A COMPARATIVE STUDY OF THE EFFECTS OF TRADITIONAL TEACHING AND COMPUTER INSTRUCTION ON SECONDARY ASSISTED SCHOOL STUDENTS’ ATTITUDE AND ACHIEVEMENT IN PHYSICAL SCIENCE

ABSTRACT
SUBMITTED FOR THE AWARD OF THE DEGREE OF

Doctor of Philosophy
IN
EDUCATION

BY
UZMA SIDDIQUI

Under the Supervision of
DR. TAHIRA KHATOON
(Associate Professor)

DEPARTMENT OF EDUCATION
ALIGARH MUSLIM UNIVERSITY
ALIGARH-202002, INDIA

2013
ABSTRACT

Great emphasis is placed on the science and technology courses in the educational curricula of the developed as well as developing countries. One of the aims of the science and technology course is to train individuals capable of keeping up the fast developing and changing science world and capable of utilizing the recent technological discoveries in every field. However, Physical Science has been viewed by students as one of the most difficult subjects in the secondary school curricula. Many students find Physical Science to be difficult because it is one of the subjects in which the processes and phenomena cannot be directly observed. These difficulties arise due to the abstract, symbolic, and molecular representations of phenomena. From diagrams in textbooks to model kits, the representations of physical and chemical phenomena have taken on different forms in the traditional classroom. These representations, however, have many limitations to providing the proficient level of conceptual understanding in Physical Science. Since students cannot draw from direct physical experience of such phenomena, conceptual understanding of Physical Science poses a hardship for learning. This is especially true in the secondary school environment, where educational tools and resources are limited in the area of Physical Science. As a result, a number of changes has been made in the development of courses and curricula and in the teaching methods not only in India but also across the world. Changes to courses, curricula and instructional methods, or in some cases, the contemplation of changes, have been driven by concerns about traditional teaching methods that they are not the most appropriate for teaching science in general and Physical Science in particular to all students and do not make the best use of advanced technologies.

Advancing technology has opened many doors in science education. The use of computer assisted instruction (CAI) in science provides a number of alternatives to students such as visualization of abstract concepts that will foster their conceptual understanding. Although the research studies on the effectiveness of computers in the field of education reveals contradictory results, majority of the research studies indicates that CAI brings several possible advantages as a teaching-learning tool. The main strength of the computer as a learning medium is its ability to process information quickly. This makes it possible for the computer to accept and act
upon a variety of different kinds of response from the learner and to provide information in textual, graphical, and animated form. CAI benefits most students when compared with traditional instruction because it increases student interest, reduces anxiety, provides more time on task, and provides instant feedback for the student. Besides, CAI could also students with opportunities for self-sufficient learning, independent learning, the exercising of various senses and the ability to represent content in a variety of media. Inspite of these benefits, computer technology has not been fully utilized and implemented in appropriate, effective and creative ways in school education in India. The recent Indian government efforts to integrate ICT into the school curriculum (National Curriculum Framework, 2005) need to be supported with a research into how the programme can be implemented and the effects such a programme may have on the teaching and learning situations. If the government is making these efforts, then research should be geared towards how ICT can be fully integrated into teaching and learning and the impact it would have on teaching and learning science particularly Physical Science concepts which this research is concerned with. Therefore, the investigator had conducted the present study to explore whether CAI (teacher-centered CAI and student-centered CAI) is more effective than traditional instruction in enhancing students’ attitude and achievement in Physical Science at secondary school level. Furthermore, two latent variables, namely, CAI attitude and CAI Environment Attitude subscales were also used as predictors to estimate their contribution towards students’ attitude and achievement in Physical Science.

**Statement of the Problem**

“A Comparative Study of the Effects of Traditional Teaching and Computer Assisted Instruction on Secondary School Students’ Attitude and Achievement in Physical Science”

**Objectives of the Study**

1. To develop three measuring instruments, namely, Physical Science Attitude Scale, Physical Science Achievement test, and Computer Assisted Instruction Attitude Scale.
2. To evaluate the effectiveness of multimedia CAI software for teaching Physical Science to secondary school students.

3. To compare the attitude towards Physical Science at pre-test and post-test stages respectively for students in the control group.

4. To compare the attitude towards Physical Science at pre-test and post-test stages respectively for students in the Teacher-centered CAI (TCCAI) group.

