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RESEARCH REPORT

ICT in Science Education: A quasi-experimental study of achievement, attitudes toward science, and career aspirations of Korean middle school students

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The Seventh School Curriculum Reform in Korea was introduced in 2000 to prepare school-aged Koreans for an information and knowledge-based society. The reform effort emphasises information and communication technology (ICT) in the K–12 curriculum and a learner-centred pedagogy. This study examines the contributions of ICT, specifically, computer-assisted instruction (CAI), in Korean science classrooms. A sample of 234 Korean middle school students was categorised into five achievement groups. Data were collected from pre- and post-achievement test scores and pre- and post-questionnaires for attitudes toward science, future courses, and career aspirations in science. Findings include: (1) the lowest achievement group showed the most significant improvement after CAI (p=.000); (2) an improvement in student achievement in science significantly influenced students' attitudes toward science (p=.019), future course selections, and career aspirations related to science (p=.000); and (3) boys tended to perform better with CAI than girls. This research provides evidence that CAI has the potential to help lower achieving students in Korean science classes and may encourage enrolment in science.

Introduction

Demographic, economic, political, social and technological changes are challenging educators to reform curriculum and instruction (Hargreaves, 2003; Notar, Friery & Wilson, 2002). For example, workplaces in most Asian and North American countries are increasingly information-based, challenging educators to rethink what

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is 'basic' for numeracy and scientific and technological literacy (Notar et al., 2002). Without basic numeracy and scientific and technological literacy, students may struggle in today's labour market and with civic participation (Frantom, Green & Hoffman, 2002; Hargreaves, 2003).

Changes in and the economy account for many of the reforms in Korea's educational system (Ministry of Education and Human Resources Development (MOE & HRD), 2000). For Korea's MOE & HRD (2000), adapting education to a knowledge and information age is integral to the country's national competitiveness. As suggested in a national motto, 'Korea, a Country Strong in Science and Technology', the challenge is to cultivate human resources with the creativity and individuality required for a globally competitive society. Hence, Korea's MOE & HRD have endeavoured to transform the built school environment into a technology-enhanced learning environment, equipping K–12 classrooms with hardware such as computers, high-speed Internet connections and wide screen televisions. In addition, a new curriculum has been introduced to be enacted within this environment. Korea's Seventh Curriculum Reformation commenced in the year 2000 for elementary schools and in the year 2001 for middle schools. The Seventh Curriculum stresses information and communication technology (ICT) literacy and requires teachers to use ICT in at least 10% of their class activities.

The development of Korean educational software and its deployment in schools, however, has yet to be sufficiently realised (Lee, 2002; Lee et al., 2001; Noh, Cha & Kim, 1999) to keep pace with new curricular mandates. Furthermore, the quality of existing Korean educational software, scepticism regarding the effectiveness of ICT, and questions regarding how to adopt ICT in a science classroom have dissuaded Korean teachers from utilising ICT to any great degree (Kim, Yoon, & Kim, 2003; Lee et al., 2001). Without further research and dissemination on the effectiveness of ICT in Korean contexts and examples of computer-assisted instruction that are plausible for Korean science teachers, the curricular mandate may be a challenge for teachers to reach.

This study investigates the integration of ICT in a Korean science classroom. Specifically, we examined: (a) the contribution of ICT (otherwise referred to as computer-assisted instruction (CAI)) to three science outcomes among a sample of Korean middle school students; (b) the effects of CAI among different achievement levels of these students; and (c) gender differences associated with CAI. The three outcomes referred to measured changes in students' (1) achievement; (2) attitudes towards science; and (3) choices of future courses and career aspirations before and after CAI in science. The next sections elaborate on the Korean context of the study, the theorised role of ICT in promoting conceptual change in science, and select literature on CAIs contribution to student achievement, attitudes, and career aspirations in science.

Korean Context

The Seventh Curriculum Reform is intended to be a benchmark reflecting a national movement towards modernisation (MOE & HRD, 2000, 2001). This movement has lead to 'computers' being an official subject and the aforementioned 10% use of ICT in Korean classroom activities mandate. Since the 1960s, the Korean government has emphasised industrialisation and modernisation. However, since that time, growing concerns of the lack of student creativity and flexibility (Kim, 2003), unequal distribution of educational opportunities depending on social economic status (SES) (Kang et al., 2004; Kim, 2005; Yang, 2006), and students' avoidance of majoring in science and technology (Cho, Lee & Park, 2003; Jeon, 2004; Park et al., 2004), have led to a re-examination of the goals in education and the curriculum.

