionnaire in terms of attitudes as a conceptual ecology in physics class. Other researchers (An & Koo, 1996; Cannon & Simpson, 1985) used the meaning of AtoS in a general sense rather than specifying the category of science. However, these researchers provided specific questions and they were helpful in generating test instrument. Moore and Foy (1997) also gave attitude areas through the explanation of revising process of the Scientific Attitude Inventory (SAI II). Koballa (1988) and Kim (1974) provided the concept of "attitude" which related different concepts such as belief, opinion, value, and behavior intention.

The definition of AtoS in this research includes two focal constructs belonged to theoretical domain which Haladyan & Shaughnessy (1982) found as common constructs: learning predisposition and response to a consistently favorable or unfavorable toward science. The constructs in empirical domain are: self-concept in science, science as a school curriculum, science and society, and scientific principles and everyday life.

3.5.2.2 Instrument Development

The empirical constructs of AtoS were excerpted associated with the research foci and the definition. Thirty-two questions were generated based on the previous research. Each empirical construct had multi-item questions (average 6.4 questions), which are more reliable than single question (Wang & Turner, 1999). The questions were composed of a Likert five point scale (strongly disagree, disagree, neutral, agree, strongly agree) and each question was assigned point value from 1 to 5. For the negative questions, the point values were inversely ordered, so the point of summing the total should be consistent.

3.5.2.3 Instrument Refinement

The refinement processes were conducted by three steps. The first step was conducted by the researcher herself. While selecting the questions, she considered whether the contents of questions were relevant and appropriate for the research purposes. In addition she modified the existing questions given that the participants were Korean and middle school students (about 14 years old), and their language and intellectual level of understanding had to be adjusted for. In the second step, three Korean teachers were selected to revise12 questions from the pool of thirty-two questions and refined the language. One is the research associate and her two colleagues (one is a science teacher and the other is a Korean language teacher), and all have been working as middle school teachers for more than 15 years. They selected at least two questions each construct. Finally two panels who had research experiences in education area refined the questions and examined the appropriateness of them, one was an experienced science teacher in North America, and the other was a language teacher in China for 16 years.

3.5.2.4 Investigation of Validity of the Instrument

There are several different approaches to validation of an instrument. AERA et al. (1999) suggest that the validation process includes evidence based on content, evidence based on response process, evidence on internal structure and evidence based on consequences. These are not used to classify validity but to accumulate evidence of an instrument's validity (Benson, 1998). In this research, the validity was verified by content validity, response process validity, and criterion-referenced validity as internal structure evidence.

Content Validity Identifying and articulating an instrument's content are essential for

providing instrument validity (Osterlind, 2006). Benson (1998) also argues that the validity evidence based on content can be found by the previous research. Therefore the evidence of the content validity was conducted by the relationship with the previous studies.

The origins of questions were from the previous studies which were coherent in AtoS. Instead of importing the questions directly, the language was changed to be appropriate for middle school students, but the content was not changed. The detailed information of the empirical domain constructs came from:

- Strike and Posner (1992) and ROSE (n.d.) (self-concept toward science and science as a school curriculum)
- Moore and Foy (1997) and ROSE (n.d.) (relationships between science and a scientist and a society)
- Strike and Posner (1992), Moore and Foy (1997), and An and Koo (1996) (scientific principles and everyday life)
- An and Koo (1996) and ROSE (n.d.) (choices of future courses and careers)

Figure 3-6 illustrates how focal constructs of AtoS were related with the empirical domain of constructs. The theoretical domain represents common characteristics of AtoS, i.e., learning traits, and favorable and unfavorable traits. Learning is dependent on several factors, such as pertinent learning theories, favorable and unfavorable traits, and prior experiences and prior learning. The empirical domain represents specific areas which operationalize the theoretical constructs. Even though each of the empirical domains of constructs does not evenly contribute to the theoretical domain, the empirical constructs revealed not only a learning trait but also favorable and unfavorable traits. For instance, the construct science as school

curriculum impacts on the learning trait; it also affects students' favorable and unfavorable traits.

In short, the content of the instrument measured the constructs of AtoS, which this research addressed.

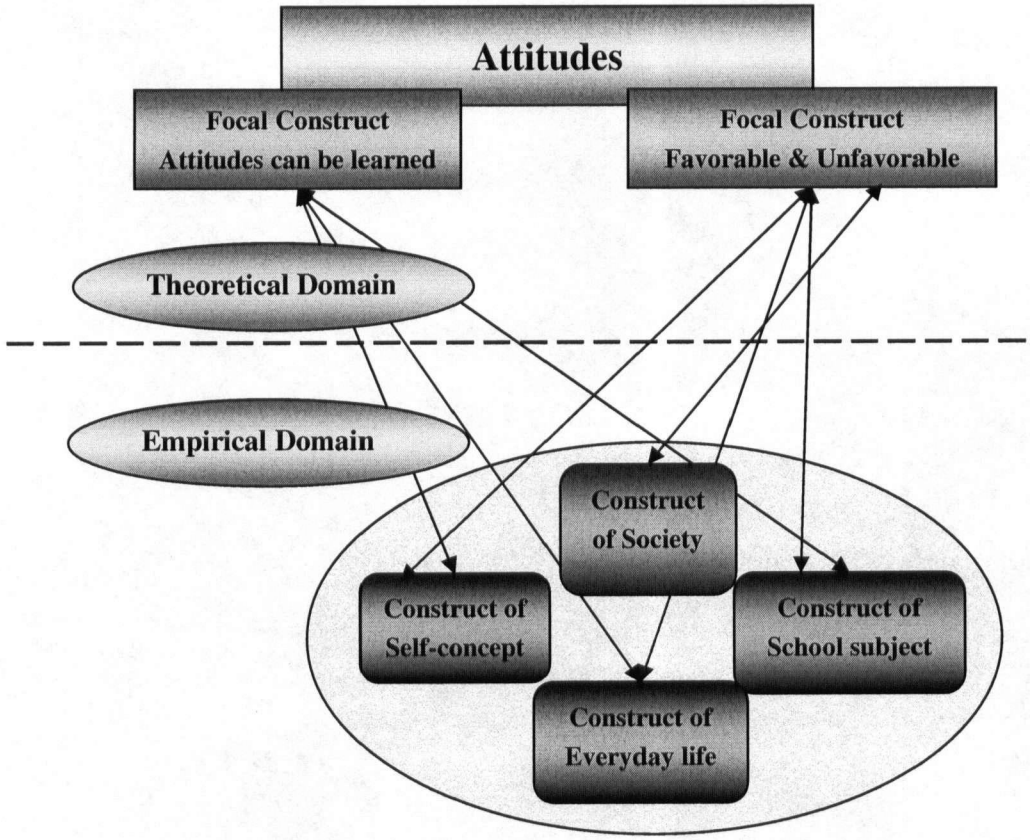

Figure 3-6. Theoretical constructs and empirical

Response Process. Related to the validity of the response process, the *Standards* (AERA et al., 1999) recommend that the evaluation of validity includes the stipulation of the response processes as a requirement for validity evaluation. The answers to the questions utilized a Likert scale, so there existed the possibility that some participants were insincere and chose only neutral answers or only answered one number throughout the whole test instead of answering carefully. This problem must be considered in proving the validity by probing individual's OMR card and checking all the answers to find tests where the items were answered using the same

numbers or where more than 80% of the answers were the same. In the pre-questionnaire there were no participants who answered using the same Likert number every time or chose one number 90% of the time. However, there were five participants (2.14%) who answered using the same number over 80% of the time on the post-questionnaire. There were no participants whose answers were all the same number. There were six participants (2.56%) who answered using the same number more than 90% of the time and three participants whose (1.3%) who answered using the same numbers over 80% of the time. There was a relatively small portion of insincere answers in both pre- and post-questionnaires.

Criterion-Referenced Validity The instrument of this study has five categorized constructs in empirical domains. For the attitudes toward science to have criterion-related validity, it should predict students' perceptions of their choices of future courses or career paths. Table 3-3 provides the Pearson correlation matrix among categorized constructs. As is evident, all correlations among the overall categorized constructs were significant at $\alpha<.001$. Furthermore, AERA et al. (1999) emphasize evidence based on consequence of testing when a researcher attempts to verify the validity of a test. In other words the validity evidence based on the test consequences should be considered: "How well do the test consequences match and how much do the test consequences reach the research objectives?" The correlation of self-concept on science and other constructs were significant, $p<.01$. The correlation of science as a school curriculum and other constructs were also significant and the Pearson's correlation coefficients were above .5. In the processes of testing hypotheses, the relationship between school science achievement and AtoS were significant. In addition those participants who have high AtoS scores in the test were likely to have positive inclination for choices of future courses and career

aspirations. The criterion-referenced validity also demonstrates the same results.

Table 3-5 Pearson Correlation Matrix among Attitudes

	Self-concept	School curriculum	Society	Everyday life	Choices
Self-concept	1.00				
School curriculum	.5855(**)	1.00			
Society	.5767(**)	.5418(**)	1.00		
Everyday life	.4493(**)	.6142(**)	.5771(**)	1.00	
Choices	.4759(**)	.7659(**)	.5585(**)	.5153(**)	1.00

** Correlation is significant at the 0.01 level

3.5.2.5 Reliability

According to classical test theory, the reliability of test scores becomes higher as the error variance in the test scores becomes lower (Osterlind, 2006)[16].

Additionally a Cronbach alpha reliability coefficient was used to investigate the reliability. Alpha was .8634 and this value was acceptable conventionally (Howell, 2005; Spatz, 2004)

3.5.2.6 Conclusions

Testing validity of this research instrument, which measured participants' AtoS, was conducted by content, response process and criterion-related validity. Based on previous studies and this research purposes AtoS was defined. The measuring instrument was developed with five categories of empirical constructs which reflected on the focal constructs of AtoS. Probing individual participant's OMR cards also revealed that above 95% of participants were sincere in

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16 $$\rho^2_{XT} = \frac{\sigma^2_T}{\sigma^2_X} = \frac{\sigma^2_T}{\sigma^2_X + \sigma^2_E}$$

ρ^2_{XT}: reliability
σ^2_X: observed score variance
σ^2_T: true score variance
σ^2_E: Error score variance

answering pre- and post-questionnaires, and criterion-referenced showed that the relationship among the sub-categorized constructs were significant at α=.01.

At the beginning of this research, I postulated that self-concept toward science would influence significantly every criterion and particularly an individual's choice of a future career path. The results, however, demonstrated that science in a school curriculum was the most significant construct in the choices. As the definition of AtoS, which included learning as a focal construct, science as a school curriculum was higher relationship than any other construct. Even though one cannot say learning occurs only through instruction in school, we cannot deny that much of learning occurs in school. Therefore the process provides evidence that the research results obtained and interpretations arrived at by utilizing the instrument (pre- and post-survey) were valid.

3.6 Procedure

3.6.1 Class Overview

This study lasted for 11 weeks at intervals of two times a week. The students had science classes in a science laboratory with ten computers or a computer lab with eighteen computers for 34 students and one for the teacher. In the computer lab, participants were paired and in the science lab participants were four to a group and grouping was done by the science teacher. According to White and Fredrickson (1998), An and Koo (1996) and Noh, et al., (1998) heterogeneous groups are more effective than homogeneous groups for the lower achievement students, because peer tutoring occurs more actively in heterogeneous group. One reason for grouping is the limitation of available computers, and the other is that collaborative learning is more

effective than individual learning in terms of operating CAI programs and understanding the content. Therefore, pairs or groups consisted of heterogeneous members based on the previous science test achievement.

Every class the teacher gave the participants the guidelines which included the core content of class. All students answered a few questions and wrote a short journal every class to prevent from doing other activities like searching different web sites that were not related to the class content.

3.6.2 Procedure

After volunteers were established and consent forms were collected, pre- and post questionnaires were given at the beginning and at the end of the study to all participants. The following four phases were used in the study (Figure 3-7):

1. Pre-questionnaire: The questionnaire was delivered to the participants by their science teacher. It was conducted in the initial block and it took about 15 minutes.

2. Classroom teaching: The science teacher conducted 19 periods of computer assisted instruction with her students. The students were exposed to the computer-assisted learning environment through a shift in teaching style from lecture-based to computer-assisted.

3. Unit Assessment: The normal curriculum assessment for this science unit (the Earth, the moon and the solar system and galaxy) was used by the teacher. The content of the assessment were related to what the participants learned with computer assisted classes and were the same as these to be used with the other students who were not participants of this study. The test style, questions, and test time were above the researcher's control. The unit assessment included a paper-based test with 30 questions.

4. Post-questionnaire: In the 22nd period, the last class of this research, the participants completed the post-questionnaire. Participants were invited to offer additional comments or opinions about the classes on the back side of the OMR cards.

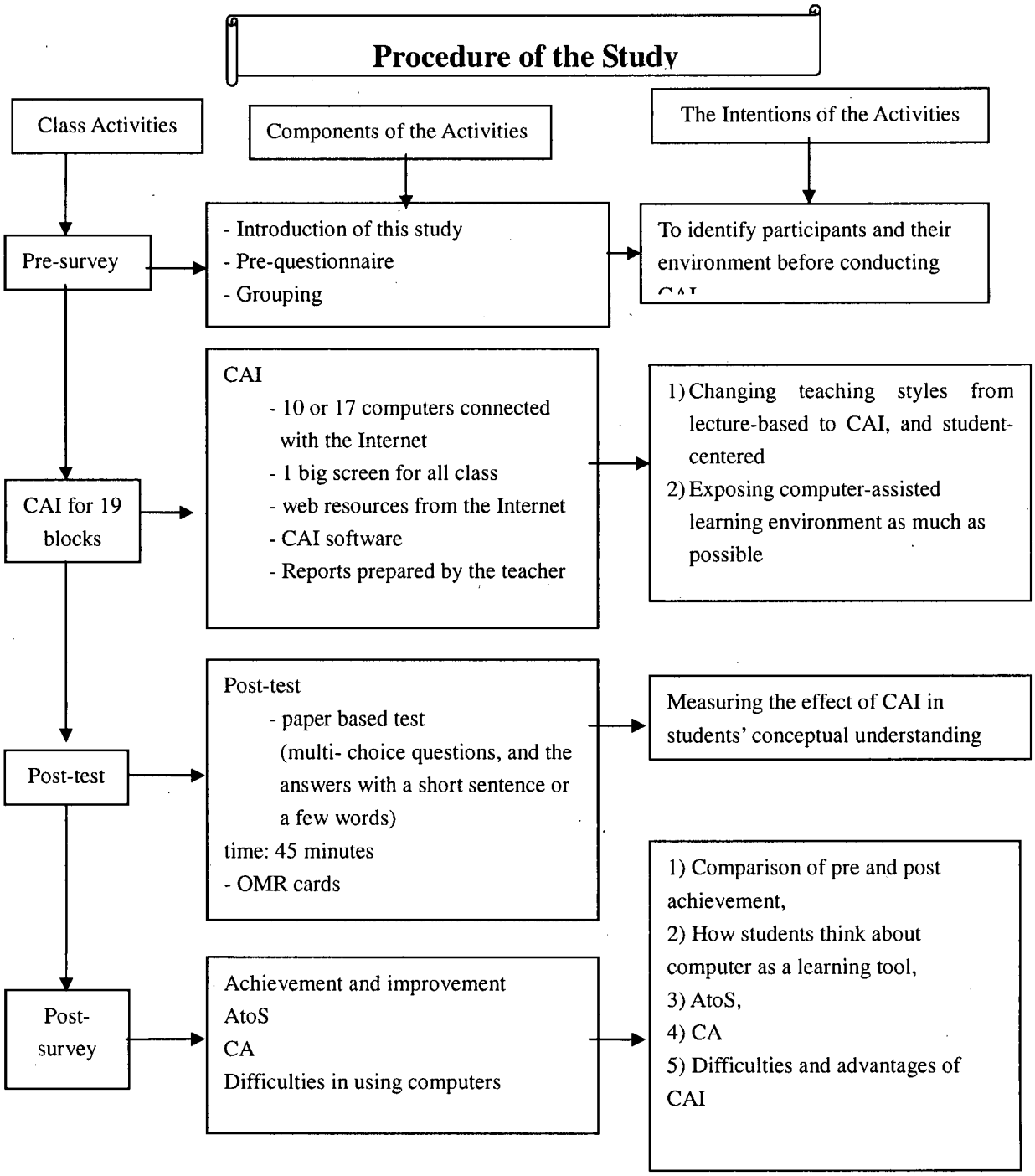

Figure 3-7 Research Procedure

3. 7 Data Collection

The data collection devices included written pre-and post-questionnaires. All participants marked their answers on the OMR cards. The answers were read by card readers and saved as EXCEL and SPSS files.

Demographics. Pre-questionnaire items from 1 to 3. Item 4 is about participants' preference school subject.

Achievement. Previous year achievement results (GPA) could be collected through the pre-questionnaire item number 5. Participants provided their achievement group as one of five levels: lower than 59, 60~69, 70~79, 80~89, and above 90. Post-achievement was collected the same way. The achievement groupings adapted the nationwide (Korea) grading system for middle school and high school so that the research results could easily be understood by those who are accustomed to the national grading system. Another reason for grouping is that if the results were to be compared to different subjects, they would not need to be converted.

Rationale for Using the Previous Year GPA as a Pre-Achievement. This research used the students' GPA from the previous year as pre-achievement scores. When the students were in middle school grade one, they took paper-based achievement tests in science five times. The previous year GPA was the average scores of these test results. Using the average as a pre-achievement baseline has one limitation and several benefits.

The potential limitation may be that the content areas covered in the grade one are not the same as this research. The content area of this research, the Earth, the Moon, and the Solar System may be more interesting than the previous years', which included characteristics of light, three phases of materials, our body, and forces and movement. However, it is also possible that

some students are more interested in the content that they learned the previous year. The different interests in content areas can be compensated by different students' preference. If content differences affect student achievement, the difference would not be significant.

On the other hand, there are benefits for using the previous year GPA as pre-achievement scores. It is not one test result; rather it is the average of four tests. Therefore the GPA score is likely to be more a measure of student achievement than the score from only one test. Another issue is that if the pre-test is conducted in the same content area as the post-test, the improvement is not caused by a treatment such as CAI (changing instructional method) but by additional opportunities (19 blocks of learning opportunities). Thus, the meaning of a pre-test is reduced to a measure of prior knowledge, not the students' achievement. Because of these benefits, I used the previous year GPA as pre-achievement scores.

AtoS and CA. Twelve items from pre- and post-questionnaires

Reasons of improvement and deterioration. Post-questionnaire items from 4 to 9

Benefits and difficulties utilizing CAI. Additional information such inconvenience or benefits of using CAI programs or self-evaluations were added in the post-questionnaire.

3.8 Data Analysis

In this study SPSS WIN 11.5 was used for statistical data analysis. I analyzed the data, not item by item but by aggregating related items. Data collected from pre-and post-questionnaires were analyzed separately and then compared in order to answer the research questions and test the hypotheses with following techniques (Figure 3-8): Pearson's correlation coefficient, regression coefficient (β), a paired samples T-test, one way analysis of variance (ANOVA) and a repeated-

measures design ANOVA.

A. Descriptive statistics: Pre-questionnaire and post-questionnaires were analyzed separately (i.e., mean and standard deviation for each item and the frequencies of 5 achievement groups).

B. Pearson's correlation coefficient (r) and regression coefficient (β): r and β were used to look at the relationships between:

- Achievement and AtoS
- Achievement and CA
- Improvement and AtoS.

C. Paired Sample T-Tests were demonstrated the differences of means in pre- and post-achievement, AtoS, and CA. Additionally in order to figure out how CAI differently affected boys and girls, I ran the paired sample T-tests for boys and girls in separately.

D. ANOVA test: In the cases of the differences of improvement, AtoS, and the choices of future courses and careers among different achievement groups (5 levels), I used one-way ANOVA as an analytical method. On the other hand the differences of the variables before and after CAI among different achievement groups, I used a repeated measures factorial ANOVA. The dependent variables (within-subjects factors) are the pre-and post-questionnaire scores. The between-subjects factors are five different pre-achievement groups. In this research a repeated measures analysis was approached a univariate way since the dependent variables are the scores of within-subjects factors. Interaction effects are also investigated between and within subject factors. The validity of the F statistic used in the univariate approach can be assured if the variance-covariance matrix is circular in

form[17]. A repeated-measures analysis of variance (ANOVA) was used to test the differences in terms of achievement, attitude changes, and CA among the five different achievement groups. The effect size (η^2), how strongly or weakly the independent variable is associated with the dependent variable, was compared to the scale Cohen (1992) suggested[18]. Additionally the power[19] will demonstrate the probability of rejecting the false null hypothesis, H_0.

E. Post-hoc test: A post-hoc test was preformed by Tukey's Honestly Significant Difference (HSD), if the ANOVA test results demonstrate statistically significant differences of the variables among groups, to determine which means are different from other means. The Tukey's HSD procedure keeps the experimentalwise error rate at the significant level of .05. Even though this advantage comes at a cost of reducing the power, more conservative in the experimentalwise error rate would be preferred in this research which aimed to

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[17] To test this assumption, Mauchly's test of sphericity can be used, which performs a test of sphericity on the variance-covariance matrix of an orthonormalized transformed dependent variable. Mauchly's test is automatically displayed for a repeated measures analysis by SPSS. For small sample sizes, this test is not very powerful. For large sample sizes, the test may be significant even when the impact of the departure on the results is small. If the significance of the test is large, the hypothesis of sphericity can be assumed. However, if the significance is small and the sphericity assumption appears to be violated, an adjustment to the numerator and denominator degrees of freedom can be made in order to validate the univariate F statistic. If the sphericity assumption may be severely violated, I would use one of the more conservative tests, i.e., Greenhouse-Geisser. Greenhouse-Geisser correction is applied to adjust degrees of freedom downward to avid an inflated Type I error rate in the tests involving repeated measures (Howell, 2002).

[18]

η^2 =.10	small
η^2 =.25	Medium
η^2 =.40	Large

[19] The definition of power is the probability of correctly rejecting a false H_0 (Howell, 2005). Therefore, power=1-β. (β: the probability of Type II error). A more powerful experiment is one that has a better chance of rejecting a false H_0 than does a less powerful experiment. "The power of a test is the probability of rejecting H_0, when it is actually false (Howell, 2005, p.107)."

investigate the most effective learning environments for the middle school students.

F. Reliability is the consistency of a set of scores (Spatz, 2005). Reliability analysis informs the properties of measurement scales and the items that make them up. The reliability analysis procedure calculates a number of commonly used measures of scale reliability and also provides information about the relationships between individual items in the scale. Intraclass correlation coefficients give the information to compute interrater reliability estimates. For example, if a questionnaire tried to measure students' attitudes toward science, the researcher can use reliability analysis in order to determine the extent to which the items in his/her questionnaire are related to each other. He/she can get an overall index of the repeatability or internal consistency of the scale as a whole. In this research I used Cronbach Alpha which is a model of internal consistency, based on the average inter-item correlation.