5. To compare the attitude towards Physical Science at pre-test and post-test stages respectively for students in the Student-centered CAI (SCCAI) group.

6. To compare the effects of traditional teaching and Computer Assisted Instruction (Teacher-centered CAI and Student-centered CAI) on attitude towards Physical Science for students in the control group and two experimental groups (TCCAI and SCCAI) respectively.

7. To compare the achievement in Physical Science at pre-test and post-test stages respectively for students in the control group.

8. To compare the achievement in Physical Science at pre-test and post-test stages respectively for students in the Teacher-centered CAI (TCCAI) group.

9. To compare the achievement in Physical Science at pre-test and post-test stages respectively for students in the Student-centered CAI (SCCAI) group.

10. To compare the effects of traditional teaching and Computer Assisted Instruction (Teacher-centered CAI and Student-centered CAI) on achievement in Physical Science for students in the control group and two experimental groups respectively.

11. To examine the effects of traditional teaching and Computer Assisted Instruction (Teacher-centered CAI and Student-centered CAI) on achievement in Physical Science for students in the control group and two experimental groups respectively at different levels of the cognitive domain (viz., knowledge, comprehension, application, HOTS).

12. To explore the effects of traditional teaching and Computer Assisted Instruction (Teacher-centered CAI and Student-centered CAI) on achievement in Physical Science for students in the control group and two experimental groups respectively in different content areas (Physics and Chemistry) of Physical Science.

13. To study the combined and individual effect of CAI attitude subscales on attitude towards Physical Science for students in the TCCAI and SCCAI groups respectively.
14. To study the combined and individual effect of CAI attitude subscales on achievement in Physical Science for students in the TCCAI and SCCAI groups respectively.

15. To study the combined and individual effect of CAI environmental subscales on attitude towards Physical Science for students in the TCCAI and SCCAI groups respectively.

16. To study the combined and individual effect of CAI environmental subscales on achievement in Physical Science for students in the TCCAI and SCCAI groups respectively.

17. To point out the main educational implications of this study.

Hypotheses of the Study

**H₀ 1:** There is no significant difference between the mean pre-test and post-test Physical Science attitude scores for students in the control group.

**H₀ 2:** There is no significant difference between the mean pre-test and post-test Physical Science attitude scores for students in the TCCAI group.

**H₀ 3:** There is no significant difference between the mean pre-test and post-test Physical Science attitude scores for students in the SCCAI group.

**H₀ 4.1:** There is no significant main effect of instructional method on mean post-test Physical Science attitude scores for students in the control, TCCAI, and SCCAI groups respectively, after controlling for the effect of pre-test as a covariate.

**H₀ 4.2:** There is no significant main effect of gender on mean post-test Physical Science attitude scores in the control, TCCAI, and SCCAI groups respectively, after controlling for the effect of pre-test as a covariate.

**H₀ 4.3:** There is no significant interaction effect of instructional method and gender on mean post-test Physical Science attitude scores for students in the control, TCCAI, and SCCAI groups respectively, after controlling for the effect of pre-test as a covariate.

**H₀ 5:** There is no significant difference between the mean pre-test and post-test achievement scores for students in the control group.

**H₀ 6:** There is no significant difference between the mean pre-test and post-test achievement scores for students in the TCCAI group.

**H₀ 7:** There is no significant difference between the mean pre-test and post-test achievement scores for students in the SCCAI group.
**H₀ 8.1:** There is no significant main effect of instructional method on mean post-test achievement scores for students in the control, TCCAI, and SCCAI groups respectively, after controlling for the effect of pre-test as a covariate.

**H₀ 8.2:** There is no significant main effect of gender on mean post-test achievement scores for students in the control, TCCAI, and SCCAI groups respectively, after controlling for the effect of pre-test as a covariate.

**H₀ 8.3:** There is no significant interaction effect of treatment and gender on mean post-test achievement scores for students in the control, TCCAI, and SCCAI groups respectively, after controlling for the effect of pre-test as a covariate.

**H₀ 9:** There is no significant difference between the mean post-test scores for students in the control, TCCAI, and SCCAI groups respectively, at different levels of cognitive domain, after controlling for the effect of pre-test as a covariate.