Like other countries, Korea currently is experiencing an ever-widening gap between high and low achieving students with different SES, as suggested by the OECD Programme for International Student Assessment (PISA) in mathematics and science and others (Kang et al., 2004; Kim, 2005; Yang, 2006). Kim (2005) explored the relationship between students' scholastic aptitude test (SAT) scores in Korea and family income and found that there was a 30 point (out of 400) difference on average between high and low income families. SAT scores are decisive factors for matriculation to upper stages of education in Korea and, in large effect, are considered the determining factor in one's future occupation. Kim notes that SAT scores, however, reflect family backgrounds rather than aptitudes. Trends to avoid majoring in science or occupations related to science or technology are becoming noticeable in Korea (Cho et al., 2003; Jeon, 2004; Park et al., 2004; Yeo, 2000). As a prerequisite subject for entry into most of the high status professions, science is unattractive not only for low achieving students, but for some high achieving students as well. Like other countries, Korea also has challenges in attracting students into science and encouraging low achieving students to consider science careers.

Consistent with research in other countries, in Korea, gender differences in achievement have also been documented in science classrooms (Jang, Kim & Ryu, 2005; Kim, 2001; Noh, Kang & Jeon, 2004) as well as attitudes toward professional science careers (Choi et al., 2003; Oh & Sin, 2005). Jang et al. (2005) investigated 220 middle school students in Korea in terms of their understanding of science concepts and how they apply such concepts to problems. In their study, they found that boys were better in applying science concepts. One hypothesis is that gender-biased contexts and systematic aspects in favour of boys produce differences in the selection of courses and occupations (Preece et al., 1999; Choi et al., 2003). The research conducted by Choi et al. (2003) investigated why the proportion of Korean girls taking science courses in high school has gradually declined since 1997. According to their interpretation of this phenomenon, when the economic situation in Korea declined in 1997, women had fewer chances to find work in scientific areas than men. Korean women occupy less than 10% of the job markets in science and engineering (Ministry of Commerce, Industry and Energy & Korean Industrial Technology Foundation, 2004).

Korean curriculum developers and science instructors are faced with the following challenges:

1. how to satisfy the demands of a society in transition towards a knowledge-based society;

2. how to adjust to new paedagogical perspectives regarding CAI;
3. how to encourage all students to engage in learning activities that will promote their full participation in a knowledge-based society; and
4. how to provide and realise equal educational experiences in terms of equitable distribution of educational resources for all Korean students (MOE & HRD, 2000; Park et al., 2004; Oh & Sin, 2005; Yang, 2006).

This study aims to contribute to the growing body of knowledge on these challenges with a statistical analysis of the potential outcomes of integrating CAI in Korean science classrooms.

Conceptual Underpinnings

The Role of ICT in Promoting Conceptual Change in Science

Science courses have been criticised for failing to engage students in the kinds of experiences they encounter in information and knowledge-based societies such as the critical interpretation of persuasive messages in advertisements, searching for reliable information on the Internet, or finding answers to everyday problems (Baggott La Velle, McFarlane & Brawn, 2003; Cha, Lee & Noh, 2005; Lee, 2002; Linn, Davis, & Bell, 2004). Students' lack of engagement in science in school may translate into an unwillingness to take science courses beyond high school or pursue scientific careers (Baggott La Velle et al., 2003; Choi, et al., 2003; Jeon, 2004; Park, et al., 2004; Yeo, 2000). Indeed, in Korea, the number of students who want to major in science and technology areas has decreased from 42.4% in 1998 to 26.9% in 2002 (Park, 2002). In order to address this disinterest in science careers, science educators and educational policy makers in Korea are trying to find ways to encourage less motivated students to engage in science learning activities and increase the low levels of enrolment.

Both constructivism and CAI have been helpful resources to educators. Constructivists generally adopt an epistemological standpoint that knowledge is not received, accumulated and stored, but instead acquired through a process that involves active interaction of learners with their physical and social environment and a constant reorganisation of mental concepts and structures (Cobb, 1994; Driver, Asoko, Leach, Mortimer & Scott, 1994; Lin & Hsieh, 2001). Erickson (2001) notes that constructivism has been helpful, and perhaps most notably in recognising that 'all learners, even very young children, are capable of constructing plausible conceptions while engaging with their physical and social worlds' (p. 7). Similarly, conceptual change theory (Hewson & Hewson, 1984; Posner, Strike, Hewson, & Gertzog, 1982) suggests that changes can be fostered when a new conception is intelligible and plausible. Posner et al. (1982) listed four conditions for students' adoption of new concepts:

1. there must be dissatisfaction with existing concepts;
2. a new conception must be intelligible;
3. a new conception must appear initially plausible; and
4. a new concept should be fruitful.

A practical way to foster conceptual change in science education is to provide students with opportunities to experience scientific phenomena through laboratory activities and to link scientific concepts to everyday life. Korea's MOE (2000, 2001) encourages science teachers to carry out experimental lab activities with small groups to help students construct their knowledge and enhance their understanding of science concepts. When students operate and manipulate experimental equipment, observe changes and take measurements, as well as negotiate and discuss with peers while they carry out lab activities, they are not simply listeners any more. They are active participants in their learning environments. This image of learning science through laboratory investigations is promoted in Korea.