G. Rationale for the alpha (α) level: Alpha level is a significance level i.e., the probability of making a Type I error (rejection of the null hypothesis when it is true). When a researcher tries to test his/her hypothesis, significance level could be a yardstick whether or not to retain or reject the null hypothesis. He/She must decide whether the study with a certain probability is a sufficiently unlikely cause to reject H_0. There is no universal rule of setting alpha level, but conventionally in social science study, most researchers are willing to have a risk of 5 % (Howell, 2002). The rationale for deciding significant level in conventional studies is: 1) 0.05, and 2) 0.01. The probability under H_0 is less than or equal to 0.05 (p<=0.05), while alpha level, .01, is more conservative with respect to the probability of rejecting H_0. If there is less than a 5% chance of making a Type I error, I am willing to conclude that the result of the statistics is significant (reject the null hypothesis). In this study I set the alpha level as .05

instead of .01 or .001 because falsely retaining a false null hypothesis (Type II error) was of greater consequence than rejecting a false null hypothesis (Type I error) (Gay & Airasian, 2003; Howell, 2002; Spatz, 2004)

Results of the study are presented as the analyses of each questionnaire's descriptive and inferential statistics. The comparisons will be performed in association with students' different academic levels and improvement of achievement, attitude changes and the choices of courses and careers.

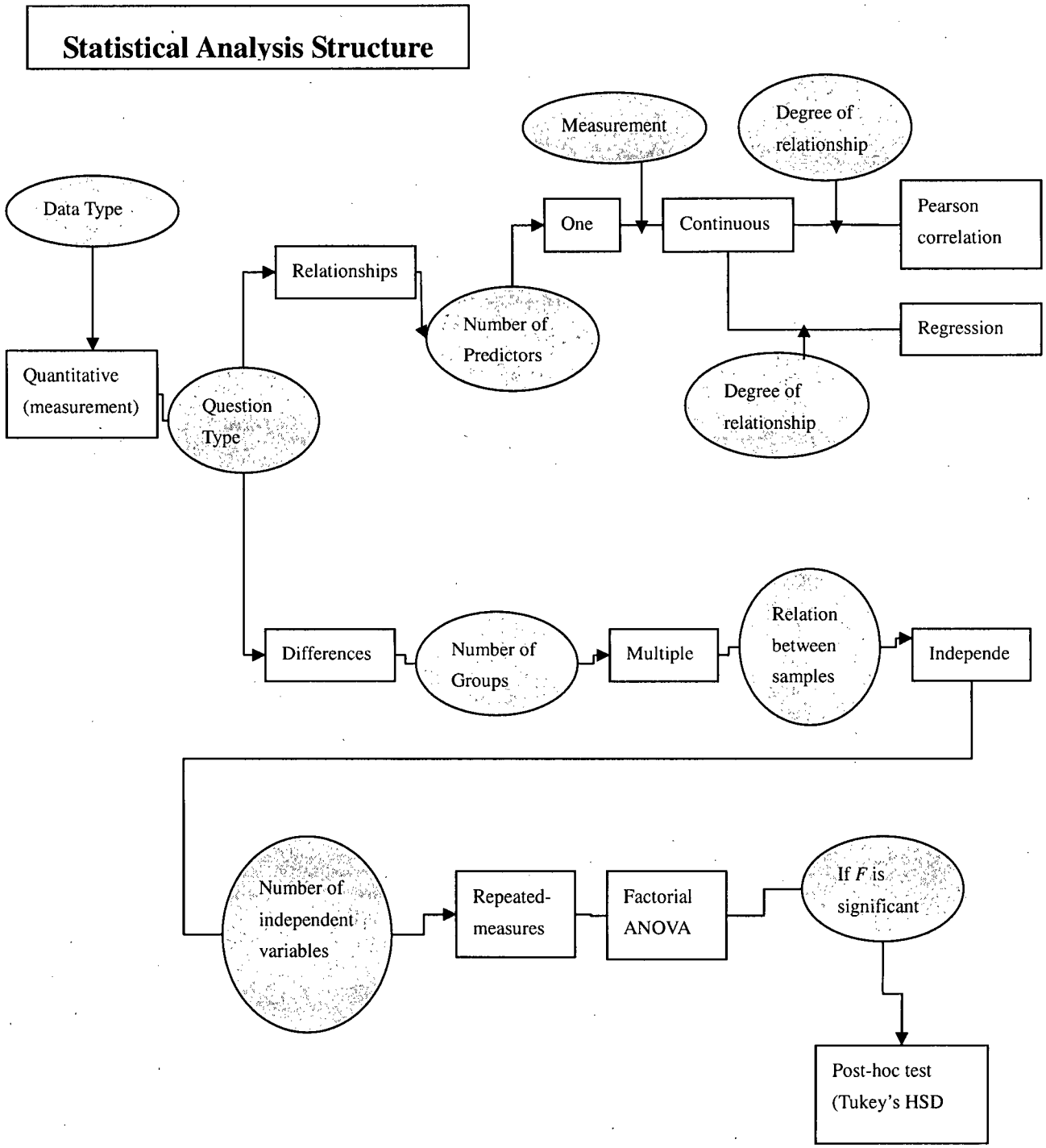


Figure 3-8 Statistical analysis structures

CHAPTER 4

RESULTS

4.1 Introduction

This chapter includes the analyses of the research data and deals with the hypotheses stated in Chapter 1 in terms of differences of achievement, Atos, choices of future courses and career aspirations and gender. Descriptive statistics such as means, standard deviations and frequencies are used to describe how the participants did in their science classes by analyzing pre- and post-surveys. Inferential statistics such as paired samples T tests and *F* ratios are used in order to test the hypotheses and interpret the effectiveness of CAI.

4.2 Description of the Pre-Survey

A sample of 110 of boys and 124 of girls participated in this research. Students were asked whether they and/or their parents owned a computer at home and were 231 students out of 234 owned (98.7%) computers in their house and which wired to the Internet. Two students said that they do not have a computer and one student did not answer the question. Table 4-1 shows that participants' preference in subject areas and reasons. Nineteen girls chose science as most interesting subject while four boys chose it. Achievement was the most important factor for choosing a preference subject, the next was usefulness or everyday life, and the third was the relatedness of one's future professional career aspiration (See Table 4-1).

Table 4-1 Preference Subject and Reasons

	Favorable subject				Reasons		
	Total	Boys	Girls		Total	Boys	Girls
Art (Music, Drawing, Physical Exercise)	84	24	60	**achievement**	60	29	31
Social Study	27	23	4	**Future career**	40	24	16
Korean or English	51	36	15	**Usefulness for everyday life**	72	28	44
Mathematics	50	23	27	**Instructional methods**	18	9	9
Science	23	4	19	**Other reasons**	45	20	25

4.2.1. Achievement

The mean of pre-test achievement in science for all participants was 2.93[20] and the standard deviation was 1.596. Graph 4-1 and Table 4-2 provide the information which the distribution of the achievement groups showed that the lowest group I had the highest distribution (75 out of 234, 32%). The next highest was group V (56 out of 234, 23.9%). The middle groups II and III had fewer participants 25 (10.7%), and 32 (13.7 %) respectively. According to Korea's grading system, most of the students failed science in the previous year. Even though I considered the wide ranges of group I, i.e., lower than 60 scores, student achievement distribution was extremely skewed. Further analysis is required to figure out the reasons why participants were divided into two extreme groups, i.e., either very low achievement students or very high achievement students.

Although the range of group I is wider than other groups, the achievement distribution

[20] All participants were categorized into five groups. 2.93 is the weighted group average.

is completely different from that of normal distributions. Reasons for this type of achievement distribution were considered by researchers (Bang & Kim 2002; Heck et al., 2004; Kim et al., 1994; Oakes, 2003). Their literature concluded that family background accounted for these types of distribution. Another possible reason is students' aptitude, as formalists argues, whereas student achievement depends on an individual's innate aptitude, and each student has to be responsible his/her academic achievement (Burbules, Lord, and Sherman, 1982; Lessard, 1995; Renner and Moore, 2004).

Graph 4-1 Distribution of Pre-achievement

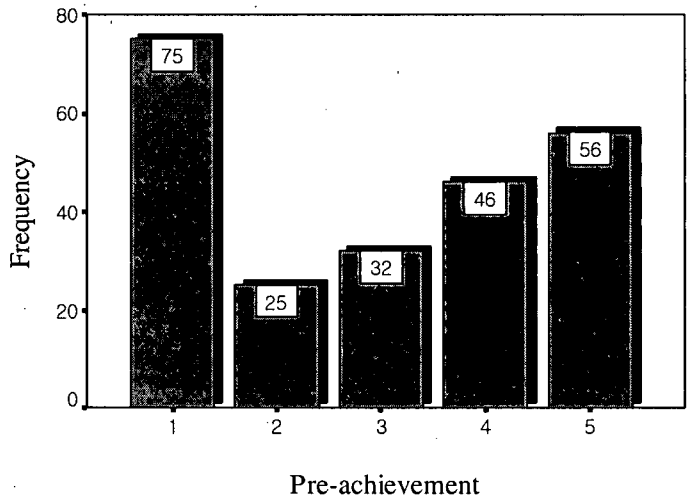


Table 4-2 Pre-achievement Distribution

group	Frequency	Valid Percent (%)
I	75	32.1
II	25	10.7
III	32	13.7
IV	46	19.7
V	56	23.9
Total	234	100.0

4.2.2 AtoS

As depicted in Table 4-3 the mean of all participants' attitudes was 30.74 out of 50 points. The Confidence Interval (CI) showed that 95% of the students fell between 30.12 and 31.36. The students' AtoS did not vary much. According to measurement theory (Osterlind, 2006), a narrow range of CI means that the mean is a fairly accurate representation of the true scores. The mean scores of each group are likely to increase as the achievement of the group increases.

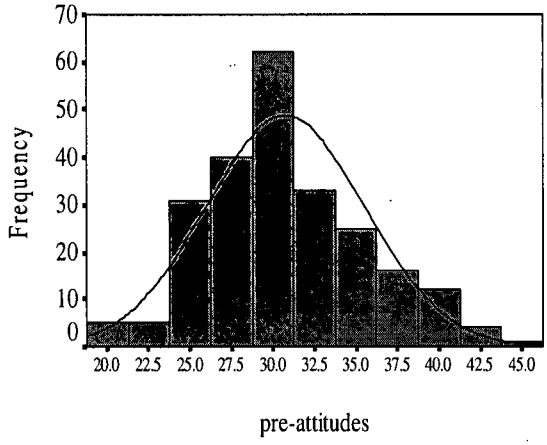
Table 4-3 Pre-AtoS

Group	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval (CI) LB	UP
I	75	28.61	3.890	.449	27.72	29.51
II	25	29.44	4.104	.821	27.75	31.13
III	32	30.28	3.531	.624	29.01	31.55
IV	46	32.00	4.867	.718	30.55	33.45
V	56	33.39	5.211	.696	32.00	34.79
Total	234	30.74	4.781	.313	30.12	31.36

Graph 4-2 demonstrates that the frequency distribution of attitudes is similar to a normal curve, the skewness is 0.413, slightly positively skewed and kurtosis is -0.087. In other words the negative kurtosis value means that the attitude score distributed less tailed than a normal curve. Participants' attitudes are related to their achievement in science. This result is consistent of the subject preference and the reasons (Refer table 4-1). AS the regression Graph 4-3 shows, when participants' achievements increase the attitude scores also increase, β=0.397 p=0.000. The higher achievement a student has the higher are his or her scores on AtoS.

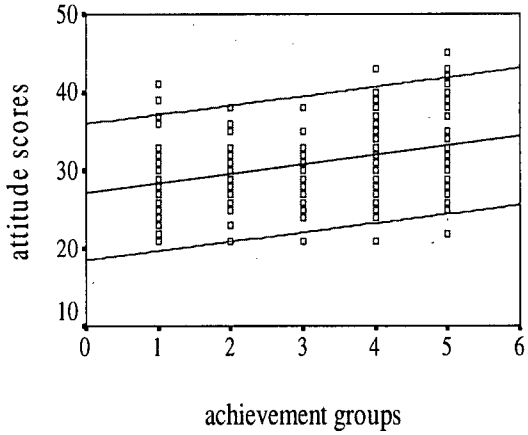
Graph 4-2

Pre-Attitude Distribution



Graph 4-3

A Regression of Pre-Attitudes



In order to figure out whether or not the differences of AtoS among different achievement groups are significant, *F*-ratio is used. An ANOVA Table 4-4 illustrates the differences in attitudes among different achievement groups are statistically significant, $F(4,229)=10.955$, $p=.000$, *power*=1.00. By a Tukey HSD test, the group V (33.39) AtoS were significantly higher than those of the group I (28.61), group II (29.44), and group III (30.28). Group IV (32.00) was also significantly higher than group I (28.61). There were no other significant differences at $\alpha=0.05$.

Table 4-4 *F* ratio of Pre-survey of Attitudes

Dependent Variable: AtoS

Source	Sum of Squares	df[21]	Mean Square	F	Sig.	Observed Power(a)
Achievement	855.326	4	213.831	10.955	.000	1.000
Error	4469.773	229	19.519			
Total	226433.000	234				

a Computed using alpha = .05
b R Squared = .161 (Adjusted R Squared = .146)

[21] df: degree of freedom

4.2.3. The Choices of Future Courses and Career Aspirations

Table 4-5 gives detail information about participants' choices of future courses and career aspirations in pre-survey results. The mean for the entire sample is 5.84 out of a total of 10 points and CI is from 5.57 and 6.12. With the entire participants' mean score 5.84, it is difficult to judge the participants inclined to choose their future in science areas. The highest mean score (6.86) is by group V, whereas the lowest mean score (5.07) is by group I. There is a strong likelihood that when participants consider their future courses or careers in scientific fields, their achievement in science affects their choices.

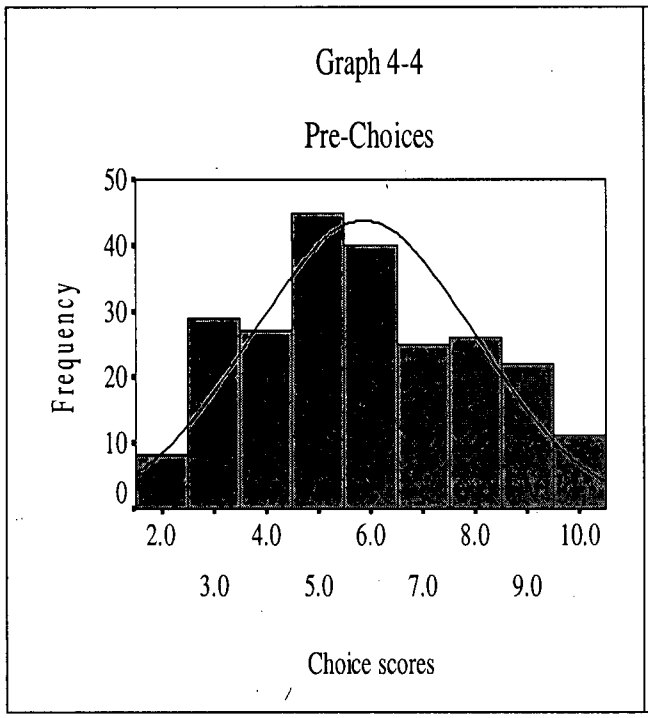
Table 4-5 Choices of Future Courses and Career Aspirations

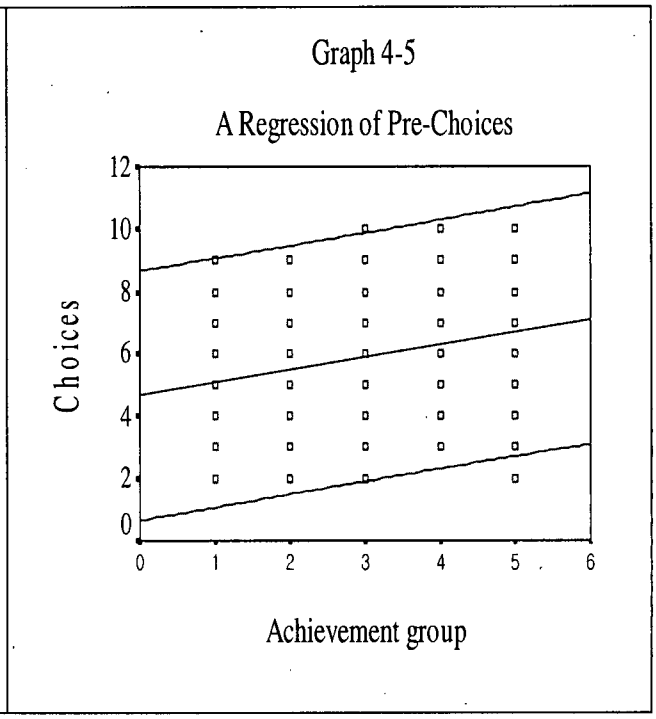
Group	N	Mean	Std. Deviation	Std. Error	95% CI for Mean		Minimum	Maximum
					LB	UB		
I	75	5.07	1.833	.212	4.64	5.49	0[22]	9
II	25	5.72	1.904	.381	4.93	6.51	2	9
III	32	5.34	2.238	.396	4.54	6.15	2	10
IV	46	6.28	2.167	.320	5.64	6.93	3	10
V	56	6.86	2.144	.287	6.28	7.43	2	10
Total	234	5.84	2.148	.140	5.57	6.12	0	10

Graph 4-4 establishes that the frequency distribution of the choices was not close to a normal curve, kurtosis was -0.839. Students' distribution was less tail directed (platykuric) than a normal curve. Graph 4-5 gives the idea of a relationship between achievement and participants' choices. As students' achievement increased the choices also increased, β=0.309, p=0.000. The choices of future courses and careers are significantly related to the students'

[22] One of group I students did not answer, so the minimum score was 0

achievement, i.e., the higher achievement a student was the higher scores of his/ her choices.





The differences among different achievement groups were statistically significant, $F(4, 228)=6.858$, $p=.000$, *power*=.993.[23] A post hoc test by a Tukey HSD showed that the group V (6.86) AtoS were significantly higher than the group I (5.07), and group III (5.34). Group IV (6.28) was also statistically significantly higher than group I (5.07). There were no other significant differences at $\alpha=.05$.

Table 4-6 Choices of Future Courses and Career Aspirations

Dependent Variable: choices

Source	Sum of Squares	df	Mean Square	F	Sig.	Observed Power(a)
Achievement	111.785	4	27.946	6.858	.000	.993
Error	929.091	228	4.075			
Total	9061.000	233				

a Computed using alpha = .05
b R Squared = .107 (Adjusted R Squared = .092)

[23] One student did not answer the choices of future courses and career aspirations. With this reason, the degree of freedom was reduced by one.

4.2.4 Gender Difference

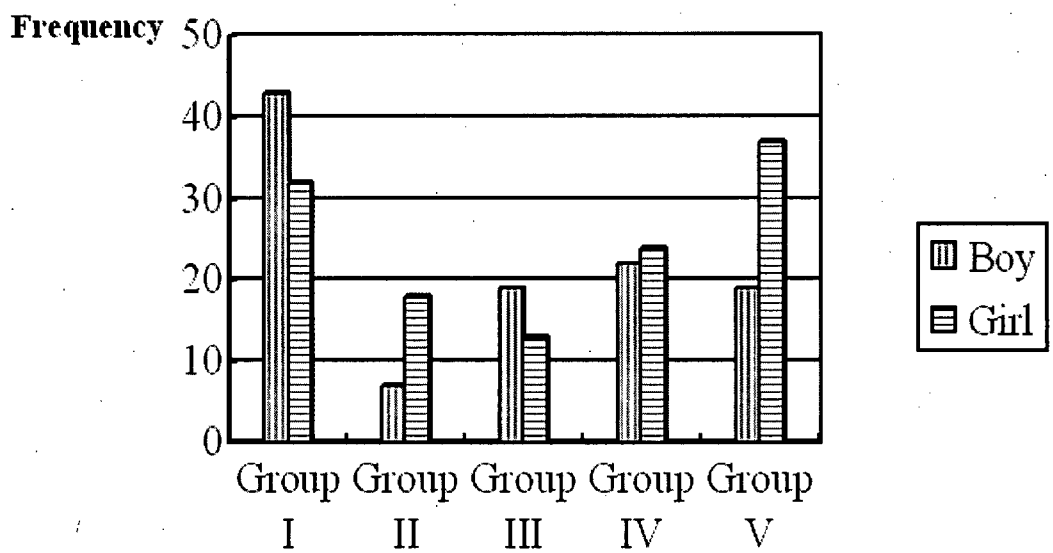
4.2.4.1 Achievement Differences between Boys and Girls

The achievement mean for the girls (3.13) was higher than that for the boys (2.70). The boys (43 out of 110, 39.10%) were more frequently found in group I than the girls (32 out of 124, 25.81%). On the other hand, more girls belonged to group V (37 out of 124, 29.84%) than did the boys (19 out of 110, 17.27%). Graph 4-6 demonstrates that the distribution is "U" shaped for boys and it inclines to the lower achievement groups. The difference of the means overall between the boys and the girls in achievement was significant, $F(1,232)=4.269$, $p=0.040$.

Table 4-7 Distribution of Boys and Girls in Achievement

	Group I	II	III	IV	V	total
Boy	43 (39.10%)	7 (6.36%)	19 (17.27%)	22 (20.00%)	19 (17.27%)	110 (100.00%)
Girl	32 (25.81%)	18 (15.52%)	13 (10.48%)	24 (19.35%)	37 (29.84%)	124 (100.00%)
Total	75	25	32	46	56	234

Graph 4-6 Distribution of Boys and Girls in Pre-Test Achievement



4.2.4.2 Attitudes Differences between Boys and Girls

The mean of the girls' attitudes (31.46) was higher than the boys (29.93). A look at Graph 4-7 clearly shows that girls were higher than boys in attitudes except in group IV. Both boys' and girls' attitudes increased as achievement increased, r=0.397, p=0.000.

The attitude differences between boys and girls were significant, $F(1, 233)=6.121$, p=0.021.

A factorial ANOVA (Table 4-8) shows the differences among different achievement groups between boys and girls. There were two independent variables, gender and pre-test achievement groups, and one continuous dependent variable, attitudes, with all combinations of levels of the first independent variable with two levels and of the second independent variable with 5 levels. The difference was not significant in attitudes between boys and girls in different achievement groups, $F(1,224)= 2.673$, p=0.103. However, students' achievements had an effect on their attitudes, $F(4,224) =9.216$, p=0.000, *power* = 0.999. The interaction between the two independent variables is not significant, $F(4,224)=0.357$, p=0.839.