**H₀ 10:** There is no significant difference between the mean post-test scores for students in the control, TCCAI, and SCCAI groups respectively, in different content areas of Physical Science, after controlling for the effect of pre-test as a covariate.

**H₀ 11:** CAI attitude subscales do not significantly predict the attitude towards Physical Science for students in the TCCAI and SCCAI groups respectively.

**H₀ 12:** CAI attitude subscales do not significantly predict the achievement in Physical Science for students in the TCCAI and SCCAI groups respectively.

**H₀ 13:** CAI environment subscales do not significantly predict the attitude towards Physical Science for students in the TCCAI and SCCAI groups respectively.

**H₀ 14:** CAI environmental subscales do not significantly predict the achievement in Physical Science for students in the TCCAI and SCCAI groups respectively.

**Research Design and Methodology**

In this study, a randomized pretest-posttest control group design (Campbell and Stanley, 1966) was used because it is a true experimental design which controls for nearly all sources of internal and external invalidity.

**Sample**

The subjects of the present study included 210 students who were enrolled in class X in Ayesha Tarin Modern Public School, Aligarh, Uttar Pradesh, India. Using a table of random numbers, these students were randomly assigned to 6 sections, each section consisting of 35 students. Further, the three teaching approaches were
randomly assigned to these 6 sections in such a way that the 2 sections were subjected to traditional teaching, another 2 sections were subjected to teacher-centered CAI and the remaining 2 to student-centered CAI. In other words, 2 sections, subjected to traditional teaching, were considered as control group and the remaining 4 sections, subjected to CAI, were considered as experimental groups: 2 sections as teacher-centered CAI experimental group and the remaining 2 sections as student-centered experimental group. Moreover, two teachers were also randomly assigned to these sections so that each teacher had three sections to teach by making use of each type of teaching approach. This was done to minimize teacher differences and bias. Thus, a total of 210 students and 2 teachers (including researcher) were selected as participants for this study.

**Tools used in the Study**

- Science textbook and multimedia CAI software were the main intervention instruments of this study.
- The dependent measure instruments used were:
  - Physical Science Attitude Scale (PSAS)
  - Physical Science Achievement Test (PSAT)
  - Computer Assisted Instruction Attitude Scale (CAIAS)
  - Computer Assisted Instruction Environment Scale (CAIES)

  PSAS, PSAT, and CAIAS were developed by the investigator; whereas Multimedia CAI software was developed by the investigator with the help of a computer expert.

**Data Collected for the Study**

In order to measure students’ attitude towards Physical Science and their achievement in Physical Science, Physical Science Attitude Scale and Physical Science Achievement Test were administered as pre-tests and post-tests respectively to students in all the three groups at the beginning and end of the treatment. In order to compare attitudes toward CAI and CAI environment, CAI attitude scale and CAI
environment scale were administered only to the students of both the experimental groups at the end of the treatment.

Statistical Techniques Employed

The main statistical techniques used in this study were:

- Item analysis using Pearson’s Product Moment Correlation
- Determination of reliability and validity of tools developed by the investigator, namely, PSAS, PSAT, and CAIAS
- Computation of mean and standard deviation
- Independent samples $t$-test to see the significant difference between two means
- Paired-samples $t$-test to see the significant difference in pre- and post-mean measurements on PSAS and PSAT respectively within the same group
- Factorial ANOVA to determine the significant difference between the experimental and control groups’ attitude and achievement in Physical Science as measured by using PSAS and PSAT at pre-test stage
- Factorial ANCOVA to determine the significant difference between the experimental and control groups’ attitude and achievement in Physical Science as measured by using PSAS and PSAT at post-test stage, by taking their respective pre-test measurements as covariate
- Standard multiple regression to find out the combined and individual effect of CAI attitude and CAI environment subscales as predictors on attitude and achievement in Physical Science, of students of TCCAI and SCCAI groups

Findings

The main findings emanating from the present investigation are as follows:

Effects of Traditional Teaching and Computer Assisted Instruction (TCCAI and SCCAI) on Students’ Attitude towards Physical Science

1. Paired-samples $t$-test results showed that there was a significant difference between the Pre-PSA and Post-PSA means for the control group, $t (67) = -19.87$, $p < .05$. This indicates that traditional teaching had some positive impact on attitude towards Physical Science for students in the control group.
2. There was a significant difference between the Pre-PSA and Post-PSA means for the TCCAI group, as indicated by the paired-samples t-test, \( t (67) = -22.75, p < .05 \). This shows that TCCAI had greater positive impact on attitude towards Physical Science for students in the TCCAI group as compared to traditional teaching.