The image extends to the integration of ICT, such as computers, in science education. In a large-scale meta-analysis of the effectiveness of CAI in science education (Bayraktar, 2001), it was found that secondary students' achievement in science improved when CAI was used. Webb (2005) and others have suggested that conceptual change can be facilitated with CAI, such as software that contains advanced graphical interfaces and scientific visualisation for understanding micro and macro scale concepts in science such as equilibrium (Kahn, 2008; Kim, Kang, Kwun, Wang, & Noh, 2006; Park, 2002). Computers can generate patterns, animate particles and processes, and display trends that trigger dissatisfaction with a prior concept, support the plausibility of a new idea, and suggest intelligibility and fruitfulness of this idea (Kahn, 2005). The contributions of CAI have had documented positive impacts on students' understanding, including the historically low achieving student (Bang, 2003; Baggott la Velle et al., 2003; Kozma & Wagner, in press), especially if guidance was also provided in conjunction with the ICT.

The relationship between student achievement, CAI, students' attitudes and career aspirations in science is sufficiently complex. In terms of students' attitudes towards science, students' attitudes appear to be positively influenced when they do better in science subjects, but not necessarily due to CAI (Soyibo & Hudson, 2000; Chang, 2002, Cepni et al., 2006). CAI appears to have less of an effect on students' attitudes than achievement in science. In terms of students' career choices, while there appears to be a relationship between student achievement in science and retention in science to careers in the field (Seymour & Hewitt, 1997; Kahn, 2005); it remains less clear about CAIs contribution to students' career aspirations in science. Although the aim of this study is not to produce a causal web consisting of these factors and outcomes, we will posit several hypotheses about some potential connections between CAI in science education and achievement, attitudinal, and career-related outcomes based on the findings.

Methods

Research Design

Time series quasi-experimental research designs can provide information about participants' changes and one reliable picture of achievement before and after an intervention (Gribbons & Herman, 1997). For this study, we carried out a time series quasi-experimental research design to establish baseline data on the contributions of ICT to science education in Korea. Our hope was to contribute baseline data such as this to ongoing research that is qualitative in nature and investigations science education in technology-enhanced classrooms.

234 grade eight middle school students (110 boys and 124 girls) from a school in Korea participated in the study. At the beginning of the study, a pre-questionnaire was administered to all participants to identify their attitudes toward science (A to S) and their choices of future courses and career aspirations (CA). After two and half months of utilising CAI in the science classrooms, a post-achievement test and a post-questionnaire were administered and analysed with descriptive and inferential statistical techniques (i.e., mean, standard deviation, a paired-samples *t*-test, ANOVA). The analysis occurred by achievement groupings and gender.

Study Participants

The participants in the study were one science teacher and her eight science classes. The science teacher had 17 years of teaching experience and was the main facilitator and resource for information in the classroom. The researchers acted as guides for the teacher in conducting CAI, provided the questionnaires, and gave advice on the selection of CAI software and web resources. The researchers and the science teacher discussed how to select CAI software, how much class time be allocated for CAI, how to prevent the students from playing games or making time consuming website searches, and what her role in the class would be, i.e., a supervisor or a facilitator.

The student participants from the science classes were assigned to the school by the district school board because of their geographic proximity to the school. Each of the eight classes had approximately 15 or 16 girls and 18 or19 boys between the ages of 13 and 14. School data revealed that 98% of the students enrolled had computers connected to high speed Internet at home. Also, as part of the official curriculum, the students studied computers since the first year (grade 7) of middle school and by the time of the study, had acquired the skills and proficiencies necessary to use computers.

Characteristics of the CAI Initiative

The participating Korean school in this study had one computer lab with 18 computers for 34 students per class, a projector, and a large television. The school had two science labs in total, one of which had lab benchtops equipped with computers. A single computer was typically shared by two students (in the computer lab) or four students (in the science lab).

Science classes were two hours a week. The study took place over a two-and-a-half-month period. The content of the science class in this study included curriculum units on the movement of the Earth, the Moon, the Solar System, and galaxies. There were 19 blocks of instruction on this unit. In consultation with the science teacher, the researchers selected software and web resources that would support CAI for these topics of study. The standards used for selecting the resources were:

1. Does the resource have provisions for students who are at different stages or levels in the curriculum?
2. Is it possible for the students to manipulate the conditions or variables?
3. Is the content appropriate for students?

An example of the software that met these criteria and was utilised in the CAI initative included: 'Let's look at the universe and the Earth in 3D'. This software garnered an award from a nationwide educational software contest (Busan Institute of Science Education, 2005). Other web resources employed by the teacher were primarily drawn from the Ministry of Education of Busan Province (http://cyber.busan-edu.net), the Korea Science and Culture Foundation (http://scienceall.com), and from the following sites: http://home.hanmir.com/~kng1103/frame1.htm and http://dangun5.com.ne.kr/sol01.htm. Figure 1 shows the interface of one of the Ministry recommended web sites and Figure 2 depicts two activities on this website.