Graph 4-7 Attitudes Differences between Boys and Girls

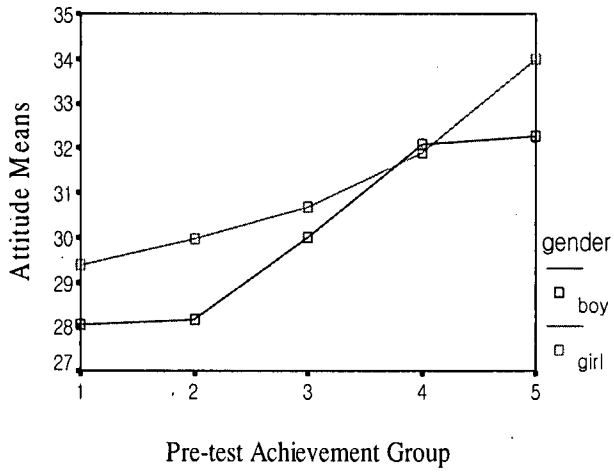


Table 4-8 Tests of Between-Subjects Effects

Dependent Variable: Attitudes

Source	Sum of Squares	df	Mean Square	F	Sig.	Observed Power(a)
Achievement	720.854	4	180.214	9.216	.000	.999
Gender	52.267	1	52.267	2.673	.103	.370
Achievement * Gender	27.924	4	6.981	.357	.839	.131
Error	4380.286	224	19.555			
Total	226433.000	234				

a Computed using alpha = .05

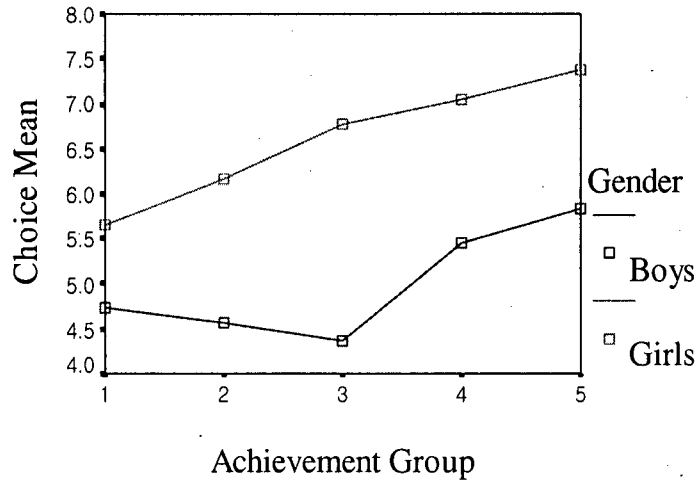
b R Squared = .177 (Adjusted R Squared = .144)

4.2.4.3 Differences of the Choices of Future Courses and Career Aspirations between Boys and Girls

The mean of the girls' choices for future courses and career aspirations (6.63) is higher than that of the boys' (5.00). This difference was statistically significant, $F(1,232)=40.093$, $p=0.000$. Graph 4-8 shows that there is a likelihood that as achievements increase both boys and girls' choices also increase. Overall, the girls ranked much higher than the boys in making choices for their future courses and careers in science areas.

<Graph 4-8>

Choices of Future Courses and Careers



A factorial ANOVA (Table 4-9) demonstrates how different achievement levels in boys and girls affected their choices differently. The two independent variables were gender and different achievement groups and the one continuous dependent variable was choices of future courses and career aspirations. Achievement differences affect students' choices for their future courses and career aspirations significantly, $F(4,223)=5.168$, $p=.001$, *power*=.966. In addition, gender differences also significantly affected the choices, $F(1,223)=32.839$, $p=0.000$, *power*=1.000. The interaction of gender and achievement was not significant, $F(4,223)=0.874$, $p=0.480$, *power*=0.276.

Table 4-9 Choices of Future Courses and Career Aspirations
Dependent Variable: choices

Source	Sum of Squares	df	Mean Square	F	Sig.	Observed Power(a)
Achievement	73.967	4	18.492	5.168	.001	.966
Gender	117.501	1	117.501	32.839	.000	1.000
Achievement * Gender	12.510	4	3.128	.874	.480	.276
Error	797.923	223	3.578			
Total	9061.000	233				

a Computed using alpha = .05
b R Squared = .233 (Adjusted R Squared = .202)

4.2.5. Summary of Pre-Survey

This study is about the effectiveness of CAI in a group of 234 middle school students studying science. The analyses of pre-survey identify participants' achievements, attitudes, choices, and gender differences. Descriptive statistics, as means, frequencies, and confidence intervals, were used to analyze the data. Further analyses of the differences among different achievement groups were determined using ANOVA.

The characteristics of participants' before CAI were: First, the achievement distribution showed that participants were divided into two groups, high achievement and low achievement groups. The most serious problem was many participants (32.10%) could not reach the level which the society and the educational government required for them to reach at the grade level. According to Korean government's guidelines, for minimal achievement for the subject area through regular instructions and learning activities, all students should score above 60 points (that is the marginal level). Those participants who belonged to group I failed to pass this level in the previous year of science. Second, AtoS were positively related to their achievement in their science. Third, achievement also impacted participants' choices of future courses and career aspirations. Those participants who achieved high were inclined to choose their future courses and career aspirations in science areas whereas those students who achieved low in science did not. The last point was that gender differences were significant in achievement, attitudes and the choices in science. Girls scored higher than boys in achievement and AtoS. Gender was also a factor which affected the attitudes and the choices. However, gender did not significantly affect the attitudes among different achievement groups.

4. 3 Description of the Post-Survey

4.3.1. Achievement

The mean for all participants in the post-test achievement is 3.12 and the standard deviation was 1.599. Table 4-10 and Graph 4-9 demonstrate that the students are still prevailingly distributed in the lowest and the highest groups. The distribution shape is "U". However, the number of the lowest achievement group I is reduced from seventy-five to sixty-six and the achievement group II is reduced from twenty-five to twenty-one. The number of the highest achievement group V

increases from 56 to 66 and group II is from 46 to 50. The number of the middle group did not change much.

Table 4-10 Comparison of Pre- and Post-Test Achievement

		Post-achievement					Pre-group total
		I	II	III	IV	V	
Pre-achievement	I	47	11	9	6	2	75
	II	8	8	4	3	2	25
	III	5	0	10	10	7	32
	IV	2	1	6	18	19	46
	V	4	1	2	13	36	56
Post-group total		66	21	31	50	66	234

Graph 4-9 Post-achievement

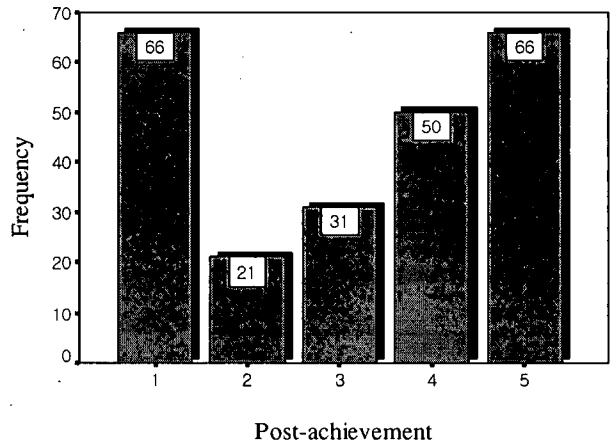


Table 4-11 gives the detail information that which groups of participants improved or dropped by in the post-test. There were eighty-five participants (36.32%) who improved by more than 7 points. Thirty-three (14.10%) participants improved by between 3 and 6 points while fifty-seven (24.36%) students dropped by more than 7 points. Twenty-six (11.11%) dropped by between 3 and 6 points in their post-test. Thirty-three (14.10%) students did not change much. A total of one hundred and eighteen students (50.42%) improved, thirty-three

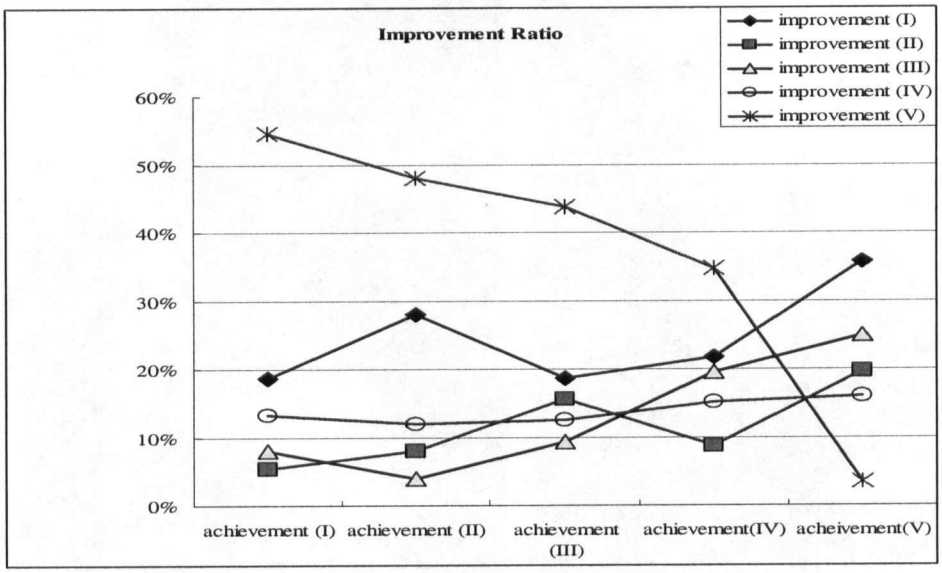
(14.10%) remained constant, and eighty-three (35.47%) dropped.

Participant improvement was different according to pre-test achievement levels. Lower achievement participants improved more than higher achievement participants (i.e., the higher achievement groups, the lower improvement on the post-test). The participants who improved more than 7 points were forty-one students (54.67%), twelve students (48.00%), fourteen students (43.75%), sixteen students (34.78%) and two students (3.57%) in pre-test achievement group I, II, III, IV and V respectively. There were ten (13.3%), three students (12.00%), four students (9.38%), seven students (15.2%) and nine students (16.07%) who improved by between 3 and 6 points in each group respectively. On the contrary, group V deterioration was serious. Twenty students (35.71 %) dropped by more than 7 points and eleven students (19.64%) dropped by between 3 and 6 points, whereas for group I fourteen students (18.67%) dropped by more than 7 points and four (5.33%) dropped by more between 3 and 6 points. Graph 4-10 demonstrates the improvement and deterioration tendencies depending on the achievement groups, too.

Table 4-11 Improvement in Achievement

		Improvement					**Total**
		I (~ -7)	**II** (-6~-3)	**III** (-2~2)	**IV** (3~6)	**V** (7 ~	
Pre-achievement Group	**I**	14 (18.67%)	4 (5.33%)	6 (8.00%)	10 (13.30%)	41 (54.67%)	75
	II	7 (28.00%)	2 (8.00%)	1 (4.00%)	3 (12.00%)	12 (48.00%)	25
	III	6 (18.75%)	5 (15.63%)	3 (9.38%)	4 (9.38%)	14 (43.75%)	32
	IV	10 (21.74%)	4 (8.70%)	9 (19.57%)	7 (15.20%)	16 (34.78%)	46
	V	20 (35.71%)	11 (19.64%)	14 (25.00%)	9 (16.07%)	2 (3.57%)	56
Improvement Total		57 (24.26%)	26 (11.06%)	33 (14.04%)	33 (14.04%)	85 (36.17%)	235

Graph 4-10 Improvement Ratios in the Post-Test



The differences in improvement among different achievement groups were statistically significant, $F(4, 229)=7.853$, $p=0.000$, *power*=0.998. A post hoc test of Tukey HSD showed that the improvement of group I (3.80) was significantly higher than group V (2.32). Group III (3.47) was higher than group V (2.32). Group II (3.44) and group IV (3.33) were also higher than group V at a significant level of 0.05. There were no other statistically significant differences.

4.3.2. AtoS

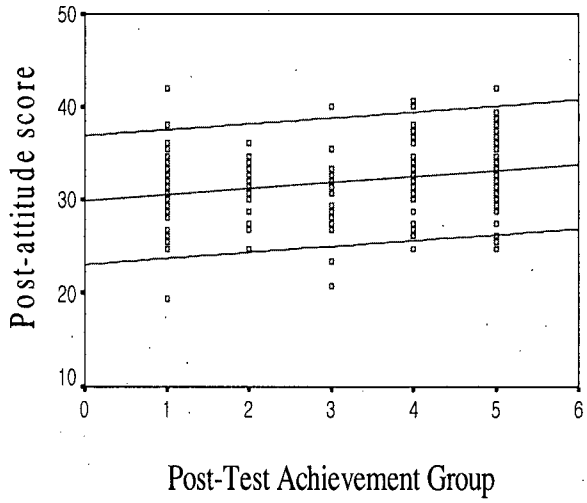
A look at Table 4-12 displays the information of AtoS in the post-survey. The mean of participants' AtoS is 31.90, which is higher than the mean of the pre-survey (30.74) and the standard deviation is reduced from 4.743 to 3.643. CI is between 31.43 and 32.37. The gaps among achievement groups were narrower than pre-survey results; on the pre-survey, the highest and the lowest gaps are 4.78 while on the post-survey it is 2.48. As Graph 4-11 shows, as achievement increases attitude scores also increase. The relationship between participants' achievements and attitude scores were statistically significant, Pearson's correlation coefficient $r=.278$, $p=.000$. The higher achievement participants had more positive attitudes while the lower

achievement participants had lower attitude scores.

Table 4-12 AtoS at the Post-survey

Post-achievement Group	N	Mean	Std. Deviation	Std. Error	CI(95%)	
					LB	UB
I	66	30.86	3.698	.455	29.95	31.77
II	21	31.24	2.984	.651	29.88	32.60
III	31	30.34	3.540	.636	29.05	31.64
IV	50	32.61	3.431	.485	31.64	33.59
V	66	33.34	3.406	.419	32.51	34.18
Total	234	31.90	3.643	.238	31.43	32.37

<Graph 4-11> Post-Test Achievement Group & Post-Attitude Scores



Among five different achievement groups, the differences of attitudes are statistically significant, $F(4, 229)=3.082$, $p=0.017$, *power*=0.805. Tukey HSD shows that group V (33.08) is significantly higher than group I (31.15). There are no other significant differences at $\alpha=.05$.

Table 4-13 Tests of Between-Subjects Effects

Dependent Variable: Post-Attitudes

Source	Sum of Squares	df	Mean Square	F	Sig.	Observed Power(a)
Achievement	157.970	4	39.493	3.082	.017	.805
Error	2934.370	229	12.814			
Total	241217.333	234				

a Computed using alpha = .05

b R Squared = .051 (Adjusted R Squared = .035)

4.3.3. Choices of Future Courses and CA

Table 4-14 of the post-survey results shows that the mean of choices for all participants' is 6.57, which is higher than that on the pre-survey (5.84). On the post-results, achievement group III marks the lowest mean (5.98) while the mean of group I is 6.12. Actually if I considered the improvement between pre- and post-choices, group I's mean was improved the most. There is a likelihood that group V of participants (mean: 7.18) tend to make their choices for the future courses and career aspirations in science areas. The relationship between participants' achievement and choices is statistically significant, r=0.242, p=0.000. In other words, at the post-survey the choices of future courses and careers are also significantly related to the students' achievement, i.e., the higher achievement, the higher scores of choices.

Table 4-14 Choice of Future Courses and CA at the Post-survey

V	66	7.18	1.734	.213	6.76	7.61
Total	234	6.57	1.653	.108	6.36	6.79
I	66	6.12	1.474	.181	5.76	6.48
II	21	6.16	1.332	.291	5.55	6.76
III	31	5.98	1.573	.282	5.40	6.56
IV	50	6.91	1.643	.232	6.44	7.37

The differences of the choices among achievement groups are statistically significant, $F(4,229)=5.746$, $p=0.000$, and *power*=0.980. A post hoc test of Tukey HSD shows that group V (7.18) is significantly higher than group III (5.98) and group I (6.12). There are no other significant differences at the mean difference of .05 significance level.

Table 4-15 Choice of Future Courses and CA at the Post-survey
Dependent Variable: post-choice

Source	Sum of Squares	df	Mean Square	F	Sig.	Observed Power(a)
Achievement	58.062	4	14.516	5.746	.000	.980
Error	578.536	229	2.526			
Total	10745.333	234				

a Computed using alpha = .05
b R Squared = .091 (Adjusted R Squared = .075)

4.3.4. Gender

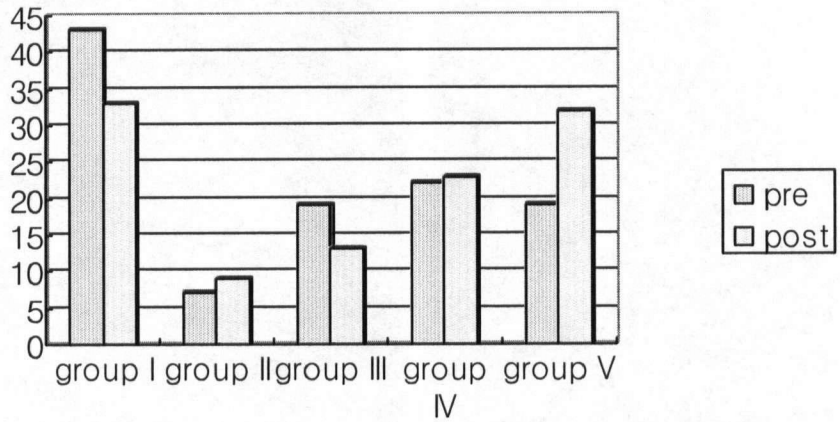
4.3.4.1.Achievement Differences between Boys and Girls

***Boys*:** The mean of post-achievement (3.11) for boys was improved over the mean of pre-achievement (2.70). Graph 4-12 illustrates the comparison of before with after CAI for the boys. Before taking CAI, forty three boys belonged to group I and nineteen belonged to group V, but after taking CAI, thirty three belonged to group I and thirty two moved to group V, but the numbers of middle groups (II, III, and IV) did not change much (Refer to Table 4-16). A paired samples T-test result showed that the improvement was statistically significant, $t(109)=3.513$, $p=0.001$.

Table 4-16 Pre- and Post-achievement Distribution for Boys

Boy		post-achievement Group					Total
		I	II	III	IV	V	
Pre-achievement Group	I	27	5	5	5	1	43
	II	2	2	1	2	0	7
	III	3	0	5	4	7	19
	IV	1	1	2	7	11	22
	V	0	1	0	5	13	19
	Total	33	9	13	23	32	110

Graph 4-12 Pre- and Post-Achievement Distribution for Boys



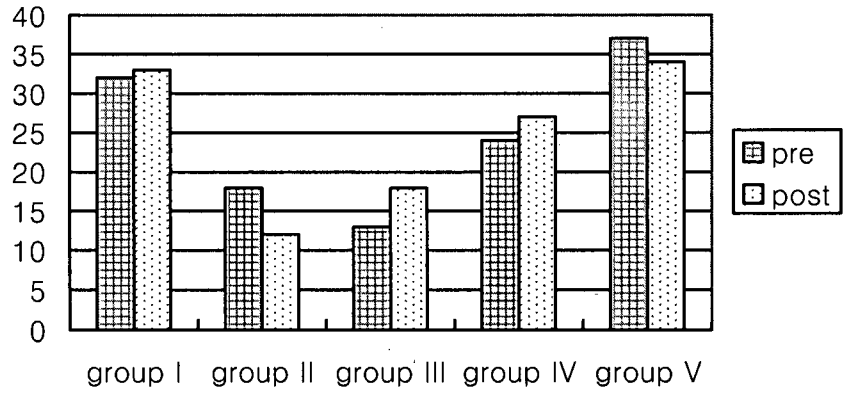
Girls: For girls, the mean of achievement before CAI was 3.13 whereas after CAI program, the mean was 3.14. Table 4-17 shows that before CAI thirty two and thirty seven girls belonged to group I and group V respectively while after CAI thirty three and thirty four girls belonged to group I and group V respectively. Graph 4-13 illustrates the changes of frequencies in different achievement groups. The frequencies of the post-test (height of bar) do not differ from the frequencies of pre-test achievement. Also, a paired samples T-test result proved that there was no significant difference between pre- and post-test achievement for girls, $t(123)=0.072$,

p=0.943.

Table 4-17 Pre- and Post-achievement Distribution for Girls

Girl		Post-achievement Group					Total
		I	II	III	IV	V	
Pre-achievement Group	I	20	6	4	1	1	32
	II	6	6	3	1	2	18
	III	2	0	5	6	0	13
	IV	1	0	4	11	8	24
	V	4	0	2	8	23	37
	Total	33	12	18	27	34	124

Graph 4-13 Pre- and Post-achievement Distribution for Girls



4.3.4.2 Attitude Differences in Gender

***Boys*:** The mean of the post-AtoS for boys is 31.27, which was higher than their pre-attitudes (29.85). There is likelihood that as achievement increases, more positive attitudes develop. Graph 4-14 shows the distribution is close to a normal curve. The mean of the attitudes changed positively (from 29.85 to 31.27) and a paired samples T-test demonstrated this change is significant, $t(109)=3.155$, $p=0.002$, suggesting that CAI is effective in changing the boys' AtoS. Boys' attitudes among different achievement groups are significantly different, $F(4,105)=3.908$,

p=0.005. According to Tukey HSD group V (32.58) was significantly higher than group I (29.90).

Graph 4-14

Boys' Post-Attitudes

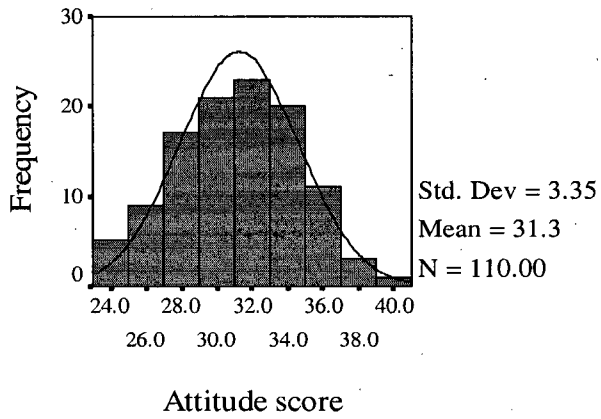


Table 4-18 F-ratio of AtoS Differences for Boys

AtoS of Post-CAI

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	158.435	4	39.609	3.908	.005
Within Groups	1064.272	105	10.136		
Total	1222.707	109			

Girls: The means of pre- and post AtoS were 31.57 and 32.46 respectively. As Graph 4-15 demonstrates, girls' distribution is highly focused on one point and long tailed for each direction. The kurtosis is 1.352, leptokurtic. The girls' attitudes also changed positively, but the change was not statistically significant $t(123)=1.750$, $p=0.083$. The girls' attitudes among different achievement groups were statistically significantly different, $F(4,119)=3.441$, $p=0.011$. A post hoc test of Tukey HSD, group V (34.06) was significantly higher than group III (30.59). There was no other significant difference at significance level 0.05.

Graph 4-15 Girls' Post-Attitudes

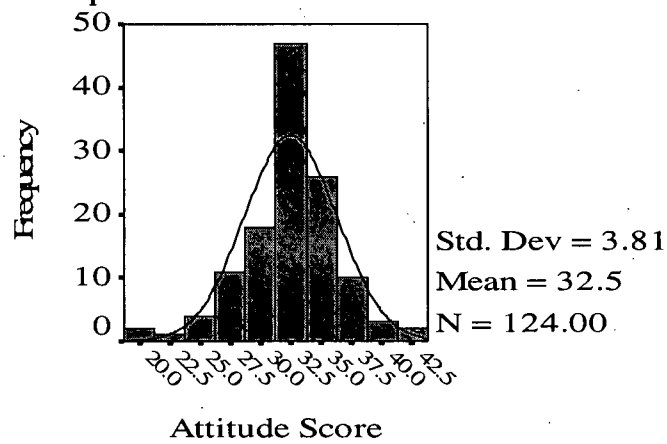


Table 4-19 *F*-ratio of AtoS Differences for Girls

AtoS of Post-CAI

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	185.337	4	46.334	3.441	.011
Within Groups	1602.545	119	13.467		
Total	1787.882	123			

4.3.4.3 Choices of Future Courses and Career Aspirations

Boys: The means for pre- and post choices of future courses and career aspirations in science areas are 4.95 and 6.11 respectively. Graph 4-16 shows that boys' post-choices distribute heavily both sides of the mean, 6.1. Kurtosis is -.426, platykuric. The changes are statistically significant, $t(109)=6.107$, $p=0.000$. This result shows that for the boys in the second year of middle school, CAI is positively affected their choices of future courses and careers. Boys' choices among different achievement groups are significantly different, $F(4,105)=3.256$, $p=0.015$. The Tukey HSD shows that group V (6.67) is significantly higher than group III (5.13).