3. Paired-samples t-test results showed that there was a significant difference between the Pre-PSA and Post-PSA means for the SCCAI group, \( t (67) = -29.88, p < .05 \). This indicates that SCCAI had greater positive impact on attitude towards Physical Science for students in the SCCAI group as compared to traditional teaching but lesser positive impact as compared to TCCAI.

4. At the pre-test stage, there was no significant difference in attitude towards Physical Science among the control, TCCAI, and SCCAI groups. In other words, these three groups were found to be equivalent as far as their attitude towards Physical Science at pre-test stage was concerned. But at the post-test stage, two-way ANCOVA results indicated a significant main effect for the instructional method. That is, there was a significant difference in attitude towards Physical Science among the control, TCCAI, and SCCAI groups, \( F (2, 197) = 15.21, p < .05, \text{partial } \eta^2 = .134 \). Instructional method accounted for 13.4 percent of the total variance in attitude towards Physical Science, after controlling for the effect of Pre-PSA scores used as a covariate.

   Pairwise comparisons showed that after adjustment for the Pre-PSA scores used as covariate, the Post-PSA mean of TCCAI group was 3.35 and 7.01 points higher than that of SCCAI and control groups respectively. Moreover, the Post-PSA mean of SCCAI group was 3.66 points higher than that of control group. In other words, ANCOVA followed by pairwise comparisons indicated the superiority for the instructional methods, as far as their effects on students’ attitude towards Physical Science was concerned, in the following order: TCCAI > SCCAI > Traditional Teaching.

5. Results of two-way ANCOVA also indicated a non-significant main effect for gender, \( F (1, 197) = 0.01, p > .05 \). That is, there was no significant difference
in attitude towards Physical Science among the male and female students of control, TCCAI, and SCCAI groups.

6. There was no significant interaction between instructional method and gender as shown by the results of two-way ANCOVA, $F(2, 197) = 0.50, p > .05$.

**Effects of Traditional Teaching and Computer Assisted Instruction (TCCAI and SCCAI) on Students’ Achievement in Physical Science**

1. Paired-samples t-test results showed that there was a significant difference between the Pre-test and Post-test means for the control group, $t(67) = -30.72, p < .05$. This indicates that traditional teaching had some positive impact on achievement in Physical Science for students in the control group.

2. There was a significant difference between the Pre-test and Post-test means for the TCCAI group, as indicated by the paired-samples t-test, $t(67) = 44.01, p < .05$. This shows that TCCAI had greater positive impact on achievement in Physical Science for students in the TCCAI group as compared to traditional teaching.

3. Paired-samples t-test results showed that there was a significant difference between the Pre-test and Post-test means for the SCCAI group, $t(67) = -32.53, p < .05$. This indicates that SCCAI had greater positive impact on achievement in Physical Science for students in the SCCAI group as compared to traditional teaching but lesser positive impact as compared to TCCAI.

4. At the pre-test stage, there was no significant difference in achievement in Physical Science among the control, TCCAI, and SCCAI groups. In other words, these three groups were found to be equivalent as far as their achievement in Physical Science at pre-test stage was concerned. But at the post-test stage, two-way ANCOVA results indicated a significant main effect for the instructional method. That is, there was a significant difference in achievement in Physical Science among the control, TCCAI, and SCCAI groups, $F(2, 197) = 40.40, p < .05$, partial $\eta^2 = .291$. Instructional method accounted for 29.1 percent of the total variance in achievement in Physical Science, after controlling for the effect of Pre-test scores used as a covariate.
Pairwise comparisons showed that after adjustment for the Pre-test scores used as covariate, the Post-test mean of TCCAI group was 4.98 and 9.83 points higher than that of SCCAI and control groups respectively. Moreover, the Post-test mean of SCCAI group was 4.85 points higher than that of control group. In other words, ANCOVA followed by pairwise comparisons indicated the superiority for the instructional methods, as far as their effects on students’ achievement in Physical Science was concerned, in the following order: TCCAI > SCCAI > Traditional Teaching.