The CAI approach in the science classes followed three general paedagogical steps:

1. the science teacher presented the topic of study and provided a brief lecture on the salient concepts of the unit, utilising the educational software to display major phenomena;

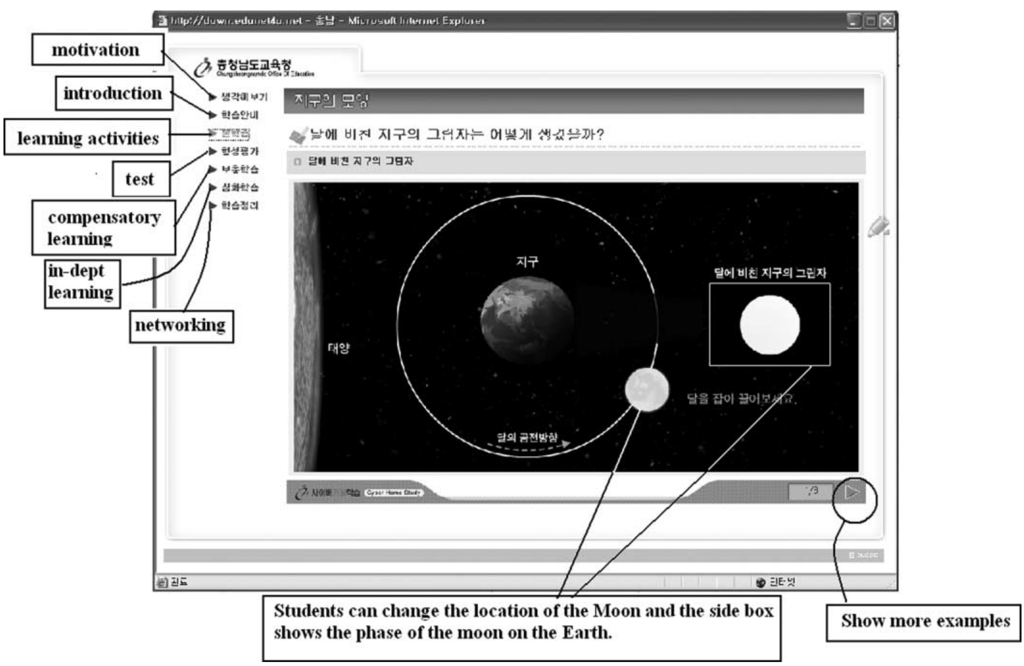
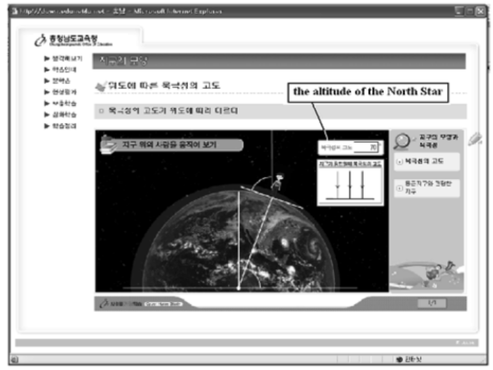


Figure 1. Educational software utilised in study from http://www.edunet4u.net/student6/self/midl/list_2_sci_11_1.jsp?schl=midl&org_cd=SVCZ000001&data_no=20458&seq_no=1&grade=8&subj=08sci



The boat and the rocket are animated and can move around the Earth. The animated boy can travel to the Moon by rocket and appears in the animation to observe that the Earth is in round shape.	Students can change the location of the boy by dragging him along the surface of the Earth and observe the change of the altitude of the North Star.

Figure 2. Two CAI science activities for students on the site

2. the science teacher encouraged the students to solve problems presented by the teacher using the software; and
3. the science teacher provided students with opportunities to express their solutions to the class.

When the science teacher presented the topics and basic concepts, she lectured and used the computer in demonstration mode to display certain relevant phenomena. The next step in her CAI approach was to provide students with problems. The problems tended to be ones that required students to figure out the meaning of a word, locate additional evidence to verify a concept, or locate examples of the concept (See Figure 3 for an example of a teacher handout with a student problem). The students were allowed to search the Internet resources freely or they could use the resources that the teacher presented to them, and they should complete the assigned task within approximately twenty minutes. Cyber Lab software in particular enable students to observe an experiment in astronomy that normally has many constraints (e.g., weather). For example, in one problem, students were asked to measure the earth's radius using Eratosthenes's method. Using the software, students compared places such as Cyrene and Alexandria at first with other places like Seoul and Kwangjoo in Korea (http://www.cyber.busanedu.net) where the longitudes are the same. Similar problems in one topic enabled the students to find general patterns and construct their own knowledge. While changing the variable conditions, students could observe what the differences were, postulate hypotheses, locate relevant examples to support hypotheses, and amend their hypotheses. For