Graph 4-16

Boys' Post-Choices

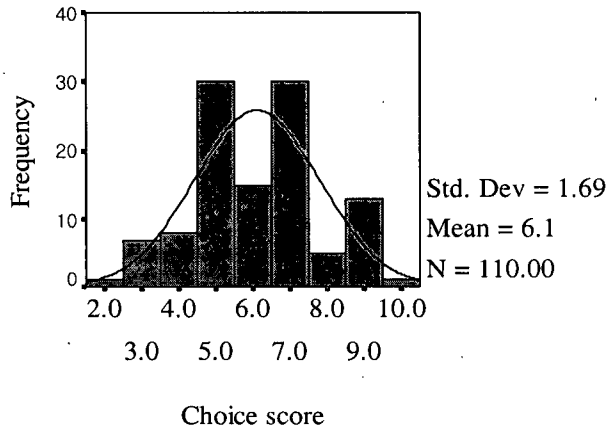


Table 4-20 *F*-ratio of CA for Boys

CA of Post-CAI

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34.380	4	8.595	3.256	.015
Within Groups	277.200	105	2.640		
Total	311.580	109			

Girls: The means for pre- and post choices of future courses and career aspirations in science areas are 6.63 and 6.98 respectively. The differences pre and post CAI are statistically significant, $t(123)=2.097$, $p=0.038$. The girls' choices among different achievement groups are statistically significantly different, $F(4,119)=4.695$, $p=0.001$. A post-hoc test of Tukey HSD, group V (7.67) is significantly higher than group I (6.63) and group III (6.59). There are no other significant differences at significance level, 0.05.

Graph 4-17

Girls' Post-Choices

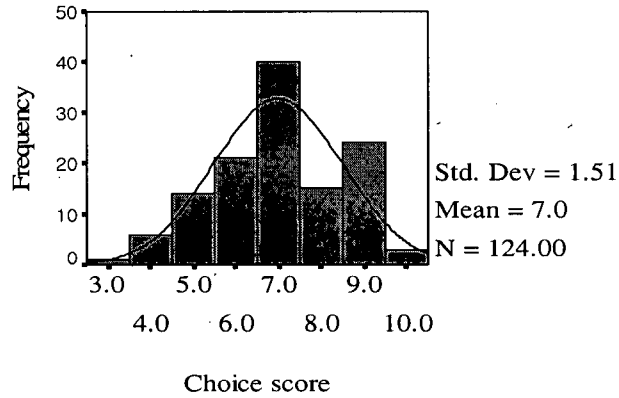


Table 4-21 *F*-ratio of CA Differences for Girls

CA of Post-CAI

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	38.223	4	9.556	4.695	.001
Within Groups	242.189	119	2.035		
Total	280.412	123			

Table 4-22 Paired Samples Comparisons

pre- and post- achievement, AtoS, and CA

Pre-and post-Surveys		Paired Differences			t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean			
Achievement	B	-.41	1.221	.116	-3.513	109	.001
	G	-.01	1.253	.112	-.072	123	.943
AtoS	B	-1.43	4.745	.452	-3.155	109	.002
	G	-.88	5.626	.505	-1.750	123	.083
CA	B	-1.15	1.983	.189	-6.107	109	.000
	G	-.35	1.885	.169	-2.097	123	.038

4.3.5 Summary of Post-Survey

Overall comparisons of pre- and post- achievement, attitudes, and choices of future courses and

career aspirations showed statistically significant differences. Table 4-23 demonstrates the differences between pre- and post-CAI with paired samples T-tests in terms of test-achievement, attitude changes toward science and the choices of future courses and career aspirations.

After 19 blocks of CAI, the achievement mean (3.12) of all participants showed an improvement from before (2.93). There was a significant effect of CAI on student achievement in science, $t(233)=2.403$, $p=0.017$, particularly among those participants who belonged to the lowest group at the time of the pre-test improved. Noticeably, 41 participants of group I improved more than 7 points. However, 20 participants in group V deteriorated more than 7 points. Considering the highest students might have more possibility for their scores to deteriorate than the lowest group, and more difficulties to get more points than the lowest group students, but their rate of deterioration is still alarming.

There was a significant effect of CAI on student AtoS, $t(233)=3.514$, $p=.001$. Before and after the participants took CAI, the means of their AtoS were 30.74 and 31.90 respectively. High achievement students are likelihood to have high scores in attitudes.

The effect of CAI was also significant on the students' choices of future courses and career aspirations, $t(232)=5.568$, $p=0.000$. After CAI the mean (6.57) of the choices was significantly higher than with the mean from before CAI (5.87).

Gender differences on the effect of CAI were significant. The improvement of boys in achievement, attitudes and choices were significant. Not so for the girls. This result is consistent with research (Canada, 2001, Fishman et al., 2001) reporting that the attitudes toward using computers are different between girls and boys. Boys used computers more actively and voluntarily while girls were somewhat passive users. The results seemed to show that CAI was

more effective for the boys than for the girls, but I could not conclude from this study whether or not boys simply preferred to use computers more than the girls.

Table 4-23 Overall Comparison (Paired Samples t-Tests: pre-and post)

	Paired Differences			t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean			
Achievement	-.20	1.252	.082	-2.403	233	.017
AtoS	-1.16	5.054	.330	-3.514	233	.001
CA	-.71	1.934	.127	-5.568	232	.000

4.4 Disposition of Hypotheses

In this section, the statistical tests of the hypotheses were described along with interpretations of the findings. The purpose of hypothesis testing is to test the viability of the null hypothesis in the light of experimental data (Howel, 2005; Spatz, 2004). The null hypothesis is a hypothesis about a population parameter and is the reverse of what I am actually trying to prove; it is put forward to allow the data to contradict what I try to prove. In the experiment on the effect of CAI, I expected CAI to have a significant effect on improving students' conceptual changes and attitudes in science. If the experimental data showed a sufficiently large effect of CAI, then the null hypothesis that CAI had no effect could be rejected. Since the null hypothesis would be that there was no difference between pre and post CAI, I would be hoping to reject the null hypothesis and conclude that CAI was more effective than the lecture-based traditional teaching style.

I tested four main hypotheses: the improvement of students' achievements, attitude changes towards science, the choices of future courses and career aspirations, and gender effects.

4.4.1 Hypothesis 1: CAI can enhance Korea's second grade middle school students' understanding in science.

H_0: A null hypothesis (H_0) is that there is no significant difference in student achievement in science between means of before and after CAI.

H_0: $\mu_{0ach} = \mu_{1ach}$

H_1: An alternative hypothesis (H_1) is that there is a significant difference between means before and after CAI.

H_1: $\mu_{0ach} \neq \mu_{1ach}$

- Are there any differences in students' improvement among different achievement groups?

H_0: There is no significant difference in student improvement in the post-test among five different achievement groups.

H_0: $\mu_{0achI} = \mu_{0achII} = \mu_{0achIII} = \mu_{0achIV} = \mu_{0achV}$

H_1: There is a significant difference of student improvement in the post-test among the five different achievement groups

H_1: $\mu_{0achI} \neq \mu_{0achII} \neq \mu_{0achIII} \neq \mu_{0achIV} \neq \mu_{0achV}$

The mean of the pre-test was 2.93, and the mean of the post-test was 3.12. Even though many participants belonged to the lowest group in the post-test, the frequency reduced by ten students compared to the pre-tests. As Table 4-11 showed, eighty-five participants improved more than 7 points in the post-test and thirty three participants improved from 3 to 6 points, however, fifty-seven participants' scores deteriorated more than 7 points and twenty-six students' scores deteriorated from 3 to 6 points. The forty-one participants out of eighty-five (48.24%) whose

improvement was more than 7 points were from the pre-achievement group I, and twelve students were from the pre-achievement group II. Most students who belonged to group I, and group II improved in their achievement in the post-test. These descriptive statistics showed that after students took 19 blocks of CAI, more students improved than deteriorated. A paired samples T-test showed that the improvement was statistically significant, $t(233)=2.403$, $p=.017$. I rejected the null hypothesis which postulated no difference (Refer to Table 4-24).

The effectiveness of CAI on improvement in different achievement groups was also investigated by comparing pre- and post-tests. The means of improvement in each group were: group I, 3.80, group II, 3.44, group III, 3.47, group IV, 3.33 and group V, 2.32. A repeated measures factorial ANOVA (Table 4-25) informed that the differences in the improvement on the post-test among five different achievement groups were statistically significant, $F(4,229)=7.853$, $p=0.000$, $\eta^2=.137$. A Tukey's HSD at the .05 level showed that group I (3.80) was significantly higher than group V (2.32). Group II (3.44) was significantly higher than group V (2.32). Group III (3.47) was statistically significantly higher than group V (2.32). Group IV (3.33) was also significantly higher than group V (2.32). There was no other significant difference. This result meant that students in the lower group improved much more than those in the higher groups. Before I conclude that CAI is more effective for low achievement students as compared to high achievement students, other aspects must be considered. First, for the highest group of students, their maximum improvement score was10 points, but for the lowest students, their improvement score has a wider range. Another aspect is that it is more difficult for the highest group of students to improve than the lowest group of students. This is demonstrated by the improvement ratios where a gain of more than 7 points

was noted on the post-test: group I, group II, group III, group IV, and group V were 55%, 48%, 44%, 35% and 4% respectively. On the other hand the deterioration ratios of more than 7 points showed an inversion of the improvement ratios, i.e., 19%, 28%, 19%, 22%, and 36% respectively (Refer to Table 4-11 and Graph 4-11).

Table 4-24 Differences Pre and Post Achievement

	Paired Differences			t	df	Sig. (2-tailed)
	Mean	Std.	Std. Error Mean			
Achievement	-.20	1.252	.082	-2.403	233	.017

Table 4-25 Improvement

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	73.587	4	18.397	7.853	.000
Within Groups	536.452	229	2.343		
Total	610.038	233			

4.4.2 Hypothesis 2

The second hypothesis involves students' AtoS and the CAI environment.

H_0: CAI does not influence students' attitudes such as self-confidence, motivation and interest towards science.

H_0: $\mu_{0att} = \mu_{1att}$

H_1: CAI does influence students' AtoS

H_1: $\mu_{0att} \neq \mu_{1att}$

- What is the difference among different achievement groups and AtoS?

H_0: There is no significant difference of the student attitudes among five different achievement groups.

H_0: $\mu_{0attI} = \mu_{0attII} = \mu_{attIII} = \mu_{0attIV} = \mu_{0attV}$

H_1: There is significant difference in the student attitudes among five different achievement groups

H_1: $\mu_{0attI} \neq \mu_{0attII} \neq \mu_{attIII} \neq \mu_{0attIV} \neq \mu_{0attV}$

The means of student AtoS before and after CAI were 30.74 and 31.90 respectively. According to a paired sample t-test (Table 4-26) the mean differences were significant, $t(233)=3.514$, $p=.001$.CAI was effective on student AtoS. According to this result, the null hypothesis is rejected and the alternative hypothesis is accepted. Student AtoS were enhanced significantly after CAI. Descriptive statistics (Table 4-27) showed that for groups I, II and III the post-AtoS means were enhanced, but for group IV and V the post-AtoS means decreased.

Table 4-26 Paired Samples t-test Result Pre- and Post-AtoS

	Paired Differences			t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean			
Attitudes	-1.16	5.054	.330	-3.514	233	.001

Table 4-27 Descriptive Statistics of Pre and Post AtoS in 5 Achievement Groups

	Achievement Groups	Mean	Std. Deviation	N		Achievement Groups	Mean	Std. Deviation	N
Pre-AtoS	I	28.49	4.221	75	**Post-AtoS**	I	31.15	3.198	75
	II	29.84	5.289	25		II	31.09	3.887	25
	III	30.28	3.531	32		III	31.44	2.804	32
	IV	32.09	5.098	46		IV	32.45	3.818	46
	V	33.39	5.211	56		V	33.08	4.079	56
	Total	30.76	5.042	234		Total	31.90	3.643	234

A repeated measures factorial ANOVA was used for the AtoS differences among achievement groups (Table 4-28). The within-subject variables were pre- and post-AtoS, and the between-subject variable was the pre-achievement groups from the 5 groupings. The difference of within-subject variables (pre-and post-AtoS) was significant, $F(1,229)=7.981$, $p=0.050$, $\eta^2=0.034$, *power*=0.803. Interaction effect of within- subject variables was also significant, $F(4,229)=3.007$, $p=0.019$, $\eta^2=0.050$, *power*=0.794. Even though the effect size (η^2) was small, the power was large enough to avoid a Type II error. For between-subject effects, the difference of attitude changes among different achievement groups were significant, $F(4,229)=10.202$, $p=.000$, $\eta^2=0.151$, *power*=1.000.

The null hypothesis, no differences before and after CAI in participants' AtoS, is rejected and the alternative hypothesis is accepted. The AtoS score of the higher achievement group of students were higher than those of the lower achievement group students. However, the mean differences from pre- and post-AtoS showed that the lower achievement groups' (I and II) means should be greater improvement.

Table 4-28 Tests of Within-Subjects Contrasts

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power(a)
AtoS	105.374	1	105.374	7.981	.005	.034	.803
AtoS * Achievement Group	158.788	4	39.697	3.007	.019	.050	.794
Error	3023.599	229	13.203				

a Computed using alpha = .05

Tests of Between-Subjects Effects

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power(a)
Achievement Group	882.196	4	220.549	10.202	.000	.151	1.000
Error	4950.356	229	21.617				

a Computed using alpha = .05

- What is the difference among different improvement and attitudes?

H_0: There is no significant difference in the student attitudes among five different improvement groups (ranges).

H_0: $\mu_{0attI} = \mu_{0attII} = \mu_{attIII} = \mu_{0attIV} = \mu_{0attV}$

H_1: There is significant difference in the student attitudes among five different improvement groups (ranges).

H_1: $\mu_{0attI} \neq \mu_{0attII} \neq \mu_{attIII} \neq \mu_{0attIV} \neq \mu_{0attV}$

To answer this question I sorted groups depending on their improvement in five ranges. The students whose post-test scores deteriorated more than 7 points belonged to Range I, those that deteriorated around 3~6 points were Range II, -2~+2, Range III, +3~+6, Range IV, and more than 7 points were in Range V. Table 4-29 gives information of mean differences of each Range. The highest improvement Range's mean was the highest value, 2.84; meanwhile, the improvement Range III, i.e., similar (constant) achievement at pre- and post-test was the lowest: -0.58. Ranges I and II do not increase but Ranges IV and V increase. It is difficult to conclude that improvement impacted student attitudes in all groups, but I observed that the attitudes on the post-test in the highest improvement group changed drastically from 29.73 to 32.57.

Table 4-29 Pre and Post AtoS

Range	N	Mean (a)	Std. Deviation	Std. Error	95% CI for Mean LB	UB
I	57	.70	5.552	.735	-.77	2.17
II	26	-.08	4.525	.887	-1.90	1.75
III	33	-.58	4.886	.851	-2.31	1.16
IV	33	.42	5.380	.936	-1.48	2.33
V	85	2.84	4.847	.526	1.79	3.88
Total	234	1.17	5.204	.340	.50	1.84

(a) Mean=post-attitudes – pre-attitudes

A repeated measures design factorial ANOVA was used to determine the difference of the attitude changes before and after CAI depending on one's improvement. The within-subject variables were pre- and post-attitudes and a between-subject variable was the improvement from each of the 5 ranges. Table 4-30 shows the result. The difference of within-subject variables (pre-and post-attitudes) was not significant, $F(1,229)=3.092$, $p=0.080$. The interaction effect of within-subject variables was significant, $F(4,229)=4.887$, $p=0.001$ $\eta^2=0.079$, *power*=0.956. For between-subject effects, the improvement on the post-test was effective in changing attitudes, $F(4,229)=2.791$, $p=.027$, $\eta^2=0.046$, *power*=.759.

Table 4-30 Tests of Within-Subjects Contrasts

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power(a)
AtoS difference	37.012	1	37.012	3.092	.080	.013	.417
AtoS dif.* Im. Range	234.027	4	58.507	4.887	.001	.079	.956
Error(AtoS difference)	2741.441	229	11.971				

a Computed using alpha = .05

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power(a)
Improvement Range	252.981	4	63.245	2.791	.027	.046	.759
Error	5188.989	229	22.659				

a Computed using alpha = .05

In summary even though the individual attitude changes before and after CAI were not significantly different, different improvement rates affected student attitudes, $F(4,229)=2.791$, $p=.027$, *power*=.759. I reject the null hypothesis, which was no difference among different improvement groups and accept the alternative hypothesis.

4.4.3 Hypothesis 3

Can positive AtoS be a motivation to the second grade middle school students to choose their majors and future careers in scientific fields?

H_0: There is no significant difference in choices of future courses and CA between the positive AtoS changes group and no or reduced AtoS change groups.

H_0: $\mu_{0cose} = \mu_{1cose}$

H_1: There is significant difference in choices of future courses and CA between the positive AtoS changes group and no or reduced AtoS change groups.

H_1: $\mu_{0cose} \neq \mu_{1cose}$

This research question focused on how AtoS changes affect on the choices for future courses and CA. A repeated measures factorial ANOVA could give the information of how positive AtoS differences impacted on the individual's choices of future courses and CA. Therefore, it required the data rearrangement, i.e., the AtoS differences between pre- and post-

surveys. If a participant's AtoS differences were negative or zero, he/she was grouped as "A". If the differences were positive, he/she was grouped as "B". 88 participants were assigned group "A" and 146 participants were assigned group "B". A within-subject variable was pre- and post-choices of courses and CA, a between-subject variable was the AtoS change groups (2 levels). Table 4-31 is the result. When an individual student's AtoS changed positively, his/her choices of future courses and CA was affected significantly by the AtoS changes, $F(1,232)=448.416$, $p=0.000$, $\eta^2=0,659$, and *power*=1.000. In the contrast of within-subjects, the interaction between choices and AtoS was significant, $F(1,232)=12.367$, $p=0.001$, $\eta^2=0,051$, and *power*=0.938. However, the tests of between-subjects showed that there was no significant difference between AtoS groups, $F(1,232)=0.795$, $p=0.373$.

Table 4-31 Tests of Within-Subjects Contrasts

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power(a)
CA	3109.184	1	3109.184	448.416	.000	.659	1.000
CA * AtoS difference	85.748	1	85.748	12.367	.001	.051	.938
Error(CA)	1608.621	232	6.934				

a Computed using alpha = .05

Tests of Between-Subjects Effects

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power(a)
AtoS Difference	1.118	1	1.118	.795	.373	.003	.144
Error	326.277	232	1.406				

a Computed using alpha = .05

In summary the null hypothesis was rejected, and the alternative hypothesis was accepted. The AtoS changes had a significant effect on the student's choices of future courses

and CA. Based on analysis of a repeated measures ANOVA before and after CAI, individual student's choices of future courses and future careers were significantly impacted by CAI; however, the differences between participants' were not significant. In other words it is natural that different people have different preferences, so I can not expect all students to head into science after CAI.

4.4.4 Hypothesis 4 (Gender Differences)

The hypotheses related to the differences between genders were that there were no differences in terms of the improvement of achievement, attitude changes, and the choice changes in their future courses and career aspirations.

4.4.4.1 Achievement Differences between Boys and Girls

H_0: There is no difference in the improvement in the post-test achievement between boys and girls.

H_0: $\mu_{0achb} = \mu_{1achg}$

H_1: There is a difference in the improvement in the post-test achievement between the boys and the girls.

H_1: $\mu_{0achb} \neq \mu_{1achg}$

Through the pre- and post-survey analyses, the girls' achievement was found to be higher than the boys'. The means of boys' achievement in the pre- and post-test were 2.70 and 3.11 respectively. Paired samples t-test showed that the differences between pre- and post-test for boys was statistically significant, $t(109)=3.515$, $p=.001$. The girls' means of the achievement in the pre-and post-test were 3.13 and 3.14 respectively. Paired samples t-test showed that the differences between pre- and post-tests for girls were not statistically significant, $t(123)=.072$,

p=.943. This result demonstrated that the null hypothesis should be rejected, and the alternative hypothesis should be accepted. In other words, the effect of CAI was different for the boys and for the girls in their achievement; CAI positively affected the boys' understanding of scientific concepts, but CAI did not have much impact on the girls' scientific concept enhancement.

4.4.4.2 Attitude Differences between Boys and Girls

H_0: There is no difference in the attitude changes in the pre- and post-survey between the boys and the girls.

$$H_0: \quad \mu_{0attb} = \mu_{1attg}$$

H_1: There is a difference in the attitude changes in the pre- and post-survey between the boys and the girls.

$$H_1: \mu_{0attb} \neq \mu_{1attg}$$

Pre- and post-survey results showed that the girls' attitudes were higher than the boys, and the AtoS scores were enhanced at the post-survey. The means of boys' AtoS in the pre- and post-tests were 29.85 and 31.27 each. Paired samples t-test showed that the differences between pre- and post-test were statistically significant, $t(109)=3.155$, $p=.002$. The girls' means in the pre- and post-test were 31.57 and 32.46 each. Paired samples t-test showed that the differences between pre- and post-test were not statistically significant, $t(123)=1.750$, $p=.083$. The effectiveness of CAI on changing AtoS was not the same for the boys and for the girls. Thus, I rejected the null hypothesis, and accepted the alternative hypothesis. Boys enhanced their AtoS through CAI. But CAI had no impact on the enhancement of girls' AtoS.

Further investigation for the interaction effect of gender and improvement was done by a repeated measures factorial ANOVA (Table 4-32). A within-subjects variable was pre- and

post-AtoS scores and between subject variables were improvement ranges and gender. In the test of within-subjects contrasts, the interaction of improvement ranges and AtoS was significant, $F(4,224)=5.070$, $p=0.001$, *power*=0.963. The tests of between-subjects showed that the difference by improvement ranges was significant, $F(4, 224)=2.495$, $p=0.043$, *power*=0.705 and gender was also significant, $F(1,224)=5.440$, $p=0.021$, and *power*=0.641. According to these statistical results, gender and the improvement of post-test achievement affected pre- and post-AtoS changes significantly, AtoS was affected by one's improvement in one's science test scores.

Table 4-32 Tests of Within-Subjects Contrasts

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power(a)
Pre- and Post-AtoS	25.189	1	25.189	2.104	.148	.009	.303
AtoS * Improvement	242.755	4	60.689	5.070	.001	.083	.963
AtoS * Gender	5.268	1	5.268	.440	.508	.002	.101
AtoS* Improvement * Gender	59.925	4	14.981	1.251	.290	.022	.389
Error(AtoS)	2681.487	224	11.971				

a Computed using alpha = .05

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Observed Power(a)
Improvement	221.169	4	55.292	2.495	.044	.043	.705
Gender	120.538	1	120.538	5.440	.021	.024	.641
Improvement * Gender	57.755	4	14.439	.652	.626	.012	.211
Error	4963.396	224	22.158				

a Computed using alpha = .05

4.4.4.3 Choices of Future Courses and CA Differences

H_0: There is no difference in choices of future courses and CA in the pre- and post-survey between the boys and the girls.

H_0: $\mu_{0cab} \neq \mu_{1cag}$

H_1: There is a difference in the choices changes in the pre- and post-survey between the boys and the girls.

H_1: $\mu_{0cab} \neq \mu_{1cag}$

In the pre-survey, boys' scores were much lower than those of the girls, 4.95 and 6.63 respectively. In the post-survey the scores of boys (6.11) and girls (6.98) were both improved. Paired samples t-test for the boys showed that the differences were statistically significant, $t(109)=6.107$, $p=0.000$, and for the girls the differences were also statistically significant, $t(123)=2.097$, $p=0.038$. Even though, the t-values were not the same between the boys and the girls, the differences of change choices were statistically significant. The null hypothesis is thereby rejected; CAI affected both boys' and girls' choices of future courses and their career aspirations.