5. Results of two-way ANCOVA also indicated a non-significant main effect for gender, $F(1, 197) = 0.09, p > .05$. That is, there was no significant difference in achievement in Physical Science among the male and female students of control, TCCAI, and SCCAI groups.

6. There was no significant interaction between instructional method and gender as shown by the results of two-way ANCOVA, $F(2, 197) = 0.72, p > .05$.

**Effects of Traditional Teaching and Computer Assisted Instruction (TCCAI and SCCAI) on Students’ Achievement in Physical Science at different levels of the cognitive domain**

1. At the post-test stage, one-way ANCOVA yielded a significant main effect for the instructional method on students’ achievement on knowledge component of PSAT, $F(2, 200) = 32.61, p < .05$, partial $\eta^2 = .246$. Instructional method accounted for 24.6 percent of the total variance in post-test scores on knowledge component of PSAT, after controlling for the effect of pre-test scores used as a covariate. This result indicated that there was a significant difference between the mean post-test achievement scores for students in the control, TCCAI, and SCCAI groups respectively, on knowledge component of achievement test, after controlling for the effect of pre-test as a covariate.

Pairwise comparisons showed that the adjusted post-test mean of TCCAI group was 1.01 and 2.84 points higher than that of SCCAI and control groups respectively, on knowledge component of PSAT. Moreover, the Post-test mean of SCCAI group was 1.83 points higher than that of control group. In other words, ANCOVA followed by pairwise comparisons indicated the
superiority for the instructional methods, as far as their effects on students’ achievement on knowledge component of PSAT was concerned, in the following order: TCCAI > SCCAI > Traditional Teaching.

2. At the post-test stage, one-way ANCOVA yielded a significant main effect for the instructional method on students’ achievement on comprehension component of PSAT, $F (2, 200) = 13.90$, $p < .05$, partial $\eta^2 = .122$. Instructional method accounted for 12.2 percent of the total variance in post-test scores on comprehension component of PSAT, after controlling for the effect of pre-test scores used as a covariate. This result indicated that there was a significant difference between the mean post-test achievement scores for students in the control, TCCAI, and SCCAI groups respectively, on comprehension component of achievement test, after controlling for the effect of pre-test as a covariate.

Pairwise comparisons showed that the adjusted post-test mean of TCCAI group was 1.20 and 2.41 points higher than that of SCCAI and control groups respectively, on comprehension component of PSAT. Moreover, the Post-test mean of SCCAI group was 1.21 points higher than that of control group. In other words, ANCOVA followed by pairwise comparisons indicated the superiority for the instructional methods, as far as their effects on students’ achievement on comprehension component of PSAT was concerned, in the following order: TCCAI > SCCAI > Traditional Teaching.

3. At the post-test stage, one-way ANCOVA yielded a significant main effect for the instructional method on students’ achievement on application component of PSAT, $F (2, 200) = 16.11$, $p < .05$, partial $\eta^2 = .139$. Instructional method accounted for 13.9 percent of the total variance in post-test scores on application component of PSAT, after controlling for the effect of pre-test scores used as a covariate. This result indicated that there was a significant difference between the mean post-test achievement scores for students in the control, TCCAI, and SCCAI groups respectively, on application component of achievement test, after controlling for the effect of pre-test as a covariate.
Pairwise comparisons showed that the adjusted post-test mean of TCCAI group was 1.19 and 2.28 points higher than that of SCCAI and control groups respectively, on application component of PSAT. Moreover, the Post-test mean of SCCAI group was 1.09 points higher than that of control group. In other words, ANCOVA followed by pairwise comparisons indicated the superiority for the instructional methods, as far as their effects on students’ achievement on application component of PSAT was concerned, in the following order: TCCAI > SCCAI > Traditional Teaching.

4. At the post-test stage, one-way ANCOVA yielded a significant main effect for the instructional method on students’ achievement on HOTS component of PSAT, $F (2, 200) = 9.36, p < .05$, partial $\eta^2 = .085$. Instructional method accounted for 8.5 percent of the total variance in post-test scores on HOTS component of PSAT, after controlling for the effect of pre-test scores used as a covariate. This result indicated that there was a significant difference between the mean post-test achievement scores for students in the control, TCCAI, and SCCAI groups respectively, on HOTS component of achievement test, after controlling for the effect of pre-test as a covariate.