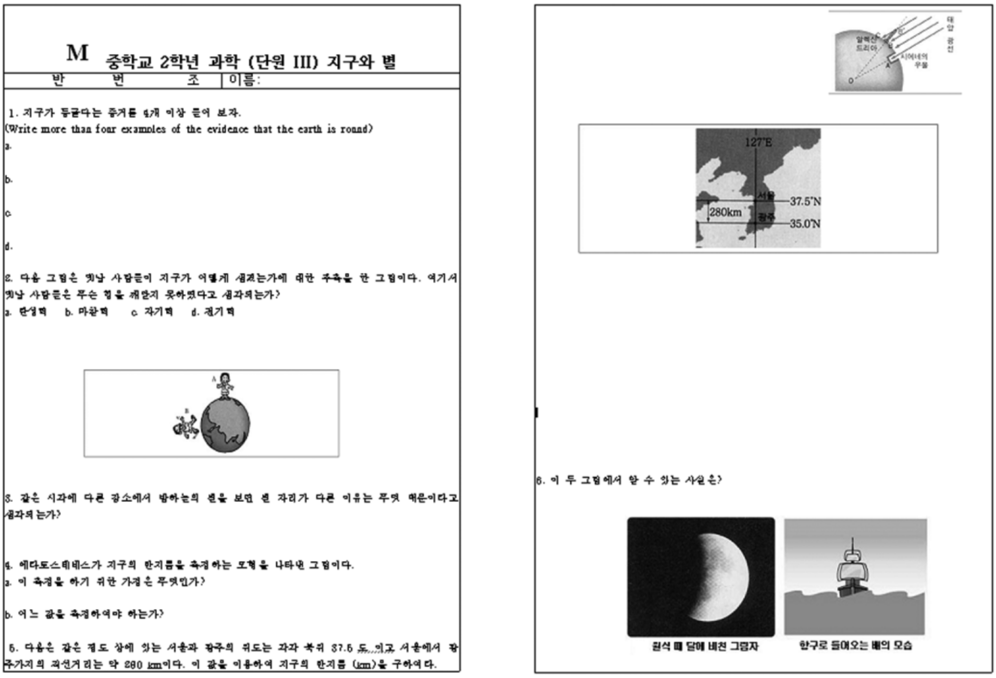


Figure 3. An example of a CAI student hand-out

the final step of CAI, the students presented what they found out through the exploration and shared this information with other students for 15 minutes.

Study Instruments

The instruments were a pre and post questionnaire and a post-achievement test. The pre- and post-questionnaires were designed to gauge students' attitudes toward science (A to S) and career aspiration (CA) using a Likert scale (strongly disagree, disagree, neutral, agree, strongly agree). The questionnaires measured four constructs of A to S (i.e., self-concept in science, science as a school curriculum, science and scientists for society, and science and everyday life) and two constructs of CA (i.e., future course and career selections). Items were drawn from Strike and Posner's (1992), Moore and Foy's (1997), An and Koo's (1996) research on the attitudes towards science for Korean middle school students and the Relevance of Science Education Project (ROSE, n.d.). Example items were 'Science is for a special person and not for me', 'The development of science causes disasters like wars, climate changes, overpopulation, and pollution' and 'I hope to get a good job in a science-related area'.

The post-achievement test consisted of a multiple choice and short answer test on the subject of astronomy. Examples of the questions included the following:

> Write more than four examples of the evidence that the earth is round.

> A model to measure the radius of the earth is shown and students are asked, 'What are the presumptions of this model, what values do we have to measure?'
>
> Seoul and Kwangloo are located at the same longitude. Seoul's latitude is 37.5 degrees and Kwangloo's latitude is 35.0 degrees. The distance between these two cities is 280 km. Calculate the radius of the earth.

The post-achievement test was compared to students' GPA in the previous year (their pre-achievement level). This was considered a reasonable comparison because the previous year's GPA established a baseline to compare future science performance and historically, students' achievement in astronomy was not inflated compared to other curricular units, nor was it a content domain that students' identified as particularly relevant to their future compared to other curricular units such as electricity.

Validity and Reliability of the Instrument

Previous research supported the use of the content in the questionnaire (An & Koo, 1996; Moore & Foy, 1997; ROSE, n.d.; Strike & Posner, 1992). No participants answered using the same Likert number every time or chose one number more than 90% of the time in both pre- and post-questionnaires. Five participants (2.14%) and six participants (2.56%) answered using the same number over 80% in the pre- and post-questionnaires respectively. The Pearson correlation among categorised constructs for attitudes towards science were significant at $\alpha<.001$. A Cronbach alpha reliability coefficient was used to investigate the reliability of the questionnaire. The alpha was .8634 and this value was acceptable conventionally (Howell, 2005; Spatz, 2004). In terms of the post-achievement test, the questions were derived from the teacher's bank of test questions. The teacher in this study had two other science teachers grade the test in order to ensure that grading was accurate.