In order to examine individuals' differences and the interaction of improvement and gender, further analysis was done with a repeated measures factorial ANOVA (Table 4-33). A within-subjects variable was pre- and post-choices scores and between-subject variables were improvement and gender. In the test of within-subjects contrasts, the individual students pre- and post-choices were different, $F(1,223)=15.371$, $p=0.000$, $\eta^2=0.064$, *power*=0.974. Improvement also affected the individual's post-choices, $F(4,223)=4.291$, $p=0.002$, $\eta^2=0.071$, *power*=0.926. The interaction of choices and gender, and choices gender and improvement was

not significant. The tests of between-subjects showed that the difference of gender was significant, $F(1,223)=32.975$, $p=0.000$, $\eta^2=0.125$, *power*=1.000. These statistical results demonstrated that for an individual the choices were affected significantly by CAI and also improvement in one's science test scores. Also, gender affected pre- and post-choice changes significantly.

Table 4-33 Tests of Within-Subjects Contrasts

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power(a)
CA	26.090	1	26.090	15.371	.000	.064	.974
CA * Imp.	29.132	4	7.283	4.291	.002	.071	.926
CA * Gender	4.523	1	4.523	2.664	.104	.012	.369
CA * Imp* Gender	13.225	4	3.306	1.948	.104	.034	.581
Error(Choices)	378.523	223	1.697				

a Computed using alpha = .05

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power(a)
Imp	10.693	4	2.673	.579	.678	.010	.190
Gender	147.647	1	147.647	31.975	.000	.125	1.000
Imp * Gender	20.922	4	5.230	1.133	.342	.020	.353
Error	1029.710	223	4.618				

a Computed using alpha = .05

4.5 Summary

At the beginning of the study, the instrument (pre-questionnaire) to identify participants' achievement in the previous year in science, their AtoS, and their choices of future courses and career aspirations was administered to all participants. After 19 blocks of CAI, a paper-based post-test and post-questionnaire were administered and analyzed with ANOVA. ANOVA was an appropriate statistical test to analyze the data as it demonstrated the differences of the several different items such as pre- and post-achievements, attitude changes, choices and gender differences. Since the instruments were administered before and after CAI, a repeated measures factorial ANOVA was useful to measure the effectiveness of CAI.

From the pre- and post-survey results, 6 important points emerge:

- the participants' achievement was heavily distributed into two groups, i.e., the lowest and the highest groups. 32.05% and 28.21% of students belonged to group I in the pre- and post-test respectively. 23.93% and 28.21% of students belonged to group V in the pre-and post-test respectively.
- the student AtoS varied according to achievements in science ($p<.05$). The high achieving students had a strong likelihood of high scores of AtoS ($p<.05$), and the differences were also statistically significant among different achievement groups ($p<.05$).
- the choices of future courses and career aspirations were positively affected by their achievements and attitudes
- girls' improvement after CAI was not significant in comparison to their pre-and post-results as well as in comparison to the scores of boys even though the girls' test scores

(pre- and post-test), the AtoS, and CA scores of pre-and post-questionnaires were higher than boys.

- CAI was effective for lower achievement students in enhancing their achievement in comparison to high achievement groups ($p<.05$).

CHAPTER 5

Summary, Conclusion and Recommendations

5.1 Introduction

Chapter 5 provides interpretation of findings and discussion. This chapter is composed of four sections: the first section is a summary of this research (i.e., research purposes, questions and hypotheses and results). The second addresses the interpretation of the results based on theoretical framework in terms of achievement, AtoS (AtoS) and Career Aspirations (CA). The third concerns limitations in generalizing the findings; and the last includes the potential of CAI as a compensatory curriculum for low achieving students, CAI for high achieving students, gender differences utilizing CAI in science class, and ICT literacy enhancement by using CAI. The fourth includes recommendations for further researches.

5.2 Summary of the Research

This research examined the effectiveness of CAI in science classrooms in terms of student achievement scores, AtoS, CA and gender differences with 234 Korean middle school students divided into five different achievement groups. Data collected from pre- and post-test scores for achievement and pre- and post-questionnaires for AtoS and CA were quantitatively analyzed. The research findings are: (1) the average rate of the student's improvement in the post-test scores (p=.017), and particularly the lowest achievement group in the pre-test showed the most significant improvement in the post-test (p=.000) and, (2) the improvement of student achievement significantly influenced AtoS (p=.019) and CA related to science areas (p=.000), and (3) CAI impacted more of the boys' achievement, AtoS and CA than of the girls'. This

research provides the evidence that CAI has the potential to help low achievement students as a compensatory curriculum in science classes and that CAI in science classes enhances students' information and technology literacy. But this potential is mediated by gender, i.e. boys are more active participants than girls under CAI environment.

The following sections are devoted to the interpretation of the results grounded in the theoretical framework.

5.3 Interpretation of Results

5.3.1 Achievement

The overall student achievement in the post-test was improved significantly, t(233)=2.403, p=.017, and in addition, the improvement rates were different in accordance with the students' pre-achievement, $F(4,229)=7.853$, p=.000, η^2=.137. A post-hoc test of Tukey's HSD confirmed that the lowest achieving group I (3.80) was significantly higher than group V(2.32). Group III (3.47) was higher than group V (2.32). Group II (3.44) and group IV (3.33) were also higher than group V (2.32) at the significance level (α)<.05. There is no other significant difference.

Behaviorist's Perspectives. Based on the post-questionnaire question 6, many students (30.48%)[24] who improved in the post-test answered that repetition was the most effective learning strategy in CAI (Refer to Appendix V). CAI programs offer similar problems in one topic, so the students could find general patterns. The students could get a firm grasp of understanding when they had one more chance to learn new knowledge (concepts).

The behaviorist approach to learning science closely resembles the experimental

[24] 116 students improved at the post-test. Among them 105 students answered the question. Response rate was 90.52%.

approach of empirical-inductivism (Gilbert and Watts, 1983). Empirical-inductivism, for instance, collects similar evidence and data, finds patterns and generalizes them into a theory; it is similar to behaviorist learning procedures. Learners are exposed repeatedly to the stimuli such as questions and visualized graphics by CAI, and eventually are able to acquire the knowledge.

Constructivist Perspectives. According to participants' answers to the post-questionnaire, CAI was a useful learning tool because they could manipulate the variables and it was easy to compare different cases (27.62% of improved students) with computers. While changing the variable conditions, participants could observe what the differences were, postulate hypotheses, strive to find some patterns, amend the hypotheses and so on. This meant that learners were not passive acceptors but active constructors of their knowledge in CAI environments. Manipulating the variables in the computer programs encouraged the learners to engage in learning activities such as formulating hypothesis and attempting to find evidence, and the students' understanding was enhanced as well as their higher order of thinking in such areas as problem solving or hypothesis generating (Khan, 2002; Hannafin, 2004; Means & Coleman, 2000; Williams et al., 2003).

The highlighted foci of constructivist perspectives in this study were conceptual change and the social aspect of learning.

Conceptual change (Cognitive constructivism): According to Posner, Strike, Hewson, and Gertzog (1982), student thinking can be fostered when a new conception is intelligible and plausible. Hewson and Hewson (1984) also emphasize the plausibility of new conceptions on conceptual changes. There are many studies that CAI had impacted positively on conceptual

changes of students (Cepni et al., 2004; Garcia, 1998; Gutwill-Wise, 2001; Hsu & Thomas, 2002; Linn, 1992; Noh et al., 1998; Olson, 1992; Phelps and Reynels, 2001; Sasha, Barab, Kenneth, Hay, Michael & Thomas, 2000). Sasha et al.'s (2000) study showed a good example of conceptual changes with topic similar to this research, the solar system. The astronomical scales were reduced, and CAI displayed the planets on the computer screen. Phenomena difficult to be observed were reproduced with dynamic simulations. CAI programs made scientific concepts plausible and students could develop conceptually rich understandings.

Delineating this research's CAI web resources, dynamic and advanced cyber labs provided diverse opportunities for the students to experience seemingly implausible situations plausibly and imaginable situations as real phenomena. For instances, the relation of the revolution of the earth and the changes of the seasons, or the observation of Mars' revolution (reverse directed for some period) which was evidence of heliocentricism allowed students to follow in the footsteps of earlier scientists' (http://www.scienceall.com/sa0educ/01/02e/viewList_2158.jsp?selMenu=ab). The scale of the earth movement and the solar system are not directly plausible with text based instruction. Visualized and simulated learning materials are very helpful in helping students to understand the subject matter. In addition, if a student can manipulate and postulate different situations, and attempt to find the evidence or the counterevidence of their hypotheses, they can firmly grasp an understanding of the natural phenomena.

Social constructivism: Reducing the gap of ZPD and collaborative classroom activities were mentioned at the points of social constructivist perspectives.

In a heterogeneous classroom, there are several factors affecting students' learning

such as learning styles, motivation, attitudes and learning abilities. Participants noted that the benefits of CAI were abundant sources for them to choose different levels of content and different styles of explanations. As Vygotsky (1978) asserted learning occurs within one's ZPD, each of the students can have different levels of a knowledgeable helper under the CAI environment. A successful instruction requires the process of identifying each learner's ZPD and providing learners with enough opportunities for each learner according to his/her own understandable levels (Yang, 2003). Individual students' current development levels are different from each other and also the level of the potential development. In a learning environment with diverse and abundant resources, learners can choose an appropriate level, according to self-diagnoses and preferred ways of learning. For instance, "Cyber Edunet" (http://cyber.busanedu.net/) provides self-diagnosis corners: basic, medium, and high, and participants can evaluate their understandings and adjust their learning levels. In addition, if a participant needed more help, CAI could provide more information with a link to the glossary and visualized graphics, so she/he could understand the content (http://cont111.edunet4u.net/2002/sangin1/earth/index1.htm).

With the help of various and abundant resources, each individual's gap of ZPD can be narrowed. Hannafin (2004), Lin & Hsieh (2001) and Smeets (2005) also noted that the flexible application of CAI programs could play the role of a knowledgeable and capable helper which adjusted to the development levels of learners. Tailored and flexible learning materials met each individual's different starting points and different ZPD.

Group learning activities such as tutoring from high achieving peers/ students to low achieving students and collaborative activities were of significance in this research. 29

participants out of 112 who improved in the post-test answered that collaborative activities and tutoring were helpful for their learning. In particular many of the low achieving students[25] answered that they were effective; on the contrary high achieving students found it less helpful.

Based on participants' additional comments and post-questionnaire number 4 and 5 (the reasons why they improved on the post test), and 7 and 8 (the reasons why they did worse in the post test) group learning activities were a controversial issue between the students who improved and the ones who did worse. The improved students who answered that collaborative learning activities were effective were 28 % [26] ranking it as the second most important reason[27] for improvement. On the other hand 12 % [28]of the students who did worse complained about disagreement among group members. This was the second most common reason given for their score's deterioration[29]. Interpreting students' answers required inferences based on the comments and prior researchers' results.

Yager (1991) showed that when a question was posed to students, who then worked in small groups, were able to discover more solutions than students who worked alone. Also, the students were encouraged to engage in authentic tasks collaboratively supported by ICTs. Because networked computers make available communication and collaborative tools, they support constructivist learning activities. According to Mevarech (1988) report, the students who interfaced in CAI-lessons were frequently misunderstood what the computer programs meant. However, the frequency of these misunderstandings decreased if more than one user

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[25] 13 out of 47 (27.66%) from group I and 5 out of 16 (31.25%) from group II who improved in the post-test answered collaborative learning was the reason why they could improve.
[26] 29 students out of 105 who answered the reasons (total number of improving student was 116).
[27] The first reason was CAI
[28] 10 students out of 65 who answered their deterioration (total number of deteriorated students was)
[29] The first reason was that the contents were difficult.

was present.

However, collaborative learning activities did not generate positive effects for some participants under specific conditions. It was the second ranked reason given for deterioration (4 out of 19). Noh et al. (1998) showed that the collaborative activity in a small group in CAI environment was not always effective for all students. In their research they found that while the high achieving students were helping the low achieving students, they could articulate what they knew, and the low achieving students could have additional explanations from the high achieving students. However, for the middle group students collaborative activities in small group were not very effective. The project, Computer as Learning Partner, (Linn, 1992) showed three different cases: one computer with two students, one computer with three students and one computer with four students. The case of two students with one computer was the best effective condition in sharing roles and easiness in access to computers. Four students with one computer increased off-task such as excluding students from the group and making insulting comments to each other. Furthermore there was a tendency to reinforce incorrect intuitions, i.e., if four group members reached a consensus, it was difficult to change it, even though their conclusion proved to be false.

Participants' complained that working in groups of two or four with one computer prevented them from concentrating on their study. The detailed reasons for their complaints were that other member(s) tried to visit different web sites, particularly game sites at every opportunity. The other complaint was that even though one student had not finished reading or solving the problems, the other group members would move ahead. In order to carry out successful collaboration in learning mutual respect and distributed knowledge are essential

factors (Linn, 1992). However, it is not easy for middle school students to practice these two key points.

In short, CAI was effective in enhancing learner's achievement in the post-test. The interpretation was based on participants' answers and prior studies. The repeated approaches of learning contents and prompt feedback could bring the enhancement of students' learning. Also, visualized, flexible and diverse resources led the students to have a firm understanding. Some agreed that the collaborative learning activities were particularly helpful for low achieving students.

5.3.2 Attitudes toward Science (AtoS)

Participants' AtoS was improved significantly, $t(233)=3.514$, $p=.001$. High achieving groups' AtoS was significantly higher than low achieving groups', i.e., between-subject, the difference of AtoS was: $F(4,229)=10.202$, $p=.000$. AtoS was examined according to the improvement of achievement in the post-test. The improvement also affected participants' AtoS significantly, $F(4, 229)=4.887$, $p=.001$.

Previous studies (An & Koo, 1996; Simpsone & Oliver, 1990; Strike & Posner, 1992) revealed that students' AtoS was a good predictor of achievement and that, achievement also significantly affected AtoS. Strike and Posner (1992) argue that learners' attitudes toward academic areas should be considered as a conceptual ecology. In their research students who did well in physics were more inclined to have positive AtoS and more seriously considered science in their future courses or careers.

CAI in science class led the improvement of students' achievement, and also brought positive changes of AtoS ($p<.05$). The previous studies reported that CAI with diverse

instructional resources, flexibility, enhancement of embodiment and embeddedness influenced learners' attitudes in motivating and offsetting the gaps between science and everyday life (Barton, 2000; Bulter, MacGregor, 2003; Bell, 2000; Cepni et al., 2004; Colella, 2000; Edelson, 2001; Gutwill-Wise, 2001; Ruthven, Hennessy & Deaney, 2005; Williams, Chen, & Seaton, 2003).

Questionnaire item analyses[30] i.e., preference to science subject, attitudes such as preparing ahead of the class, confidence in one's ability to understand science, and valuing learning science for one's own sake clearly demonstrate attitudes as a conceptual ecology. As McLeod (1992) asserted, neither attitudes nor achievement depends on the other, rather, they interact with each other in a complicated manner. Researchers (Ma & Xu, 2004; Wang & Tuner, 1999) reported the importance of the affective factors like attitudes and career aspirations as well as the cognitive factors. In the long run when a student has positive AtoS, she/he has a foundation for long lasting impetus.

5.3.3 Career Aspirations (CA)

The results of this research also showed that participants' CA was significantly different from their achievement ($p<.05$) and AtoS ($p<.05$). Those students who belonged to a high achievement group inclined to high AtoS and CA. The differences between those whose AtoS were improved and those whose AtoS dropped down after CAI were significant, $F(1,232)=448.416$, $p=.000$, $\eta^2=0.659$, *power*=1.000. Even though it is difficult to assert which one is the cause and which one is the effect, achievement in science and AtoS and CA is reciprocal. After CAI the student achievement in science and AtoS changed positively in terms

[30] Pre-questionnaire question 4, and 7-16 and post-questionnaire question number 10-19

of providing successful experience in the related subject area as a crucial component to prepare adolescents' future professional career.

The relationship between school curriculum and participants CA was significant, r=.7659, p<.01. The value of Pearson's correlation coefficient was the highest of all other criteria, i.e. self-concept about science, science and everyday life, science and scientist and society. Also, Wang and Turner's (1999) research noted that the educational outcomes were the dominant factors affecting adolescents' selection of their professional careers. The educational outcomes were achievement in and attitudes toward a school subject. However, the problems of science education are low achievement, lack of enthusiasm and reduction of enrolment (Baggott La Velle, McFarlane & Brawn, 2003; Cha & Noh, 2004; Davis et al., 2000; Linn et al., 2004). In order to attract student into science areas, science classes and educators should implant self-confidence in science areas to students (Stake & Mares, 2001; Wang & Turner, 1999), i.e., enhancing achievement in science, good impression of science and scientists, and the prosperity (the possibility of development) of science. As the research results showed the achievement in science and AtoS were improved significantly after CAI, students could have confidence in their ability and furthermore these experiences could play a key role in pursuing their future professional careers.

The Internet has abundant information related to specific careers in diverse areas. Offering exact and clear information to adolescents is important to help in their decisions for future careers. Stake and Mares (2001) reported that some students withdrew their career aspiration from science areas after participating in their project, because they recognized their misunderstandings (delusion) about the careers. Providing diverse resources of different fields

is very helpful for students to articulate and explore what their favorable or unfavorable area is. Thus the responsibility of science educators is to give information, what science is, what scientists do, and what the required components or aptitudes of specific areas are. For these reasons, in considering individual student's aptitudes and providing resources which enable students to have indirect experiences, CAI is an effective tool for helping students to develop career aspirations.

5.4 Limitations in Generalizing the Findings

In generalizing the findings of this study several potential limitations should be included. Four limitations in generalizing the findings of this research may be identified as follows: the first limitation might be from the data that depended heavily on quantitative measurements; the second could be the variables (e.g., achievement, attitudes, etc.) that are mental representations which are difficult to measure straightforwardly; the third is related to research design; and, the last is the rather small sample size and the similarities of participants' background in terms of their social and personal profiles.

The statistical analyses of numeric data brought objective information of the effectiveness of CAI and the clear relationships among variables. However, in the process of interpreting the results, it was difficult to investigate and to identify the reasons for the individuals. Due to the fact that most phenomena are characterized by the mutual constitutions of quantitative and qualitative elements (Erickson, 2001) a valid and reliable in-depth interpretation can only be obtained from a combination of qualitative and quantitative data. So identifying the reasons for the results was not an easy task as the data consisted of numeric

information. Thus, while I was testing hypotheses and interpreting the data, I had to be careful not to overgeneralize.

Thirdly, as the research was conducted a time series quasi experimental design, the researcher can not clarify the possible pre-existing variables and can not control pre-existing factors such as individual students' proficiency in using computers and how much they had been exposed to CAI environments before this research, strong causal conclusions between independent variables and dependent variables cannot be drawn. Any interpretations from the research are based upon inferences from correlations among variables in this case; however the methodological limitations of conclusions based upon quasi-experimental designs in single classroom settings are recognized.

The questionnaires measured mental constructs: the achievements in, attributes toward and career aspirations in science areas. This information was not outwardly visible. Therefore, I had to draw inferences from the paper-based tests and survey questions in terms of what the student understood in scientific concepts, how they thought about science, and what their choices were regarding future courses and career aspirations. The comments on the backside of OMR cards provided more information but not enough to articulate all outcomes to justify general reasoning. Some comments were proven to be useful in identifying the reasons of the results as a complement to the statistical methods, but some reasons, such as girl participants were less preferable than boy participants or high achievement participants' deterioration after CAI could not be explained by using either the additional comments or statistical analyses.

In addition, the sample size and unilateral participants could be a limitation to generalize the effectiveness for CAI to all population. In statistical analyses of the variables,

the sample size, 234, was not small to identify the effect of treatment. But larger numbers of participants are recommended to apply the finding to all classrooms. Another limitation is that the participants were not from diverse groups. All participants were the second year of middle school, living in an urban area of Korea. Over 95% of them had computers in their houses. The findings might not be true for elementary or high school students, or rural area students who may not have as many opportunities of using computers in their everyday lives. Thus, the findings of this research could be an example of a specific group, but not for the whole population.

5.5 Discussions

5.5.1 The Potential of CAI as a Compensatory Curriculum for Low Achieving Students

In academic achievement, if a formalist argument is right, i.e., a student's academic achievement depends on his/her innate aptitude, then other conditions like SES should be equally distributed between high and low achieving groups. On the contrary if an actualist argument is right, there might be an unequal distribution of SES or other conditions.

The achievement distribution skewed heavily on group I and group V. At the pre-test achievement (GPA of grade 1), 32.1% (75 out of 234) belonged to group I and 23.9% (56 out of 234) belonged to group V. The possible reasons could be the students' innate aptitudes or family backgrounds. If students' innate aptitude differences bring this result, I could think of IQ test (Intelligence Quotient) as a possible innate aptitude index, because it has been widely known and used in testing one's intelligence. However, I could not get participants' IQ data, because Korean students do not have an IQ test any more. If I referred to statistical data, the

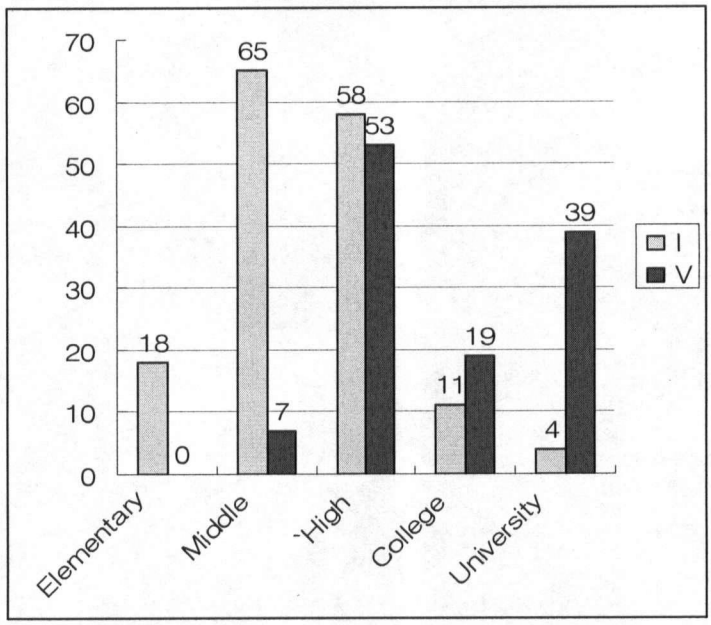
population's IQ test scores distributed a normal curve (Spatz, 2004). However, the student achievement distributed heavily at both ends, so the cause of this research result can not be students' innate aptitudes. Another possible reason is the students' family background. Parents' educational levels are considered as an index of a student's family background that reflects a student's SES.

Table 5-1and Graph 5-1 show the distribution of parents' educational levels between group I and group V. Parents of group I are generally only high or middle school graduates. On the other hand, fathers of group V had generally graduated from university and mothers from high school. The formalist assumes that educational stratification is determined by the students' abilities and aptitudes, however, previous research (Heck et al, 2004; Zimmer, 2003) and these results demonstrate students' achievement differences are not because of their academic abilities but because of their advantageous or disadvantageous situation.