Pairwise comparisons showed that the adjusted post-test mean of TCCAI group was 0.57 and 0.96 points higher than that of SCCAI and control groups respectively, on HOTS component of PSAT. Moreover, the Post-test mean of SCCAI group was 0.39 points higher than that of control group. In other words, ANCOVA followed by pairwise comparisons indicated the superiority for the instructional methods, as far as their effects on students’ achievement on HOTS component of PSAT was concerned, in the following order: TCCAI > SCCAI > Traditional Teaching.

Effects of Traditional Teaching and Computer Assisted Instruction (TCCAI and SCCAI) on Students’ Achievement in different content areas (Physics and Chemistry) of Physical Science

1. At the post-test stage, one-way ANCOVA yielded a significant main effect for the instructional method on students’ achievement on Physics part of PSAT, $F (2, 200) = 38.53, p < .05$, partial $\eta^2 = .278$. Instructional method accounted for
27.8 percent of the total variance in post-test scores on Physics part of PSAT, after controlling for the effect of pre-test scores used as a covariate. This result indicated that there was a significant difference between the mean post-test achievement scores for students in the control, TCCAI, and SCCAI groups respectively, on Physics part of achievement test, after controlling for the effect of pre-test as a covariate.

Pairwise comparisons showed that the adjusted post-test mean of TCCAI group was 2.51 and 4.82 points higher than that of SCCAI and control groups respectively, on Physics part of PSAT. Moreover, the Post-test mean of SCCAI group was 2.31 points higher than that of control group. In other words, ANCOVA followed by pairwise comparisons indicated the superiority for the instructional methods, as far as their effects on students’ achievement on Physics part of PSAT was concerned, in the following order: TCCAI > SCCAI > Traditional Teaching.

2. At the post-test stage, one-way ANCOVA yielded a significant main effect for the instructional method on students’ achievement on Chemistry part of PSAT, \( F(2, 200) = 38.56, p < .05, \) partial \( \eta^2 = .278 \). Instructional method accounted for 27.8 percent of the total variance in post-test scores on Chemistry part of PSAT, after controlling for the effect of pre-test scores used as a covariate. This result indicated that there was a significant difference between the mean post-test achievement scores for students in the control, TCCAI, and SCCAI groups respectively, on Chemistry part of achievement test, after controlling for the effect of pre-test as a covariate.

Pairwise comparisons showed that the adjusted post-test mean of TCCAI group was 2.24 and 5.02 points higher than that of SCCAI and control groups respectively, on Chemistry part of PSAT. Moreover, the Post-test mean of SCCAI group was 2.78 points higher than that of control group. In other words, ANCOVA followed by pairwise comparisons indicated the superiority for the instructional methods, as far as their effects on students’ achievement on Chemistry part of PSAT was concerned, in the following order: TCCAI > SCCAI > Traditional Teaching.
Combined and Individual effect of CAI Attitude Subscales on Attitude towards Physical Science for students in the TCCA and SCCAI groups

1. CAI attitude subscales significantly predicted the attitude towards Physical Science for students in the TCCA group, $F(5, 62) = 7.29, p < .001$. They together accounted for 31.9% of the variance in attitude towards Physical Science ($R = .608, R^2 = .370, \text{Adjusted } R^2 = .319$). Out of the five CAI attitude subscales (namely, content presentation, assessment, individualization, integration, and perceived effectiveness), integration ($t(62) = 3.78, p < .05$) and perceived effectiveness ($t(62) = 2.21, p < .05$) significantly predicted the attitude towards Physical Science for students in the TCCA group. Integration and perceived effectiveness respectively explained 14.5% and 4.5% of the variance in attitude towards Physical Science for students in the TCCA group.

2. CAI attitude subscales also significantly predicted the attitude towards Physical Science for students in the SCCAI group, $F(5, 62) = 6.88, p < .001$. They together accounted for 30.5% of the variance in attitude towards Physical Science ($R = .597, R^2 = .357, \text{Adjusted } R^2 = .305$). Out of the five CAI attitude subscales, individualization ($t(62) = 3.15, p < .05$) and perceived effectiveness ($t(62) = 2.90, p < .05$) significantly predicted the attitude towards Physical Science for students in the SCCAI group. Individualization and perceived effectiveness respectively explained 32.1% and 29.5% of the variance in attitude towards Physical Science for students in the SCCAI group.