Statistical Analyses

To analyse the data, the student participants were divided into five different achievement groups according to their grade point average (GPA) for the previous year. The previous year science GPA was the average of four nationwide standardised, mandatory, paper-based tests. Pre-achievement was the term employed in this study to refer to this previous year science GPA. Korean nationwide standards of achievement were used to divide the students into the following groupings: Group I (lower than 59%), Group II (60~69), Group III (70~79), Group IV (80~89) and Group V (90~100).

Paired-samples *t*-tests demonstrated the differences of means in pre- and post-achievement, A to S, and CA. One-way ANOVA was used to analyse the differences in achievement, A to S, and CA among the five different achievement groups. For the differences of the variables before and after CAI among different achievement groups, a repeated measures factorial ANOVA was used. The dependent variables (within-subjects factors) were the pre- and post-questionnaire scores. The between-subjects factors were five different pre-achievement groups. A post-hoc test was performed with Tukey's Honestly Significant Difference (HSD) test.

Results

To address the first hypothesis (the potential for CAI to enhance Korea's second grade middle school students' understanding of science and whether there were differences among different achievement groups) we examined the difference between students prior GPAS and their scores on the post-test, referred to as their pre and post achievement respectively. As Table 1 shows, after two and half months of CAI science classes, students' achievement in science improved significantly, $t(233)=2.403$, $p=.017$. CAI was significantly correlated with improvement in most of the achievement groups, $F(4,229)=7.853$, $p=.000$. 28 students out of 75 in Group I, 17 out of 32 in Group III, and 19 out of 46 in Group IV improved on the post-achievement test as indicated by their higher achievement levels from their pre-achievement level. On the contrary, 20 students out of 56 from Group V scores deteriorated on the post-achievement test. 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 significantly higher than Group V (2.32). Group IV (3.33) was also significantly higher than Group V (2.32).

The second major hypothesis involved whether CAI can influence students' A to S, including (a) differences of A to S among different achievement groups; and (b) whether improvement in science had an effect on students' A to S. Statistical analyses of the pre and post questionnaires showed that the mean differences of students' A to S before and after CAI were significant, $t(233)=3.514$, $p=.001$, with students having more positive attitudes towards science after CAI. The means of A to S of higher achievement groups were likely to be higher than the means of lower achievement groups. However, the A to S of lower achievement groups (I, II, and III) was enhanced while groups (IV and V) deteriorated after CAI, as depicted in Table 2.

A repeated measures factorial ANOVA for different achievement groups showed that the within-subject variables in the same group were significant, $F(1,232)8.494$, $p=.004$, power=.827 and the interaction effect of within-subject variables was significant, $F(4,229)=3.007$, $p=.019$, power=0.794. The between-subject effects among groups was also significant, $F(4,229)=10.202$, $p=.000$, power=1.000. The

Table 1. Comparison of pre- and post-achievement

		Post-achievement					
Achievement Groups		I	II	III	IV	V	Pre-group total
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

Table 2. Descriptive statistics of A to S (n=234)

Pre-Achievement Groups	n	Pre-A to S Mean	Post-A to S Mean	Improvement
I	75	28.49	31.15	2.66
II	25	29.84	31.09	1.25
III	32	30.28	31.44	1.16
IV	46	32.09	32.45	0.36
V	56	33.39	33.08	–0.31
Total	234	30.76	31.90	3.643

individual students' A to S had changed significantly after CAI and also their achievement in science and A to S interacted significantly.

In order to ascertain the effects of improved achievement in science on changes in students' attitudes towards science, the groups were reorganised depending on the differences between pre- and post-achievement as shown in Table 3. Improvement group (I or II)'s means are high because most members were from the higher achievement groups as their scores on the post-achievement test deteriorated. A repeated measures design factorial ANOVA showed that the within-subject variables were not statistically significant, $F(1,232)=3.309$, $p=0.070$, but the interaction effects of changes in A to S along the five achievement levels were significant, $F(4,229)=3.954$, $p=.004$, power=0.902. For between-subject effects, improvement on the post-achievement test was effective in changing attitudes positively, $F(4,229)=2.791$, $p=.027$, power=.759. The results demonstrate that the individual students' A to S had changed according to their achievement but were not statistically significant ($p > .05$). Between achievement groups, however, the differences in A to S were significant.