Table 5-1 Parents' Educational Distribution
(group I and group V)

	Group I			**Group V**		
	Father	**Mother**	**Father +Mother**	**Father**	**Mother**	**Father +Mother**
Elementary	3	15	18	0	0	0
Middle	28	37	65	1	6	7
`High	34	24	58	17	36	53
College	9	2	11	9	10	19
University	4	0	4	32	7	39

Graph 5-1 Parents' educational Distribution
(Group I and Group V)



Individual students are not fully responsible for their academic achievement. In order to realize social fairness, and to avoid the role of a '(society's) sorting machine', school should provide more opportunities and extra resources for those students from low SES group to enhance their academic abilities and interests, so they can develop and catch up to the higher achievement groups. Davis et al. (2000) criticize the unilateral curriculum without considering differences of students: "Teaching the same thing in the same way at the same time to a group of people who might have nothing in common except the year of their birth" (p. 127). Therefore, providing different students with different resources is a mandatory task for schools and educators. Based on the research results, CAI could be a suitable method to address this.

Characteristics of students have been identified that have important influence on academic achievements (Ma, 1997). Based on the constructivist perspective, the basic element in academic achievement is influenced by individual learner's privileges and their own rates of

learning. Considering each learner's different academic level, the advantages of CAI are: 1) flexibility of content level, 2) abundant learning resources, 3) visualization of abstract concepts, and 4) availability of each learner's knowledge facilitator. Research literature identified these advantages of CAI as an effective factor that has influenced students' academic achievement (Bell & Linn, 2000; Davis & Linn, 2000; Hannafin, 2005; Hsu & Thomas, 2002; Smeets, 2005).

In a heterogeneous class, there are differences of interest and learning ability among students. There are intrinsically highly motivated, normal, and less motivated and slow learners. The class should be differentiated according to students' requirements, but in the classroom, the reality is that it is not easy to satisfy each individual student's requirements. One teacher with more than thirty students usually lectures under the assumption that all students have the same level of background knowledge in the subject matter and are able to absorb the material at the same pace (Lord, 1999; Stofflett, 1998). On the other hand, the benefits of CAI are to provide flexibility of the content level and a sufficient amount of diverse learning resources. Students can diagnose their understanding levels in certain content areas and identify what they should know more of, and what kinds of misconceptions they have. Students can easily widen and deepen the range of learning with CAI.

Low achieving students usually do not have a strong background of prior knowledge, and they do not have enough chances to compensate for prior knowledge in a traditional lecture-based class. In addition the class time is fixed and the teacher has to teach some sort of content. She/he can not discuss basic concepts all the time. CAI can provide access to the related basic concepts whenever the individual demands. In other words each low achieving

student can have their own knowledgeable facilitators, which reduces the ZPD gap.

Additionally students who are slow learners and can not fully understand with only one explanation, the ability to repeat the lesson that CAI offers allows for more opportunities to listen to the explanation. The effectiveness of CAI for different achievement groups were significantly different ($p<.05$) and a post-hoc test of Tukey's HSD revealed that the lowest achievement group's improvement was significantly higher than that of the highest group. CAI with multiple advantageous functions has a potential for compensatory curriculum.

5.5.2 High Achieving Students Lower Rates

The results of this research showed that many participants of group V dropped significantly at the post-test, $t(55)=4.238$, $p=.000$. CAI is not only for low achieving students, but it should be an effective learning tool for students of all achieving levels. Based on the participants' self-reflection many participants answered that the reasons why they dropped at the post-test were that the content was difficult. The second reason was disagreement with other members of the group in searching web sites and with the processes of class activities. Another reason was that it was difficult to concentrate on the computer screen.

However, the first reason, that the content was difficult, needs further and in-depth consideration. If the content was difficult for the students of the highest achievement group, the other groups of students would also find it difficult. The second reason is that these were difficulties in learning with group members, but low achieving students were satisfied with group learning. This issue is different from Noh et al.'s (1998). Their research showed that high achieving students helped low achieving students and this procedure brought deep understanding and articulation of what they know. Maybe some of the high achieving students

regarded sharing their ideas and knowledge as advantageous only for the low achieving students. This should be considered when educational program designers design educational media. They should pay attention not only to the content but also to the aesthetic aspects, i.e., not many colors, consistency and so on.

The participants' answers and comments did not give enough information; therefore, the reasons of deterioration may be inferred from previous studies. What reasons could there be that even the participants could not recognize? Some studies showed that CAI was not as effective for high achieving students (Hart, 1995; Shaw & Marlow, 2000; White & Frederiksen, 1998). Shaw and Marlow (2000) examined the relationships between CAI and different learning styles. The results showed that the relationship between the advanced students and ICT were negative because the students regarded technology as impersonal. Hart (1995) noted that learning styles affect the outcomes in the CAI environment. For the learning style theorist (advanced style in Shaw and Marlow's study) CAI was not effective. In the case of White and Frederiksen's (1998) research, improvements in the rate of high achieving students were smaller than that of low achieving students.

Another possibility is the ceiling effect (Stake & Mares, 2001). This means that high achieving student are already close to the maximum achievement scores, so there is very little room for improvement, but much room for deterioration. When we measure a differential score of the pre- and post-test, the numbers likely show up as statistically significant when the difference is large. For instance, if an average student started from an achievement level of 75, and improved to 85, the difference is 10 points. For a top achieving student who has an average 95, there is no room to gain 10 points in a scale of 100. Even if the top student gained 2 points,

their gain may appear smaller. The statistical analysis methods do not differentiate among scores, i.e., 10 points for the normal student and 2 for the top achieving student.

On the other hand, problems may exist in CAI programs or in Internet resources. The programs of CAI and the web resources which were mainly used in the class might heavily target low achieving students, which might be too simple to encourage the high achieving students, or designed for individual users and not for group users. According to Kwun (1993), Kim (1996) and Park (1988), many CAI programs and educational web sites have been designed and developed for individual users, so they suggest the best condition for CAI is one student with one computer, but the classroom reality is that two or four students worked on one computer, so that some may not receive optimal interaction time with the program to benefit from the learning opportunity.

In this section I considered the possible reasons why high achieving students could not improve as much as the low achieving students: As literature shows 1) CAI may not fit for all types of learners (Hart, 1995; Shaw & Marlow, 2000), 2) ceiling effects (Stake & Mares, 2001) and the weakness of statistical analysis impose limits, and 3) computer software and classroom reality may not support optimal conditions (Kwun, 1993; Kim, 1996; Park, 1988). In order to satisfy as many students as possible, teachers have to select computer programs and web resources based on whether or not they have differentiated content for different achievement groups; furthermore, the consideration is required that the school's physical conditions (the number of available computers) and the utilization of computer programs are sufficient.

5.5.3 Gender Differences

CAI for female participants did not significantly change their achievement ($p>.05$), and AtoS ($p>.05$). On the contrary for male participants, all items, achievement in the post-test, AtoS, and CA, were significantly improved at the post-test ($p<.05$). The post-survey questionnaire and additional comments did not provide the reasons why CAI was not as effective for the girls.

Currently in ICT fields, gender differences are not consistent (contradictory). Some argue the differences between male and female are significant (Braten & Stromso, 2004; Bryson, Petrina, Braundy& de Castell, 2003; Kim, 2003) while others argue it's not significant (Mayer-Smith et al., 2000; Shaw & Marlow, 1999). In chapter 2, I reviewed the digital divide in terms of gender (Braten & Stromso, 2004; Canada, 2001; Cooper &Weaver, 2003). The big differences of using computers between boys and girls are the attitudes toward technology and the usage. Boys' attitudes are more voluntary than girls. While girls use computers for their school-work that is mandatory, boys use computers for their own interests. However, Mayer-Smith et al.'s (2000) research found no differences between high school boys and girls. Shaw and Marlow's (1999) research shows that differences between men and women toward IT exist but are not significant.

The other probability I considered was science preference. The subject preference might affect the different outcomes between boys and girls. Weinburgh (1995) did a meta-analysis of 18 studies representing 6753 students and revealed that girls have less of a preference towards science than boys. Benbow, Arjmand, and Walberg (1991) conducted a longitudinal study of the factors in the educational productivity. Gender differences were found in that males had higher educational aspirations, whereas females had better academic records

in mathematics and science. In this research, however, girls had more of a preference towards science than boys, i.e., 20 girls chose science as an interesting school subject, while only 4 boys did. Thus, subject favorability could not be the reason why the girl participants did not improve significantly.

According to the science teacher, the boys were more actively engaged and would not yield the computers to the girls. In most cases girls were excluded from manipulating computers and their roles was as observers, while boys dominated the use of the computers. Research noted that when students engage in class activity actively, their learning outcomes were improved. The differences may be originated from how a student engaged in the class activities, i.e., an observer or a doer.

Therefore, gender differences in this study may be caused by favorability towards using technology. The gender difference requires in-depth research.

5.5.4 Information Communication Technology (ICT) Literacy

A few students in this research (3 students out of 234) complained they could not find information that the science teacher asked for. However, most students' answered that they did not have difficulties in searching information or in communicating with CAI programs. They felt comfortable using computers in learning activities instead of playing games, chatting, or e-mailing. Through CAI students could widen their usage range of computers and the Internet. Utilizing computers and computer programs in science class can lead students to use computers and the Internet more productively and efficiently.

An information and technology based society requires workers and students to have proficiency and skill in ICT areas (Davis et al., 2000; Hargreaves, 2003). Computer technology

is in the centre. Khol (1995) and Alexander (1999) argue that ICT literacy is best achieved when ICT is used as part of the curriculum. Alexander (1999) reported that integrated ICT immersed classes were very helpful to help students learn and master skills using ICT tools and searching resources. In this research, most participants (98%) own household computers and 97 % of the computers had access to high speed Internet. This demographic fact does not mean that more than 95% of participants can use computers, Internet and other web utilities properly.

ICT literacy includes the ability of using ICT tools, and understanding the terms which are used in ICT areas. As November (2002) reported, most students' could search for information, but they did not have the ability to discern the trustworthiness of information. In addition some students were not able to find information efficiently. Moreover, proper netiquette such as using proper language and respecting others should be taught to young students.

Therefore, CAI in the curriculum could realize improvement not only achievement in and, attitudes toward, but also ICT literacy. Furthermore, as the result of this study shows the unequal distribution of student achievement, particularly for low achieving students who are mostly from disadvantageous backgrounds, need extra resources. School systems should feel and share the responsibility with the low achieving students. ICT can be an alternative.

5.5.5 Implications from the Research on CAI and ICT Literacy for Science Teachers, Pedagogy, and Curriculum

Literature (Bates & Poole, 2003; Baggott La Vella, 2003; Becker, 2000b) demonstrates the importance of teachers' ICT literacy for success in ICT education, and for successful utilization of ICT in a classroom. Even though the government and the educational administrators

advocated reforms in the learning environment, if teachers, who are the principle gatekeepers in classrooms, are not willing to use the computers in their classes, such reforms would be useless (Christensen, 2002). There might be difficulties adapting CAI in a classroom like computers, software and hard work load for the teachers. As this study results show, however, computers in science education is very important for students' conceptual understandings, positive attitudes changes toward science and their career aspirations. In addition teachers' perspectives on technology and ICT literacy are very important because they influence student attitudes toward technology (Christensen, 2002; Frantom et al., 2002; McQuillan, 1994; Woodrow, 1992). As our youngsters ICT literacy and proficiency are an essential part of preparing for their future professions. These should be learned properly through curriculum. Particularly when we consider most of low achieving students' situation, schools and teachers should endeavor to provide extra resources in terms of promoting greater educational equity.

The development of computer hardware and software is remarkable (Bates & Poole, 2000; Cuban, 1999). However, teachers' proficiency in technology and their ICT literacy have not been able to keep pace with these rapid changes of development (Becker, 2000). Even though computer interfaces changed from technical languages such as BASIC or FOTRAN to GUI (graphical user interface), many teachers have difficulties in utilizing computers and educational programs (Bates & Poole, 2000; Becker, 2000). If educational programs do not employ a user friendly, they may affect learning negatively. Some researchers report the negative effects of CAI programs which were complicated and had some flaws (Ruthven, Hennessy & Deaney, 2005). Therefore, educational software needs to be to be user friendly, and teachers also have to enhance their ICT literacy.

Integrating ICT with the curriculum requires lifelong learning. Teachers should not only adhere to the methods they are familiar with or the ones they learned from their teachers when they were students. They should be aware of the fact that teaching and learning are complex. If one is involved in the "teaching world", then one must be involved in the "learning world" with an understanding of the complexity of human beings and the continuously evolving learning environment.

5.6 Recommendations for Further Research

Based on the findings of this research, further research is recommended in the following areas:

- Differentiated grouping (e.g., same gender groups)
- Diversification of samples in terms of age, geographical area, social background, etc.
- Characteristics of CAI programs, and
- Mixed methodologies.

5.6.1 Differentiated Grouping

In this research, the achievement scores of high achieving students and girls did not show significant improvement in the post-test. Even though CAI has some benefits, if it is only effective for low achieving students and certain learning styles or boys, it is not a complete success. Therefore, further research should be carried out to investigate how students' learning styles can be addressed using CAI to test the effects of grouping different learning style students together. In addition, different approaches are recommended to be sure whether or not there are gender differences in digital areas. In this research, boys and girls were mixed

together, so the roles were divided into two as doers and observers in learning activities. Boys were usually doers and girls were observers. If the results of role differences caused the gender differences in CAI, further research should be conducted utilizing a single sex grouping. There could be groups made up entirely of the same sex or a group in which each student can operate his/her own computer.

5.6.2 Diversify Samples

As mentioned in the section of limitations of this research, it is important not to over generalize the results from the limited sample size and the unilateral characteristics of the samples. Therefore, it is recommended to conduct further research with more diverse samples in terms of larger sample size, diverse age ranges, and geographical and social backgrounds.

5.6.3 Research Designs to Match CAI Programs and Classroom Situations

Based on the results of this research and previous research on use of CAI, questions on designing research and implementing CAI for instruction also needs to be considered in future research. Direct manipulation of variables in CAI programs was an effective tool for students' conceptual understanding. Opportunities for students to experiment with a variety of different situations provided by CAI programs enable them to find patterns and to expect different cases (situations), so higher orders of thinking ability can be nurtured. Thus, researchers should pay attention to the characteristics of CAI programs and the classroom technological situation.

The CAI programs are designed for individual users and if classroom limitations do not allow for this, it is difficult to achieve learning objectives using CAI. Therefore, a program's appropriateness should be seriously considered regarding the classroom situation and the intention of CAI programs, i.e., whether they are designed for one learner or learners in

a group.

5.6.4 Adaptation of both Quantitative and Qualitative Research Methodology

As this research depends heavily on numeric data, the inferential statistic results were interpreted based on previous research or the students' comments. These may not provide the sufficient explanations needed to understand the specific causes of the results.

The combination of quantitative and qualitative methodology could provide the necessary tools to allow for an in-depth understanding of the results of the quantitative analyses. This would help in answering questions such as why girls could not improve their achievement scores at post-test, why the scores of high achieving students deteriorated after use of CAI when compared to the low achieving students, and what specific aspects of CAI programs and web resources best helped students to understand scientific concepts. In further studies, researchers may conduct interviews with some students in different categories, i.e., boys and girls whose scores deteriorated, improved, and remained constant.

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APPENDIX I: ACT OF PROMOTION FOR ICT LITERACY

정보화촉진기본법

제 정 1995. 8. 4 법률제 4969 호

일부개정 1999. 1.21 법률제 5669 호

일부개정 2000. 1.21 법률제 6197 호(전파법)

일부개정 2001. 1.16 법률제 6360 호(정보통신망이용촉진및정보보호등에관한법률)

제 1 장 총칙

제 1 조 (목적) 이 법은 정보화를 촉진하고 정보통신산업의 기반을 조성하며 정보통신기반의 고도화를 실현함으써 국민생활의 질을 향상하고 국민경제의 발전에 이바지 함을 목적으로 한다.

제 2 조 (정의) 이 법에서 사용하는 용어의 정의는 다음과 같다. <개정 99.1.21>

1. "정보"라 함은 자연인 또는 법인이 특정목적을 위하여 광 또는 전자적 방식으로 처리하여 부호 · 문자 · 음성 · 음향 및 영상등으로 표현한 모든 종류의 자료 또는 지식을 말한다.

2. "정보화"라 함은 정보를 생산 · 유통 또는 활용하여 사회 각 분야의 활동을 가능하게 하거나 효율화를 도모하는 것을 말한다.

3. "정보통신"이라 함은 정보의 수집 · 가공 · 저장 · 검색 · 송신 · 수신 및 그 활용과 이에 관련되는 기기 · 기술 · 역무 기타 정보화를 촉진하기 위한 일련의 활동과 수단을 말한다.

4. "정보보호"라 함은 정보의 수집 · 가공 · 저장 · 검색 · 송신 · 수신중에 정보의 훼손 · 변조 · 유출등을 방지하기 위한 관리적 · 기술적 수단(이하 "정보보호시스템"이라 한다)을 강구하는 것을 말한다.

5. "초고속정보통신기반"이라 함은 실시간으로 동영상정보를 주고 받을 수 있는 고속 · 대용량의 정보통신망(이하 "초고속정보통신망"이라 한다)과 이에 접속되어 이 용되는 각종 정보통신기기 · 소프트웨어 및 데이터베이스등을 말한다.

6. "정보자원"이라 함은 정보 및 이와 관련되는 설비 · 기술 · 인력 및 자금 등 정보화에 필요한 자원으로서 정보통신부령이 정하는 것을 말한다.

제 2 조의 2 (국가 및 지방자치단체의 책무) 국가 및 지방자치단체는 정보화의 촉진과 정보통신산업의 기반조성 및 정보통신기반의 고도화(이하 "정보화촉진등"이라 한다)를 위하여 필요한 시책을 수립 · 시행하여야 한다. [본조신설 99.1.21]

제 3 조 (정보화시책의 기본원칙) 정부는 정보화촉진등을 위하여 다음 각호의 원칙에 따라 제반시책을 강구하여야 한다. <개정 99.1.21>

1. 민간투자의 확대와 공정경쟁 촉진

2. 환경변화에 능동적으로 대응하는 제도의 수립 · 시행

3. 정보통신기반에 대한 자유로운 접근과 활용

4. 지역적 · 경제적 차별이 없는 균등한 조건의 보편적 역무 제공

5. 개인의 사생활 및 지적소유권의 보호와 각종 정보자료의 안전성 유지

6. 국제협력의 촉진

제 4 조 (연차보고등) ① 정부는 매년 정보화촉진등에 관한 동향과 시책에 관한 보고서를 정기국회 개회전까지 국회에 제출하여야 한다.

② 국가기관, 지방자치단체 및 정부투자기관 기타 대통령령이 정하는 기관의 장은 당해 기관이 보유하고 있는 정보자원의 현황 및 통계자료(이하 "정보자원현황등"이라 한다)를 체계적으로 작성 · 관리하여야 한다. <신설 99.1.21>

③ 정보통신부장관은 사회 각 분야의 정보화에 대한 지표를 조사개발 및 보급하여야 한다.

④ 정보통신부장관은 예산의 효율적인 운용을 도모하고 제 3 항의 규정에 의한 정보화에 대한 지표를 조사 · 개발 및 보급하기 위하여 필요한 경우에는 제 2 항의 규정에 의한 기관의 장에게 당해 기관의 정보자원현황등의 제공을 요청할 수 있다. 이 경우 다른 중앙행정기관의 장이 제 2 항의 규정에 의한 기관의 정보자원현황등을 이미 보유하고 있는 경우에는 그 중앙행정기관의 장에게 정보자원현황등의 제공을 요청하여야 한다. <신설 99.1.21>

⑤ 제 4 항의 규정에 의하여 정보자원현황등의 제공을 요청받은 기관의 장은 특별한 사유가 없는 한 이에 응하여야 한다. <신설 99.1.21>

제 2 장 정보화촉진등을 위한 계획의 수립과 추진체계

제 5 조 (정보화촉진기본계획의 수립) ① 정부는 정보화촉진등을 위하여 5 연의 기간을 단위로 하는 정보화촉진기본계획(이하 "기본계획"이라 한다)을 수립하여야 한다. <개정 99.1.21>

② 기본계획은 정보통신부장관이 관계중앙행정기관별 부문계획을 종합하여 수립하며, 제 8 조의 규정에 의한 정보화추진위원회의 심의를 거쳐 이를 확정한다.

③ 기본계획에는 다음 각호의 사항이 포함되어야 한다. <개정 99.1.21>

1. 정보화촉진등에 대한 시책의 기본방향

2. 행정업무의 정보화촉진에 관한 사항

3. 산업분야의 정보화촉진에 관한 사항

4. 재정 · 금융분야의 정보화촉진에 관한 사항

5. 교육 · 연구 · 과학기술 · 환경분야의 정보화촉진에 관한 사항

6. 지역 · 문화 · 생활 기타 분야의 정보화촉진에 관한 사항

7. 제 2 호 내지 제 6 호의 규정에 의한 분야별 정보보호에 관한 사항

8. 정보의 공동활용 및 정보통신 표준화의 촉진에 관한 사항

9. 개인정보 및 지적소유권의 보호와 정보통신이용자(이하 "이용자"라 한다)의 권익보호에 관한 사항

10. 정보화촉진등을 위한 법령 · 제도의 기반조성에 관한 사항

11. 정보통신기술의 연구 · 개발, 정보통신기술인력의 양성 등 정보통신산업의 기반조성에 관한 사항

12. 정보통신기반의 고도화에 관한 사항

13. 정보화촉진등과 관련된 국제협력에 관한 사항

14. 정보화촉진등에 관한 재원의 조달 및 운용에 관한 사항

15. 기타 정보화촉진등을 위하여 필요한 사항

④ 관계중앙행정기관의 장 및 지방자치단체의 장은 소관주요정책의 수립과 그 집행에 있어서 제 3 항 각호의 사항을 우선적으로 고려하여야 한다.

⑤ 정보통신부장관은 제 2 항의 규정에 의한 관계중앙행정기관별 부문계획의 작성지침을 정하여 이를 관계중앙행정기관에게 통보할 수 있다. <신설 99.1.21>

제 6 조 (시행계획의 수립) ① 관계중앙행정기관의 장은 기본계획에 따라 매년 정보화촉진시행계획(이하 "시행계획"이라 한다)을 수립 시행하여야 한다.

② 관계중앙행정기관의 장은 전년도의 시행계획 추진실적과 다음 연도의 시행계획을 제 8 조의 규정에 의한 정보화추진위원회에 제출하여 그 심의를 받아야 한다.

③ 관계중앙행정기관의 장은 제 8 조의 규정에 의한 정보화추진위원회의 심의를 거쳐 확정된 시행계획의 시행에 필요한 재원을 우선적으로 확보하여야 한다.

④ 시행계획의 수립 및 시행에 관하여 필요한 사항은 대통령령으로 정한다.

제 7 조 (정보화촉진등에 관한 정책등의 조정) 관계중앙행정기관의 장은 다른 중앙행정기관의 장이 수행하는 정보화촉진등에 관한 정책이나 사업 추진이 당해 기관의 정보화촉진등에 관한 정책이나 사업 추진에 지장을 초래할 우려가 있다고 인정할 때에는 미리 정보통신부장관과 협의를 거친 후 제 8 조의 규정에 의한 정보화촉진위원회에 이의 조정을 요청할 수 있다.

제 8 조 (정보화추진위원회) ① 정보화촉진등에 관한 사항을 심의하기 위하여 국무총리소속하에 정보화추진위원회(이하 "위원회"라 한다)를 둔다.