Combined and Individual effect of CAI Attitude Subscales on Achievement in Physical Science for students in the TCCA and SCCAI groups

1. CAI attitude subscales significantly predicted the achievement in Physical Science for students in the TCCA group, $F(5, 62) = 21.49, p < .001$. They together accounted for 60.5% of the variance in achievement in Physical Science ($R = .796, R^2 = .634, \text{Adjusted } R^2 = .605$). Out of the five CAI attitude subscales, content presentation ($t(62) = 3.19, p < .05$), integration ($t(62) = 5.35, p < .05$), and perceived effectiveness ($t(62) = 2.31, p < .05$) significantly predicted the achievement in Physical Science for students in the TCCA group. Content presentation, integration and perceived effectiveness
respectively explained 6%, 16.9% and 3.2% of the variance achievement in Physical Science for students in the TCCAI group.

2. CAI attitude subscales also significantly predicted the achievement in Physical Science for students in the SCCAI group, $F(5, 62) = 16.19, p < .001$. They together accounted for 53.1% of the variance in achievement in Physical Science ($R = .752, R^2 = .566, \text{Adjusted } R^2 = .531$). Out of the five CAI attitude subscales, content presentation ($t(62) = 2.74, p < .05$), individualization ($t(62) = 2.24, p < .05$), and perceived effectiveness ($t(62) = 3.89, p < .05$) significantly predicted the achievement in Physical Science for students in the SCCAI group. Content presentation, individualization, and perceived effectiveness respectively explained 5.2%, 3.5% and 10.6% of the variance achievement in Physical Science for students in the SCCAI group.

**Combined and Individual effect of CAI Environment Subscales on Attitude towards Physical Science for students in the TCCAI and SCCAI groups**

1. CAI environment subscales significantly predicted the attitude towards Physical Science for students in the TCCAI group, $F(3, 64) = 12.05, p < .05$. They together accounted for 33.1% of the variance in attitude towards Physical Science ($R = .601, R^2 = .361, \text{Adjusted } R^2 = .331$). Out of the three CAI environment subscales (namely, cognitive, emotional, and interaction), only cognitive factor ($t(64) = 4.67, p < .05$) significantly predicted the attitude towards Physical Science for students in the TCCAI group. Cognitive subscale accounted for 21.8% of the variance in attitude towards Physical Science for students in the TCCAI group.

2. CAI environment subscales significantly predicted the attitude towards Physical Science for students in the SCCAI group, $F(3, 64) = 8.88, p < .05$. They together accounted for 26.1% of the variance in attitude towards Physical Science ($R = .542, R^2 = .294, \text{Adjusted } R^2 = .261$). Out of the three CAI environment subscales, only emotional subscale ($t(64) = 5.03, p < .05$) significantly predicted the attitude towards Physical Science for students in the SCCAI group. Emotional subscale accounted for 27.9% of the variance in attitude towards Physical Science for students in the SCCAI group.
Combined and Individual effect of CAI Environment Subscales on Achievement in Physical Science for students in the TCCA and SCCAI groups

1. CAI environment subscales significantly predicted the achievement in Physical Science for students in the TCCA group, \( F (3, 64) = 22.19, p < .05 \). They together accounted for 48.7% of the variance in achievement in Physical Science \( (R = .714, R^2 = .510, \text{Adjusted } R^2 = .487) \). Out of the three CAI environment subscales, cognitive factor \( (t (64) = 6.80, p < .05) \) and interaction factor \( (t (64) = 2.20, p < .05) \) significantly predicted the achievement in Physical Science for students in the TCCA group. Cognitive and interaction subscales respectively accounted for 35.4% and 3.7% of the variance in achievement in Physical Science for students in the TCCA group.

2. CAI environment subscales significantly predicted the achievement in Physical Science for students in the SCCAI group, \( F (3, 64) = 10.99, p < .05 \). They together accounted for 30.9% of the variance in achievement in Physical Science \( (R = .583, R^2 = .340, \text{Adjusted } R^2 = .309) \). Out of the three CAI environment subscales, cognitive subscale \( (t (64) = 3.62, p < .05) \) and emotional subscale \( (t (64) = 3.59, p < .05) \) significantly predicted the achievement in Physical Science for students in the SCCAI group. Cognitive and emotional subscales respectively accounted for 13.5% and 13.3% of the variance in achievement in Physical Science for students in the SCCAI group.