Based on statistical analysis, among the five different achievement groups, Group V showed the highest overall mean achievement. However, achievement Group I and II's A to S improvements were greater than all other groups. CAI appeared to have a positive impact on students' A to S, according to our statistical analysis. Collectively,

Table 3. Achievement and A to S (n=234)

Differences in Achievement (post-achievement test–pre-achievement test score)	n	Mean (pre-CAI A to S)	Mean (post-CAI A to S)	Mean differences in A to S (post–pre CAI A to S)
I (~ –7)	57	30.04	30.74	.70
II (–3 ~ –6)	26	32.38	32.31	–.08
III (–2 ~ +2)	33	32.70	32.12	–.58
IV (+3 ~ +6)	33	31.45	31.88	.42
V (+7 ~)	85	29.73	32.56	2.84
Total	234	30.76	31.93	1.17

(a) Mean= (post-CAI attitudes – pre-CAI attitudes)/n

as students' achievement in science improved after their CAI experience, their A to S appeared to change positively.

A third hypothesis tested was whether positive A to S could motivate the middle school students to choose courses and future careers in science fields. A repeated measures factorial ANOVA was used to determine how A to S changes affected student's choices of future courses and career aspirations. To do this statistical analysis, the student participants were subdivided into two groups: positive and negative A to S changed groups. The analysis of the questionnaires revealed that when an individual student's A to S changed positively, his/her choices of future courses and CA were affected significantly by A to S changes, $F(1,232)=448.416$, $p=.000$, power=1.000. The interaction effect of these two variables were significant, $F(1,232)=12.367$, $p=.001$, power=.938. The results of repeated measures ANOVA before and after CAI appeared to demonstrate that individual student's choices of future courses and future careers were significantly influenced by CAI; however, the differences between participants' were not significant. In other words it is natural that different people have different preferences; one cannot expect all students to follow a science path after CAI.

Gender Differences

The girls who participated in the study did not significantly change their achievement ($p > .05$) or A to S ($p > .05$) (Table 4) after CAI in science. The boys, however, significantly improved on the post-achievement test ($p < .05$). Table 4 shows that the girls' achievement both before and after CAI was generally higher than the boys'. The means of girls' achievement before and after CAI were 3.13 and 3.14, respectively while the means of boys' were 2.70 and 3.11, respectively. As mentioned, paired samples t-test showed that the differences in achievement after CAI for boys was statistically significant, $t(109)=3.515$, $p=.001$. However, for the girls the differences were not statistically significant, $t(123)=.072$, $p=.943$. This result suggests that CAI positively affected the boys' understanding of science concepts, but CAI did not appear to have a similar impact on the girls' conceptual understanding.

Table 4. Gender differences between pre- and post-questionnaire (n=234)

		Boys (n=110)		Girls (n=124)	
		Pre	Post	Pre	Post
Achievement	Mean	2.70	3.11	3.13	3.14
	t	3.515 (p=.001)		.072 (p=.943)	
A to S	Mean	29.85	31.27	31.57	32.46
	t	3.155 (p=.002)		1.750 (p=.083)	
CA	Mean	4.95	6.11	6.63	6.98
	t	6.107 (p=.000)		2.09 (p=0.038)	

In terms of A to S, the pre- and post-questionnaire results showed that the girls' attitudes were overall more positive towards science than the boys and that A to S was enhanced after CAI. In terms of the pre and post-achievement, the means of boys' A to S were 29.85 and 31.27, respectively. Paired samples t-tests showed that the differences between pre- and post-achievement were statistically significant for boys, $t(109)=3.155$, $p=.002$. The girls' means before and after CAI were 31.57 and 32.46 respectively. A paired samples t-test showed that the differences between before and after CAI were not statistically significant, $t(123)=1.750$, $p=.083$. Thus, the boys significantly enhanced their A to S through CAI, but CAI did not appear to have the same significance for girls' A to S.

According to the questionnaires, boys' choices of future courses and career aspirations in science areas were 4.95 and 6.11 before and after CAI respectively. The changes were statistically significant, $t(109)=6.107$, $p=.000$. This result shows that for the boys in the second year of middle school, CAI positively affected their choices of future courses and careers in science fields. The means of the girls' for future courses and CA in science areas are 6.63 and 6.98 before and after CAI respectively. The differences for girls future courses and CA were statistically significant after CAI, $t(123)=2.097$, $p=.038$.

From a statistical analysis of students' achievement and their responses to a pre- and post-questionnaire, four important findings about CAI in Korean science classrooms emerged:

1. CAI appeared to be more effective for students in the lower achievement group in comparison to higher achievement groups ($p < .05$). The findings suggest that low achieving students might be able to enhance their achievement in science with CAI.
2. Students' A to S varied according to their achievement in science ($p < .05$). Gains in student achievement after CAI appeared to positively affect their A to S. This finding suggests that achievement in CAI science influences students' attitudes towards science and vice versa.
3. Students' choices of future courses and career aspirations in science fields appeared to be positively affected by their achievement in CAI science and attitudes towards science.
4. CAI appeared to positively influence boys' achievement, A to S and the choices of future courses and career aspirations. Although girls' achievement and the choices of future courses and career aspirations after CAI were enhanced, the changes were not significant.