② 위원은 위원장 · 부위원장을 포함하여 25 인이내로 한다.

③ 위원장은 국무총리가 되고, 부위원장은 재정경제부장관이 되며, 위원은 국회사무총장 · 법원행정처장 · 관계행정기관의 장중에서 위원장이 위촉하는 자로 한다. 다만, 국회사무총장과 법원행정처장은 제 9 조에서 정한 위원회의 심의사항이 당해 기관의 업무와 관련되어 있어 협조가 필요하거나 기타 필요한 경우에 한하여 위원회에 출석한다. <개정 99.1.21>

④ 위원회에 간사 1 인을 두되, 간사는 국무조정실장이 된다. <개정 99.1.21>

⑤ 위원회의 효율적인 운영을 위하여 정보화추진실무위원회를 두며, 정보화를 효율적으로 추진하기 위하여 분야별로 정보화추진분과위원회를 설치 · 운영할 수 있다.

⑥ 위원회, 정보화추진실무위원회 및 정보화추진분과위원회의 자문에 응하기 위하여 정보화촉진등에 관한 학식과 경험이 풍부한 자중에서 각 위원회의 장이 위촉하는 자로 정보화추진자문위원을 둘 수 있다.

⑦ 위원회의 운영과 정보화추진실무위원회 및 정보화추진분과위원회의 구성 · 운영등에 관하여 필요한 사항은 대통령령으로 정한다.

제 9 조 (위원회의 기능) 위원회는 다음 각호의 사항을 심의한다. <개정 99.1.21>

1. 제 5 조의 규정에 의한 기본계획, 기본계획중 대통령령이 정하는 중요한 사항의 변경 및 관계중앙행정기관별 부문계획의 작성지침에 관한 사항

2. 제 6 조의 규정에 의한 시행계획 및 시행계획중 대통령령이 정하는 중요한 사항의 변경에 관한 사항

3. 제 7 조의 규정에 의한 정보화촉진등에 관한 정책이나 사업 추진의 조정에 관한 사항

4. 제 26 조의 규정에 의한 초고속정보통신기반의 구축과 이용에 관한 사항

5. 제 33 조의 규정에 의한 정보화촉진기금의 운용방침에 관한 사항

6. 삭제 <99.1.21>

7. 정보화촉진시책의 추진실적평가에 관한 사항

8. 기타 정보화촉진등과 관련한 주요정책사항으로서 위원장이 부의하는 사항

제 9 조의 2 (정보화책임관의 임명등) ① 국가기관 및 지방자치단체의 장은 당해 기관의 정보화시책의 효율적인 수립 · 시행과 정보화사업의 조정 등 정보화업무를 총괄하는 정보화책임관을 임명할 수 있다.

② 제 1 항의 규정에 의한 정보화책임관은 소속기관의 업무와 관련하여 다음 사항을 분장한다.

1. 정보화사업계획의 종합조정 및 추진실적의 평가

2. 정책 · 계획 등의 수립 · 추진시 정보화와의 연계 · 조정

3. 정보자원의 획득 · 배분 · 이용 등의 종합조정 및 체계적 관리와 정보공동활용방안의 수립

4. 행정업무의 정보화촉진 [본조신설 99.1.21]

제 9 조의 3 (정보화계획의 반영 등) ① 사회간접자본시설사업 및 지역개발사업 등 대통영령이 정하는 대규모 투자사업을 시행하고자 하는 중앙행정기관 및 지방자치단체의 장은 당해 사업계획을 수립 · 시행함에 있어 정보기술의 활용, 정보통신기반 및 정보통신서비스의 연계이용 등을 위한 계획(이하 "정보화계획"이라 한다)을 수립하여 이를 최대한 반영하여야 한다.

② 정보통신부장관은 중앙행정기관 및 지방자치단체의 장이 정보화계획을 효과적으로 수립할 수 있도록 기술 및 인력 등 필요한 사항을 지원할 수 있다. [본조신설 99.1.21]

제 10 조 (한국전산원의 설립) ① 정부는 국가기관 · 지방자치단체 등(이하 "공공기관"이라 한다)의 정보화촉진등을 지원하고 정보화관련 정책개발을 지원하기 위한 기관으로서 한국전산원(이하 "전산원"이라 한다)을 설립한다.

② 전산원은 법인으로 한다.

③ 전산원은 다음 각호의 사업을 한다.

1. 기본계획 및 시행계획의 수립 · 시행에 필요한 전문기술의 지원

2. 공공기관의 정보통신망 관리 및 운영의 지원

3. 공공기관 주요정보의 원활한 유통과 공동활용을 위한 시스템의 구축 · 운영 및 정보통신표준화의 지원

4. 공공기관의 정보자원 관리의 지원

5. 공공기관의 정보화사업에 대한 평가 지원

6. 정보문화의 확산 지원

7. 공공기관의 정보화촉진등을 위하여 대통령령이 정하는 사업

④ 공공기관은 전산원의 설립 · 시설 및 운영 등에 필요한 경비에 충당하게 하기 위하여 전산원에 출연할 수 있으며, 정부는 전산원의 설립 및 운영 등을 위하여 필요한 국유재산을 무상으로 대부할 수 있다.

⑤ 전산원은 지원을 받고자 하는 공공기관에게 그 지원에 소요되는 비용의 전부 또는 일부를 부담하게 할 수 있다.

⑥ 전산원에 관하여 이 법에서 정한 것을 제외하고는 민법의 재단법인에 관한 규정을 준용한다.

⑦ 전산원이 아닌 자는 한국전산원의 명칭을 사용하지 못한다.

⑧ 전산원의 공공기관에 대한 정보화촉진등의 지원에 관하여 필요한 사항은 대통령영으로 정한다. [전문개정 99.1.21]

제 2 장의 2 국가사회 정보화의 촉진

제 11 조 (공공정보화등의 추진) ① 공공기관의 장은 행정업무의 정보화와 의료 · 교육 · 문화 및 환경의 정보화등 공공분야의 정보화를 추진하여야 한다.

② 지방자치단체의 장은 지역사회의 특성에 적합한 지역정보화사업을 추진하여야 하며, 정부는 이에 상응하는 행정 · 재정 · 기술등 필요한 사항을 지원할 수 있다.

③ 정부는 산업기반의 고도화와 산업의 생산성 향상을 위하여 기업의 정보화 및 기업간 정보통신망의 구축 · 이용등 산업정보화의 촉진에 필요한 사항을 지원할 수 있다.

④ 정부는 제 1 항의 규정에 의한 교육 등 공공분야의 정보화를 추진함에 있어 민간투자를 적극 유치하고, 관련 민간사업자 및 민간사업자단체에 대하여 필요한 지원을할 수 있다. <신설 99.1.21>

제 12 조 (정보문화의 확산) ① 정부는 정보화촉진등이 활성화될 수 있도록 홍보와 교육의 확대등 정보문화 확산을 위한 시책을 추진하여야 한다.

② 정부는 정보화촉진등이 광범위하게 확산될 수 있도록 신문, 방송등 언론매체를 활용한 정보통신관련교육과 홍보대책을 강구하여야 한다.

제 12 조의 2 (건전한 정보통신윤리의 확립) 정부는 건전한 정보통신윤리를 확립하기 위하여 미풍양속을 해치는 불건전한 정보의 유통을 방지하고 건전한 국민정서를 함양하며, 불건전한 정보로부터 청소년을 보호하기 위하여 필요한 시책을 강구하여야 한다. [본조신설 99.1.21]

제 13 조 (공공기관의 정보제공의 촉진 등) ① 정부는 공공기관이 보유하고 있는 정보의 독점방지와 정보에 대한 자유로운 접근을 보장하기 위하여 공공기관 보유정보의 제공을 확대하고, 그 유통을 촉진하기 위한 시책을 강구하여야 한다.

② 정부는 공공기관이 보유하고 있는 정보를 효율적으로 관리 · 유통 및 제공하기 위하여 다음 각호의 사항을 우선적으로 시행하여야 한다.

1. 전자적 방식에 의한 정보의 소재 안내에 관한 사항

2. 공공기관간 정보의 공동활용을 위하여 필요한 사항 [전문개정 99.1.21]

제 14 조 (정보보호 등) ① 정부는 정보의 안전한 유통을 위하여 정보보호에 필요한 시책을 강구하여야 한다.

② 정부는 암호기술의 개발과 이용을 촉진하고 암호기술을 이용하여 정보통신서비스의 안전을 도모할 수 있는 조치를 강구하여야 한다. [전문개정 99.1.21]

제 14 조의 2 (한국정보보호센터의 설립) ① 정부는 제 14 조의 규정에 의한 정보보호시책을 효율적으로 추진하기 위하여 한국정보보호센터(이하 "보호센터"라 한다)를 설립한다.

② 보호센터의 업무 및 운영에 관하여 필요한 사항은 대통령령으로 정한다.

③ 제 10 조제 2 항 · 제 6 항 및 제 7 항의 규정은 보호센터에 관하여 이를 준용한다. 이 경우 "한국전산원"은 "한국정보보호센터"로, "전산원"은 "보호센터"로 본다. [본조신설 99.1.21]

제 14 조의 2 삭제 <2001.1.16> [[시행일 2001.7.1]]

제 15 조 (정보보호시스템에 관한 기준고시등) ① 정보통신부장관은 관계기관의 장과 협의하여 정보보호시스템의 성능과 신뢰도에 관한 기준을 정하여 이를 고시하고, 정보보호시스템을 제조하거나 수입하는 자에 대하여 이 기준의 준수를 권고할 수 있다. <개정 99.1.21>

② 정보통신부장관은 유통중인 정보보호시스템이 제 1 항의 규정에 의한 기준에 미치지 못할 경우에 정보보호시스템의 보완 기타 필요한 사항을 권고할 수 있다.

③ 제 1 항의 규정에 의한 기준고시와 제 2 항의 규정에 의한 권고 기타 필요한 사항은 대통령령으로 정한다. <개정 99.1.21>

제 15 조의 2 (정보시스템에 대한 감리) ① 정보통신부장관은 정보를 수집 · 가공 · 저장 · 검색하기 위한 기기 및 소프트웨어의 조직화된 체제(이하 "정보시스템"이라 한다)의 효율적인 구축 · 운영과 안전성 및 신뢰성의 확보를 위하여 정보시스템에 대한 감리의 기준을 정하여 이를 고시하고, 정보시스템을 개발 · 구축 또는 운영하는 자에게 이 기준의 준수를 권고할 수 있다.

② 정보통신부장관은 제 1 항의 규정에 의한 기준을 정하는 경우 정보보호에 관한 사항에 관하여는 관계기관의 장과 협의하여야 한다. [본조신설 99.1.21]

제 16 조 (이용자의 권익보호등) ① 정부는 정보화를 촉진함에 있어 이용자의 권익보호를 위하여 다음 각호의 시책을 강구하여야 한다.

1. 건전한 이용을 위한 홍보 · 교육 및 연구

2. 이용자의 건전한 조직활동의 지원 및 육성

3. 이용자의 생명 · 신체 및 재산상의 위해방지

4. 이용자의 불만 및 피해에 대한 신속 · 공정한 구제조치

5. 기타 이용자보호와 관련된 사항

② 정보통신망이용촉진등에관한법률 제 2 조제 3 호의 규정에 의한 정보통신서비스제공자는 그 사업활동에 있어서 이용자를 보호하기 위하여 필요한 조치를 강구하여야 한다. <개정 99.1.21>

제 16 조의 2 (보편적 역무의 제공과 복지정보통신의 실현) ① 정부는 정보통신망에 대한 자유로운 접근과 이용을 보장하고 지역적 · 경제적 차별이 없는 균등한 조건의 보편적 역무가 제공될 수 있도록 필요한 시책을 강구하여야 한다.

② 정부는 장애인 · 노령자 · 저소득자 등 사회적 약자들이 자유로운 정보접근의 기회를 누리고 정보화의 혜택을 향유할 수 있도록 하기 위하여 정보통신요금, 정보통신기기의 사용편의성 및 정보이용능력의 개발 등에 필요한 대책을 강구하여야 한다. [본조신설 99.1.21]

제 16 조의 3 (정보통신응용서비스 이용 등의 활성화) 정부는 인터넷 · 원격정보통신서비스 및 전자거래 등 정보통신망을 활용한 응용서비스의 이용을 활성화하고 우수한 정보내용물의 개발을 촉진하기 위한 시책을 강구하여야 한다. [본조신설 99.1.21]

제 16 조의 4 (지적소유권의 보호) 정부는 정보화를 촉진함에 있어서 합리적인 지적소유권의 보호시책을 강구하여야 한다. [본조신설 99.1.21]

제 3 장 정보통신산업의 기반조성

제 17 조 (정보통신산업의 기반조성) 정부는 정보통신산업의 기반조성을 위하여 필요한 시책을 강구하여야 한다.

제 18 조 (기술개발의 추진) ① 정부는 정보통신산업의 기반조성에 필요한 기술개발과 기술수준의 향상을 위하여 다음 각호의 사항을 추진하여야 한다.

1. 기술수준의 조사, 기술의 연구개발, 개발기술의 평가 및 활용에 관한 사항

2. 기술협력 · 기술지도 및 기술이전에 관한 사항

3. 기술정보의 원활한 유통을 위한 사항

4. 산학협동을 촉진하기 위한 사항

5. 기타 기술개발과 관련하여 필요한 사항

② 정부는 제 1 항의 규정에 의한 사항을 효율적으로 추진하기 위하여 필요한 때에는 정보통신산업 기술개발과 관련된 연구기관 및 민간단체로 하여금 이를 대행하게 할 수 있다. 이 경우 이에 소요되는 비용은 대통령령이 정하는 바에 따라 지원할 수 있다.

제 19 조 (정보통신 표준화의 추진) 정부는 정보화를 촉진하고 정보통신의 효율적인 운영 및 호환성의 확보 등을 위하여 다음 각호의 사항을 추진하여야 한다.

1. 정보통신응용서비스에 관한 표준화

2. 정보의 공동활용을 위한 표준화

3. 기타 정보통신관련 표준화에 관한 사항 [전문개정 99.1.21]

제 20 조 (정보통신기술인력의 양성등) 정부는 정보통신산업의 기반조성에 필요한 기술인력의 양성을 위하여 다음 각호의 시책을 강구하여야 한다.

1. 각급학교 기타 교육기관에서 시행하는 정보통신교육의 지원

2. 일반국민에 대한 정보통신교육의 확대

3. 정보통신기술인력양성사업의 지원

4. 정보통신전문기술인력양성기관의 설립 · 지원

5. 정보통신 교육프로그램의 개발 및 보급 지원

6. 정보통신기술자격제도의 정착 및 전문기술인력 수급 지원

7. 기타 정보통신기술인력의 양성에 관하여 필요한 사항

제 21 조 (정보통신산업단지의 조성) ① 정부는 정보통신산업의 기반조성을 위하여 산업입지의 조성 및 공급과 정보통신산업기반시설의 지원등에 관하여 필요한 시책을 강구하고, 민간인이 공동으로 정보통신산업단지를 조성할 경우에는 우선 지원하여야 한다. <개정 99.1.21>

② 제 1 항의 규정에 의한 정보통신산업단지의 지원에 관하여 필요한 사항은 대통령령으로 정한다. <신설 99.1.21>

제 22 조 (정보통신우수신기술에 대한 지원 등) ① 정보통신부장관은 정보통신과 관련된 우수한 신기술을 정보통신우수신기술(이하 "신기술"이라 한다)로 지정하여 신기술의 사업화 등에 필요한 지원을 할 수 있다.

② 정보통신부장관은 제 1 항의 규정에 의한 지원을 받아 신기술을 사업화하여 매출이 발생한 경우에는 그 사업자로부터 기술료를 징수할 수 있다.

③ 제 1 항의 규정에 의한 신기술의 지정기준 · 지정절차 및 지원내용과 제 2 항의 규정에 의한 기술료의 징수에 관하여 필요한 사항은 대통령령으로 정한다. [전문개정 99.1.21]

제 22 조의 2 (신기술 지정의 취소) 정보통신부장관은 제 22 조제 1 항의 규정에 의하여 지정된 신기술이 다음 각호의 1 에 해당하는 때에는 신기술의 지정을 취소할 수 있다. 다만, 제 1 호에 해당하는 때에는 신기술의 지정을 취소하여야 한다.

1. 사위 기타 부정한 방법에 의하여 신기술의 지정을 받은 때

2. 제 22 조의 규정에 의한 지정기준에 미달하게 된 때 [본조신설 99.1.21]

제 23 조 (유통구조의 개선) 정부는 소프트웨어등 정보통신관련제품의 유통구조 개선을 도모하기 위하여 유통시설확충, 유통업체의 전문화등의 사업을 지원할 수 있다.

제 24 조 (정보화촉진등의 국제협력 촉진) ① 정부는 정보화에 관한 국제적 동향을 파악하고 국제협력을 촉진하여야 한다.

② 정부는 정보화촉진등에 관한 국제협력을 추진하기 위하여 관련기술 및 인력의 국제교류와 국제표준화 및 국제공동연구개발 등의 사업을 지원할 수 있다.

③ 정부는 정보화와 관련된 민간부문에서의 국제협력을 지원할 수 있다. [전문개정 99.1.21]

제 25 조 (정보통신관련기관의 지원등) 정보통신부장관은 다음 각호의 업무를 수행하고 있는 정보통신관련기관 및 단체에 대하여 정보통신부령이 정하는 바에 따라 그 업무수행에 소요되는 비용을 지원할 수 있다.

1. 정보통신관련 조사 · 통계

2. 정보통신관련 기술의 개발

3. 정보통신관련 전문인력의 양성

4. 정보통신관련 정책의 조사연구

5. 정보통신관련 표준의 연구 · 개발 및 보급

6. 정보통신관련 대외협력

7. 기타 정보통신산업의 기반조성을 위하여 필요한 업무

제 4 장 정보통신기반의 고도화

제 26 조 (초고속정보통신기반의 구축촉진 및 이용활성화) 정부는 기본계획에 따라 초고속정보통신기반을 조기에 구축하고, 공공 및 민간분야에서의 이용을 활성화할 수 있도록 필요한 시책을 강구하여야 한다.

제 27 조 (전담기관의 지정등) ① 정보통신부장관은 초고속정보통신기반의 원활한 구축과 이용촉진을 위하여 필요한 때에는 홍보, 국제협력, 기술개발등 그 업무를 전담할 기관(이하 "전담기관"이라 한다)을 분야별로 지정할 수 있다.

② 정보통신부장관은 초고속정보통신기반의 구축 및 이용촉진과 관련된 업무를 수행하는데 소요되는 자금을 제 33 조의 규정에 의한 정보화촉진기금에서 전담기관에 출연하거나 융자등을 할 수 있다.

③ 전담기관은 제 2 항의 규정에 의한 자금을 별도로 관리하여야 한다.

④ 전담기관의 지정 및 운영등에 관하여 필요한 사항은 정보통신부령으로 정한다.

제 28 조 (초고속국가망의 관리등) ① 정보통신부장관은 국가재정으로 공공기관과 대통영령이 정하는 비영리기관(이하 "비영리기관등"이라 한다)이 이용하는 초고속정보통신망(이하 "초고속국가망"이라 한다)을 구축 · 관리하거나 제 27 조의 규정에 의하여 지정된 전담기관으로 하여금 구축 · 관리하게 할 수 있다.

② 정보통신부장관은 비영리기관등이 초고속국가망을 최소의 비용으로 이용할 수 있도록 필요한 시책을 강구하여야 한다.

③ 초고속국가망의 구축 · 관리에 관하여 필요한 사항은 대통령령으로 정한다.

제 29 조 (정보통신망의 상호연동 등) ① 정부는 국가기관 및 지방자치단체가 구축한 정보통신망의 효율적인 운영과 정보의 공동활용을 촉진하기 위하여 정보통신망간 상호연동에 필요한 시책을 강구하여야 한다.

② 국가기관 및 지방자치단체가 정보통신망을 구축 · 운영하고자 하는 경우에는 다른 기관의 정보통신망을 공동활용하는 방안을 우선적으로 강구하여야 한다. [전문개정 99.1.21]

제 30 조 및 제 31 조 삭제 <99.1.21>

제 32 조 (초고속정보통신망확충을 위한 협조등) ① 정부는 초고속정보통신망의 원활한 확충을 위하여 관로 · 공동구 · 전주등(이하 "관로등"이라 한다)의 시설의 효율적 확충 · 관리에 필요한 시책을 강구하여야 한다.

② 전기통신기본법 제 7 조의 규정에 의한 기간통신사업자, 유선방송관리법에 의한 유선방송사업자 및 종합유선방송법에 의한 종합유선방송사업자(이하 이 조에서 "기간통신사업자등"이라 한다)는 도로, 철도, 지하철도, 상 · 하수도, 전기설비, 전기통신회선설비 등을 건설 · 운용 · 관리하는 기관의 장에 대하여 필요한 비용부담을 조건으로 전기통신 선로설비(유선방송관리법에 의한 유선방송시설 및 종합유선방송법에 의한 전송선로시설을 포함한다)의 설치를 위한 관로등의 건설 또는 대여를 요청할 수 있다. <개정 99.1.21>

③ 기간통신사업자등은 제 2 항의 기관과 관로등의 건설 또는 대여에 관한 합의가 이루어지지 아니할 경우 정보통신부장관에게 조정을 요청할 수 있다. <개정 99.1.21>

④ 정보통신부장관은 제 3 항의 규정에 의한 조정요청을 받아 조정을 할 경우 관계 중앙행정기관의 장과 사전에 협의하여야 한다. <개정 99.1.21>

⑤ 제 2 항 내지 제 4 항의 규정에 의한 건설 또는 대여의 요청 및 합의와 조정에 관하여 필요한 사항은 대통령령으로 정한다.

제 5 장 정보화촉진기금

제 33 조 (정보화촉진기금의 설치) 정부는 정보화촉진등을 지원하기 위하여 정보화촉진기금(이하 "기금"이라 한다)을 설치한다.

제 34 조 (기금의 재원과 용도) ① 기금은 다음 각호의 재원으로 조성한다. <개정 99.1.21, 2000.1.21>

1. 정부의 출연금 또는 융자금

2. 전기통신기본법 제 7 조의 규정에 의한 기간통신사업자 및 정부외의 자의 출연금

3. 정부가 소유하는 한국전기통신공사 주식의 배당금의 일부 또는 전부

3 의 2. 전파법 제 11 조제 2 항의 규정에 의한 주파수할당대금 및 동법 제 17 조제 2 항의 규정에 의하여 산정된 금액

4. 기금운용등에 따른 수익금

5. 차입금 기타 수입금

② 기금은 기본계획에 따라 시행되는 다음 각호의 1 에 해당하는 사업의 지원을 위하여 운용한다. <개정 99.1.21, 2000.1.21>

1. 초고속정보통신기반의 구축 및 이용활성화사업

2. 공공 · 지역 · 산업 · 생활 · 장애인을 포함한 사회적 약자의 복지등 각 분야의 정보화촉진사업

3. 정보통신에 관한 연구개발사업

3 의 2. 전파방송의 연구개발 및 지원사업

4. 정보통신관련 표준의 개발 · 제정 및 보급사업

5. 정보통신기술인력의 양성사업

6. 제 1 호 내지 제 5 호에 규정된 사업의 부대사업

7. 기타 정보화촉진등을 위하여 위원회에서 필요하다고 인정한 사업

제 35 조 (기금의 운용 · 관리) ① 기금은 정보통신부장관이 운용 · 관리한다.