Discussion

Collectively, student achievement in the post-achievement test improved significantly, $t(233)=2.403$, $p=.017$ compared to their achievement in science prior to CAI. The improvement was different in accordance with the students' pre-achievement, $F(4,229)=7.853$, $p=.000$ and gender. According to Tukey's HSD, Group I (the lowest pre-achievement group) improvement was greater than other groups. CAI may have contributed to student achievement in science as the software appeared to afford students with opportunities to engage in processes associated with science. Consistent with previous research (Hannafin, 2004; Means & Coleman, 2000; Williams, Chen & Seaton, 2003), Korean students generally responded favourably towards an ability to manipulate variables in the computer programmes, compare the data among different conditions, and generate patterns based on the data.

When the data were parsed by achievement levels, low achieving students' made the most significant gains after CAI ($p < .05$) compared with students who had high pre and post achievement levels. Bang (2003) found that there was no significant difference in doing class activities between high and low achieving students utilising CAI in class. In this study, further classroom observations and interviews would be necessary to support theories that explained the variance in student achievement, however, it is plausible that CAI can enhance students' understanding of science concepts, especially for lower achieving students who may benefit more significantly from having phenomena in science made visible and open to manipulation. Interactive software can permit students to view and review animations, slow down and repeat normally unobservable processes in science, manipulate variables to view their effects, and analyse graphs of the trends in experiments.

When the data was analysed by gender, both boys and girls' achievement on the post-achievement test was enhanced in science compared to their previous achievement in science. However, it was discovered that the gains in achievement after CAI were most significant for the boys. The post-questionnaire comments section did not reveal the reasons why CAI was not as effective for the girls compared with the boys. According to the science teacher, the boys appeared to be more actively engaged and would not yield the computers to the girls. It appeared from the teacher's account that in some cases, girls were excluded from manipulating the variables in the software and the girls' were generally reduced to observers. Although this is anecdotal evidence from the teacher, it does shed light on how interactions among students during the unit may have influenced student learning in science and may possibly explain some of the variance in achievement between students. Boys' and girls' attitudes towards science towards science were significantly enhanced and they were significantly more interested in science careers, after CAI.

The statistical analysis of the post-achievement test and questionnaires suggest that CAI in science class contributed to an improvement in students' achievement at the end of the unit, and also brought positive changes in students' A to S ($p < .05$). As recognised by researchers (e.g., Andree, 2003; Bennett, Hogarth & Lubben. 2005), when students can link science knowledge to their everyday life, science knowledge becomes relevant, and A to S are positively affected. For example, the simulation of the moon's revolution provides a rationale for the lunar calendar, which is still used in Korea along with the solar calendar. In particular most traditional holidays are based on the lunar calendar. Another example of making science knowledge more relevant for Korean students is in the selection of geographic locations to investigate with the software. For this school in particular, Busan is a coastal region and students can connect their experiences of the tide with the moon's position using the simulation. Statistical analysis of the post-achievement test and the questionnaires also suggest that students' achievement, A to S and CA are closely related. After engaged in CAI science for two and half months, students' achievement in science and A to S appeared to be positively affected compared to their historical performance the previous year in science. When students' A to S changed positively, the students' perceived choices regarding future courses and career aspirations in science fields appeared to also be positively effected. The potential effects of improved in achievement in science are not to be underestimated, because it is plausible that they can have the effect of influencing students' career paths. While the relationships suggested here among student achievement in science, attitudes towards the subject, and future career aspirations are hypothetical, if CAI is able to enhance students' experience with science, it is conceivable that more students may select science as a career or have a positive attitude towards science, and this is a goal of Korea's national programme.

Implications

The Seventh School Curriculum Reform is designed to help Korean students to prepare for an information and knowledge-based society, which demands scientific and technological literacies. Our study of Korean students suggests that CAI in science education can support this reform effort by contributing to the enhancement of student understanding of science concepts, particularly for boys' and low achieving students. Additionally, improvement in achievement in science appears to have a positive relationship with attitudes towards science and future career aspirations, as suggested by our statistical analysis.

This research provides empirical evidence that are suggestive of the possible contributions of CAI in a Korean science classroom, and the implications of the findings challenge us to consider how to interest Korean science teachers in utilising CAI and other ICTs. In order for ICT to enhance science learning, we recommend further research on specific teaching approaches that incorporate ICT to contribute to existing research on the various conditions for student success in technology-enhanced environments (Bryson, et al., 2003; Mayer-Smith, et al., 2000). We also suggest that better educational software for Korean students could be developed in conjunction with Korean teachers who are familiar with methods of classroom integration and classroom models of CAI. For example, existing educational software is not highly interactive, and interactivity provides students with opportunities to alter and experiment with variables or provide a communication network for peer learners from different schools in Korea. Although there are a number of factors that likely contributed to the outcomes measured in this study, the potential contributions of CAI on low achieving students and girls in science are intriguing and we recommend further research on this complex relationship.

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