② 정보통신부장관은 대통령령이 정하는 바에 따라 기금의 운용관리에 관한 사무의 일부를 정보통신 연구개발업무와 관련된 기관 또는 단체에 위탁할 수 있다.

③ 정보통신부장관은 정보통신 연구개발에 충당하기 위하여 기금에 별도의 계정을 설치 · 운용할 수 있다.

④ 기타 기금의 운용 및 관리에 필요한 사항은 대통령령으로 정한다.

제 35 조의 2 (정보통신연구진흥원의 설립 등) ① 정보통신연구개발사업을 효율적으로 지원하기 위하여 정보통신연구진흥원(이하 "연구진흥원"이라 한다)을 설립한다.

② 연구진흥원은 다음 각호의 사업을 한다.

1. 제 35 조제 2 항의 규정에 의하여 정보통신부장관이 위탁하는 기금의 운영 · 관리

2. 정보통신연구개발 수요조사 · 기술예측 및 연구기획

3. 정보통신연구개발사업에 대한 평가 · 관리

4. 기타 정보통신연구개발사업과 관련하여 대통령령이 정하는 사업

③ 정부는 연구진흥원의 설립 및 운영에 필요한 경비를 예산의 범위안에서 출연할 수 있다.

④ 제 10 조제 2 항 · 제 6 항 및 제 7 항의 규정은 연구진흥원에 관하여 이를 준용한다. 이 경우 "한국전산원"은 "정보통신연구진흥원"으로, "전산원"은 "연구진흥원"으로 본다. [본조신설 99.1.21]

제 6 장 보칙

제 36 조 (권한의 위임) 이 법에 의한 정보통신부장관의 권한은 그 일부를 대통령령이 정하는 바에 의하여 정보통신부의 소속기관의 장 또는 지방자치단체의 장등에게 위임할 수 있다.

제 37 조 (과태료) 제 10 조제 7 항(제 14 조의 2 제 3 항 및 제 35 조의 2 제 4 항에서 준용되는 경우를 포함한다)의 규정에 위반한 자는 500 만원이하의 과태료에 처한다. [본조신설 99.1.21]

부칙

제 1 조 (시행일) 이 법은 1996 년 1 월 1 일부터 시행한다.

제 2 조 (다른 법률의 폐지) 정보통신연구 · 개발에관한법률은 이를 폐지한다.

제 3 조 (경과조치) 이 법 시행으로 폐지하는 정보통신연구 · 개발에관한법률의 규정에 의한 정보통신진흥기금에 속하는 자산과 채권채무 기타의 권리 · 의무는 이 법에 의한 정보화촉진기금이 이를 승계한다.

제 4 조 (다른 법률의 개정) ① 기금관리기본법중 다음과 같이 개정한다. 별표중 제 28 호를 다음과 같이 한다.

28. 정보화촉진기본법

② 전산망보급확장과이용촉진에관한법률중 다음과 같이 개정한다. 제 4 조제 3 항중 "제 6 조의 규정에 의한 전산망조정위원회의 조정을"을 정보화촉진기본법 제 8 조의 규정에 의한 정보화추진위원회의 심의를"로 한다. 제 5 조 내지 제 7 조를 삭제한다.

제 5 조 (다른 법령과의 관계) 이 법 시행당시 다른 법령에서 종전의 정보통신연구 · 개발에관한법률의 규정을 인용하고 있는 경우에 이 법중 그에 해당하는 내용에 대한 규정이 있는 때에는 종전의 규정에 갈음하여 이 법 또는 이 법의 해당 규정을 인용한 것으로 본다.

부칙 <99.1.21>

제 1 조 (시행일) 이 법은 1999 년 7 월 1 일부터 시행한다. 다만, 제 10 조, 제 35 조의 2 및 부칙 제 2 조 내지 제 6 조의 개정규정은 공포한 날부터 시행한다.

제 2 조 (한국전산원의 설립근거 변경에 따른 경과조치) 부칙 제 1 조 단서의 개정규정의 시행당시 전산망보급확장과이용촉진에관한법률 제 13 조의 규정에 의하여 설립된 한국전산원은 이 법에 의하여 설립된 것으로 본다.

제 3 조 (한국정보문화센터에 관한 경과조치) ① 부칙 제 1 조 단서의 개정규정의 시행당시 전산망보급확장과이용촉진에관한법률 제 19 조의 2 의 규정에 의한 한국정보문화센터(이하 "정보센터"라 한다)는 민법중 법인의 해산 및 청산에 관한 규정에 불구하고 부칙 제 1 조 단서의 개정규정의 시행일에 해산된 것으로 본다.

② 부칙 제 1 조 단서의 개정규정의 시행당시 정보센터에 속하였던 모든 재산과 권리 · 의무는 이 법에 의한 전산원이 승계한다.

③ 부칙 제 1 조 단서의 개정규정의 시행당시 등기부 기타 공부에 표시된 정보센터의 명의는 전산원의 명의로 본다.

④ 제 2 항의 규정에 의하여 전산원에 승계되는 재산의 가액은 부칙 제 1 조 단서의 개정규정의 시행일 전일의 장부가액으로 한다.

⑤ 부칙 제 1 조 단서의 개정규정의 시행일전에 정보센터가 행한 행위 또는 정보센터에 대하여 행하여진 행위는 전산원이 행하거나 전산원에 대하여 행하여진 행위로 본다.

⑥ 부칙 제 1 조 단서의 개정규정의 시행당시 정보센터의 직원은 전산원의 직원으로 본다.

제 4 조 (연구진흥원의 설립준비) ① 정보통신부장관은 부칙 제 1 조 단서의 개정규정의 시행일전에 5 인이내의 설립위원을 위촉하여 연구진흥원의 설립을 위한 준비행위를할 수 있다.

② 설립위원은 연구진흥원의 정관을 작성하여 정보통신부장관의 인가를 받아야 한다.

③ 설립당시의 연구진흥원의 원장은 정보통신부장관이 임명한다.

④ 설립위원은 제 2 항의 규정에 의하여 정관에 대한 정보통신부장관의 인가를 받은 때에는 지체없이 연구진흥원의 설립등기를 하여야 한다.

⑤ 설립위원은 제 4 항의 규정에 의한 연구진흥원의 설립등기를 한 후에는 지체없이 연구진흥원의 원장에게 사무를 인계하여야 하며, 사무인계가 끝난 때에는 해촉된 것으로 본다.

제 5 조 (한국전자통신연구원의 권리 · 의무 승계 등) ① 전기통신기본법 제 15 조의 2 의 규정에 의한 한국전자통신연구원(이하 "연구원"이라 한다)의 재산과 권리 · 의무중 정보통신부장관이 정하는 재산과 권리 · 의무는 연구원의 이사회의 의결을 거쳐 연구진흥원의 설립등기와 동시에 연구진흥원이 포괄 승계한다.

② 제 1 항의 규정에 의하여 연구진흥원에 승계되는 재산의 가액은 연구진흥원의 설립등기일 전일의 장부가액으로 한다.

③ 부칙 제 1 조 단서의 개정규정의 시행당시 연구원에서 정보통신연구개발관리업무를 수행하는 직원은 연구진흥원의 직원으로 본다.

제 6 조 (다른 법률의 개정) 전산망보급확장과이용촉진에관한법률중 다음과 같이 개정한다.
제 13 조 및 제 19 조의 2 를 각각 삭제한다.

부칙 <2000.1.21>

제 1 조 (시행일) 이 법은 2000 년 4 월 1 일부터 시행한다.

제 2 조 내지 제 10 조 생략

부칙 <2001.1.16>

제 1 조 (시행일) 이 법은 2001 년 7 월 1 일부터 시행한다.

제 2 조 내지 제 6 조 생략

Appenix II

모라 중학교 2학년 과학 (단원 III) 지구와 별

반 번 조	이름:

1. 지구가 둥글다는 증거를 4 개 이상 들어 보자.

(Write more than four examples of the evidence that the earth is round)

a.

b.

c.

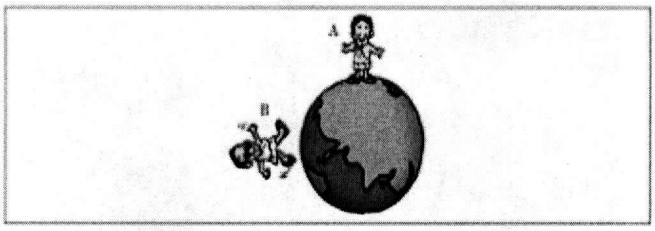
d.

2. 다음 그림은 옛날 사람들이 지구가 어떻게 생겼는가에 대한 추측을 한 그림이다. 여기서 옛날 사람들은 무슨 힘을 깨닫지 못하였다고 생각되는가? (Ancient people assumed that the earth is flat not round, because those people who live on opposite sides can not stand erectly. What force didn't they know?)

a. 탄성력 (elastic force) b. 마찰력 (frictional force)

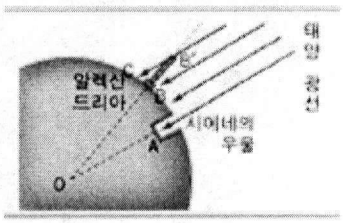
c. 자기력 (magnetic force) d. 전기력 (electric force)

e 중력 (gravity)



3. 같은 시각에 다른 장소에서 밤하늘의 별을 보면 별 자리가 다른 이유는 무엇 때문이라고 생각되는가? (If we observe constellations at night, we have different constellations from different places even though the time is the same. What is the reason?)

4. 에라토스테네스가 지구의 반지름을 측정하는 모형을 나타낸 그림이다.



(a model to measure the radius of the earth based on Eratosthenes' model)

a. 이 측정을 하기 위한 가정은 무엇인가?

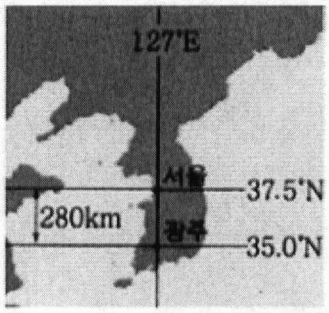
(What are presumptions to this model?)

b. 어느 값을 측정하여야 하는가? (What values do we have to measure?

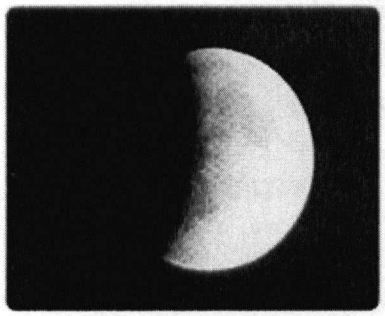
5. 다음은 같은 경도 상에 있는 서울과 광주의 위도는 각각 북위 37.5, 35.0 이다. 서울에서 광주가지의 직선거리는 약 280 km 이다. 이 값을 이용하여 지구의 반지름 (km)을 구하여라.

(Seoul and Kwangjoo are located at the same longitude. Seoul's latitude is 37.5 and

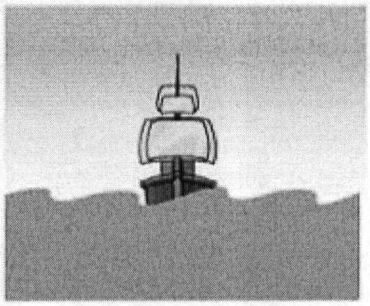
Kwangjoo's latitude is 35.0. The distance between these two cities is 280 km. Calculate the radius of the earth.)



6. 이 두 그림에서 알 수 있는 사실은? (What fact can you find related to the earth shape from below two pictures?)



월식 때 달에 비친 그림자



항구로 들어오는 배의 모습

APPENDIX III: PRE-QUESTIONNAIRE

◈ IT SHOULD TAKE YOU ABOUT 15 MINUTES TO COMPLETE THIS QUESTIONNAIRE.

◈ No identifying mark(s) should be placed on this questionnaire, so that your privacy can be assured.

◈ For each of the following items, mark the answer on OMR card.

◈ In this questionnaire we want to find out your previous year's achievement in science, and your opinions about science. Please answer the questions and let us know what you think of science. There are no right or wrong answers, so just mark the number that comes closest to what you think. Please answer all items.

1 Do you have a computer in your house?
① yes ② no

2. Is your house computer available the Internet?
① yes ② no

3. What is your gender?
① boy ② girl

4. What is your favorite subject?
① Art areas (for example, Music, Drawing, or Physical Exercise)
② Social Study
③ Language (Korean or English)
④ Mathematics
⑤ Science

5. My mark in science last year was:
① lower than 59%
② between 60~69%
③ between 70~79%
④ between 80~ 89%
⑤ higher than 90%

6. Why do you prefer this subject over other subjects?
① High achievement
② Related to future careers
③ Usefulness of contents in everyday life
④ Teaching method is good (teachers)
⑤ Learning environment is good. (for example, lab-activity, or equipments (cassette recorder, video camera, or experiment…)
⑥ Personal reasons: (write personal reasons on the back of OMR card)

7. I like to read science magazines.
① strongly disagree
② disagree
③ neutral

④ agree
⑤ strongly agree

8. I want to learn science mainly because it helps me to understand the world in which I live.
① strongly disagree
② disagree
③ neutral
④ agree
⑤ strongly agree

9. I tend to do my science homework very carefully and thoroughly.
① strongly disagree
② disagree
③ neutral
④ agree
⑤ strongly agree

10. Science is a very important and useful subject.
① strongly disagree
② disagree
③ neutral
④ agree
⑤ strongly agree

11. Do you agree with the following statement?
Scientists can bring information, insights, and analytical skills to matters of public concern and help people understand the possible causes and effects of events.
① strongly disagree
② disagree
③ neutral
④ agree
⑤ strongly agree

12. Do you agree with the following statement?
Nowadays the development of science causes the disasters like wars, climate changes, overpopulation, and pollution.
① strongly agree
② agree
③ neutral
④ disagree
⑤ strongly disagree

13. Science and scientists contribute to the development of human society.
    ① strongly disagree
    ② disagree
    ③ neutral
    ④ agree
    ⑤ strongly agree
14. I can usually remember formulas, but I am not sure which formula to use in a particular problem.
    ① Strongly disagree
    ② disagree
    ③ neutral
    ④ agree
    ⑤ strongly agree
15. You have felt a lack of relevance between science classes and scientific principles and everyday life experiences.
    ① strongly disagree
    ② disagree
    ③ neutral
    ④ agree
    ⑤ strongly agree
16. I try to relate what learn in science class to what I learn in other classes.
    ① never
    ② rare cases
    ③ sometimes
    ④ often
    ⑤ very often
17. I want to be a scientist
    ① art
    ② business
    ③ language
    ④ technology
    ⑤ science and math
18. In your choosing a major or a future career, you have seriously considered scientific fields.
    ① strongly disagree
    ② disagree
    ③ neutral
    ④ agree
    ⑤ strongly agree

Thank you for completing the questionnaire. I appreciate your valuable time.

APPENDIX IV: POST-QUESTIONNAIRE

◈ IT SHOULD TAKE YOU ABOUT 30 MINUTES TO COMPLETE THIS QUESTIONNAIRE.
◈ No identifying mark(s) should be placed on this questionnaire, so that your privacy can be assured.
◈ For each of the following items, mark the answer on the OMR card.
In this questionnaire I want to find out how much your achievement has improved in science, and if your opinions about science have changed. Please answer the questions. There are no right or wrong answers, so just mark the number corresponding most closely to what you think.

1. Which range did your previous science score belong to in previous year?
   ① lower than 59%
   ② between 60~69%
   ③ between 70~79%
   ④ between 80~ 89%
   ⑤ higher than 90%

2. Which range does your science score belong to in this term?
   ① lower than 59
   ② between 60~69
   ③ between 70~79
   ④ between 80~ 89
   ⑤ higher than 90

3. Indicate the change in achievement compared to your previous year.
   ① decreased: more than -7 points
   ② decreased: -3~ -6
   ③ nearly the same (+2 ~ -2)
   ④ improved: 3~6
   ⑤ improved: more than 7 points

4. If you improved, why do you think your examination score is improved?
   ① Teacher's explanation was very helpful and interesting.
   ②You studied harder than previous year.
   ③ The contents were easy.
   ④ I think working collaboratively helped me achieve a higher score.
   ⑤ The computer method helped me to understand more science.

5. If your answer in the question 4 is 2, why do you think you study harder than in the previous year?
   ① Outer push such as parents, or teacher

② You think that the contents were interesting and relevant than previous ones.
③ Competition with my group members makes me study harder.
④ Using computer programs in classes encouraged your motivation.
⑤ no special reasons or different from above (Please write the reasons on the backside of the OMR card)

6. Which of these is most helpful for your understanding?
① The Internet provides a variety of information.
② Manipulating a computer simulation was interesting.
③ The dynamic graphics which the computer provides are helpful for understanding the content.
④ You can study the same contents again and again until you can understand thoroughly.
⑤ no special reasons or different above
(Please write the reasons on the backside of the OMR card)

7. If your achievement has declined, why do you think the score is lower than previous year?
① Teachers' explanation was not enough and I could not understand the contents.
② I didn't study hard.
③ Computer simulation was not helpful or relevant for understanding the contents.
④ The contents were difficult to understand.
⑤ I was distracted by my group members.

8. If your answer in question 7 is 2, why do you think you study less than previous year?
① You are not accustomed to the different instructional style like using computers, 10or group studying.
② Computer programs and searching information were difficult.
③ Disagreement of group members
④ The contents were difficult.
⑤ no special reasons or different reasons above
(Please write the reasons on the backside of the OMR card)

9. If your answer in question 9 is 3, which point was not helpful or prevented for your understanding?
① You didn't know how to operate the programs.
② The computer programs were uninteresting or badly organized.
③ When you worked with computers, you had difficulties in cooperating with your group members.
④ Lack of time (when you use computer, you usually need more time than lecture-based class)
⑤ no special reasons or different reasons above (Please write the reasons on the backside of the OMR card)

10. Science is for special person not for me.

① strongly agree
② agree
③ neutral
④ disagree
⑤ strongly disagree

11. I usually watch TV program related science quiz or documentary.
① Strongly disagree
② disagree
③ neutral
④ agree
⑤ strongly agree

12. I have an interest in science as a school subject.
① strongly agree
② agree
③ neutral
④ disagree
⑤ strongly disagree

13. I tend to do my science homework very carefully and thoroughly.
① strongly disagree
② disagree
③ neutral
④ agree
⑤ strongly agree

14. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.
① strongly disagree
② disagree
③ neutral
④ agree
⑤ strongly agree

15. The benefits of science are greater than the harmful effects it could have.
① strongly disagree
② disagree
③ neutral
④ agree
⑤ strongly agree

16. Do you agree with the following statement?
Nowadays the development of science causes the disasters like wars, climate changes,

overpopulation, and pollution.

① strongly agree
② agree
③ neutral
④ disagree
⑤ strongly disagree

17. I have some experiences in using science principles to solve problems in everyday life

① strongly disagree
② disagree
③ neutral
④ agree
⑤ strongly agree

18. I can usually remember formulas, but I am not sure which formula to use in a particular problem.

① Strongly disagree
② disagree
③ neutral
④ agree
⑤ strongly agree

19. Electronics are examples of the really valuable products of science.

① strongly disagree
② disagree
③ neutral
④ agree
⑤ strongly agree

21. Understanding science is critical to success in my future career.

① never
② rare
③ sometimes
④ usually
⑤ often

22. I hope to get a good job in a science-related area

① strongly disagree
② disagree
③ neutral
④ agree
⑤ strongly agree

23. Do you have difficulties in searching for information on the Internet?
    ① strongly disagree
    ② disagree
    ③ neutral
    ④ agree
    ⑤ strongly agree

24. I was able to satisfactorily manipulate the computer simulation.
    ① strongly disagree.
    ② disagree
    ③ neutral
    ④ agree
    ⑤ strongly agree

25. What did you consider to be the good points in using computer assisted science classes?

26. What difficulties or bad points did you experience in using computer assisted science classes?

Thank you for completing the questionnaire. I appreciate your valuable time.

Appendix V Analysis of Participants Comments

1. Students' Reasons for Improvement in Astronomy Unit (N=116)

group	teacher's explanation	parents' push	Content interesting and easy to understand	competition with fellow students	CAI	total number of student responses
I	5	2	4	13	20	44
II	2	1	1	5	7	16
III	2	2	2	5	7	18
IV	2	2	4	5	6	19
V	0	0	1	1	6	8
total	11	7	12	29	46	105

2. Students' Reasons for Deterioration in Achievement at the end of the Astronomy Unit (N=76)

group	lack of teacher's explanation	disagreement among group members	difficulty of content	CAI was not interesting	not response	total number of student responses
I	1	3	14	0	1	18
II	1	0	7	0	1	8
III	0	1	5	0	2	6
IV	1	2	5	3	2	11
V	1	4	14	3	3	22 [1]
total	4	10	45	6	9	65

[1]: 2 students responded that it was difficult for them to adapt to the new ways of learning

3. What was an effective tool for understanding astronomical phenomena and concepts by using computers?
(those students who improved in the post test N=116)

group	Internet	simulation	manipulation	repetition	total number of student responses
I	15	6	13	10	44
II	5	3	5	3	16
III	1	4	3	10	17
IV	4	3	5	6	18
V	1	1	3	3	8
total	26	17	29	32	103

APPENDIX VII: PARENT CONSENT FORM AND STUDENT ASSENT FORM

THE UNIVERSITY OF BRITISH COLUMBIA

Department of Curriculum Studies
2125 Main Mall
Vancouver, B.C. Canada V6T 1Z4
Tel: (604) 822-5422 Fax:(604) 822-4714

LETTER OF INVITATION AND INFORMATION

Dear Student and Parent or Guardian,

You are invited to participate in a research study that is the effectiveness of computer-assisted science instruction. The study is entitled *Achievement, Attitudes and Technological Literacy: An Investigation of Korean Middle School Students and Computer-Assisted Science Instruction.* Since your son/daughter is a student in a class that is adopting computer-assisted instructional studies, he/she is invited to participate in the study. The research will be conducted by Dr. Stephen Petrina as a Principal investigator and Ms. HyeRan Park, as a co-investigator who is undertaking this study as part of her Master thesis.

The aim of this letter is twofold. First, it will describe the purpose and method of the research study. Second, it will request that you agree, in writing, to participate in the study. Please indicate your decision to participate in the study on the attached *Consent Form* and return it to us before September 1st, 2005.

The purpose of this research is to investigate the effectiveness of computer assisted instruction (CAI) in achievement, attitude toward science, and future course or career aspirations. Pre- and post-questionnaires will be conducted for 15 minutes (pre-questionnaire) and 30 minutes (post-questionnaire) each. The items of questionnaires include: participants' demographics (gender, household computers and Internet connectivity), achievement scores in science, attitude toward science, gaps between science classes and everyday life, and future course or career aspirations. This study will be conducted during regular class time and whether or not students participate in this study they receive the same instruction, including testing, from their science teacher. Those students who are not participating in the study will be given alternative or enrichment activities at their teacher's direction during the time that participating students are engaged with pre- and post-questionnaires. In addition there are no consequences or disadvantages for those students who do not participate in the study.

Results of this research will be published in professional journals and reported them at conferences. As the result from this study will be statistical, at no time will the actual identity of

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Student Assent

Your participation in this study is entirely voluntary and you may refuse to participate, or withdraw from the study at any time without any consequence to your class standing.

Your signature below indicates that you have received a copy of this assent form for your own records, and that you are willing to participate in this part of the study.

Signature date Please print your name here