Conclusions

The findings of this experimental study lead to a number of conclusions regarding the effects of traditional teaching and CAI (TCCA and SCCAI) on secondary school students’ attitude and achievement in Physical Science. When the Physical Science attitude at pre-test and post-test stages for control, TCCA, and SCCAI groups was compared, it was found that the increase in attitude for the TCCA group was the highest followed by SCCAI and control groups respectively. Further, at post-test stage, the results indicated a significant difference in attitude towards Physical Science among the groups. Moreover, the TCCA group exhibited significantly higher attitude towards Physical Science than the SCCAI group which, in turn, was found to have significantly higher attitude than the control group. Therefore, it can be
concluded that TCCAI is more effective in increasing the students’ attitudes towards Physical Science than SCCAI and traditional teaching. Neither significant effect of gender nor significant interaction effect of instructional method and gender was found on attitude towards Physical Science at post-test stage. Therefore, it can be concluded that TCCAI is an equally effective method for male and female students.

When the Physical Science achievement at pre-test and post-test stages for control, TCAI, and SCCAI groups was compared, it was found that the increase in achievement for the TCCAI group was the highest followed by SCCAI and control groups respectively. Further, at post-test stage, the results indicated that the overall performance of TCCAI group on Physical Science Achievement Test (PSAT) was significantly better than that of SCCAI group. Moreover, the overall performance of SCCAI group was significantly better than that of control group. Therefore, it can be concluded that TCCAI is a better instructional method for teaching Physical Science at secondary school level as compared to SCCAI and traditional teaching. Neither significant effect of gender nor significant interaction effect of instructional method and gender was found on achievement at post-test stage. Therefore, it can be concluded that TCCAI is an equally effective method for male and female students.

The results for achievement at different levels of the cognitive domain showed that TCCAI group performed significantly better than SCCAI and control groups at knowledge, comprehension, application, and HOTS components of achievement test. Further, the performance of SCCAI group was significantly better than that of control group at knowledge, comprehension, and application levels, but not on HOTS subscale. Therefore, it can be concluded that TCCAI is a more effective method as compared to SCCAI and traditional teaching to enhance student learning at knowledge, comprehension and application levels of the cognitive domain in the area of Physical Science at secondary school level.

The results for achievement in different content areas of Physical Science indicated that both the CAI experimental groups (TCCAI and SCCAI) exhibited significantly better achievement in Physics than the control group. Moreover, the TCCAI group performed better than the SCCAI group. Therefore, it can be concluded that TCCAI is a better instructional method for teaching Physics at secondary school
level as compared to SCCAI and traditional teaching. Further, both the TCCAI and SCCAI groups exhibited significantly better achievement in Chemistry than the Control Group. Moreover, the TCCAI group performed better than the SCCAI group. Therefore, it can be concluded that TCCAI is a better instructional method for teaching Chemistry at secondary school level as compared to SCCAI and traditional teaching.

The results concerning the combined and individual effects of CAI attitude subscales on attitude towards Physical Science showed that CAI attitude subscales significantly predicted the attitude towards Physical Science for students in the TCCAI and SCCAI groups respectively. Out of the five CAI attitude subscales, only two subscales, namely, integration and perceived effectiveness significantly predicted the attitude towards Physical Science for students in the TCCAI Group. Only two subscales, namely, individualization and perceived effectiveness significantly predicted the attitude towards Physical Science for students in the SCCAI Group. The results concerning the combined and individual effects of CAI attitude subscales on achievement in Physical Science showed that CAI attitude subscales significantly predicted the achievement in Physical Science for students in the TCCAI and SCCAI groups respectively. Out of the five CAI attitude subscales, only three subscales, namely, content presentation, integration, and perceived effectiveness significantly predicted the achievement in Physical Science for students in the TCCAI Group. Only three subscales, namely, content presentation, individualization, and perceived effectiveness significantly predicted the achievement in Physical Science for students in the SCCAI Group. Therefore, it can be concluded that the multimedia CAI software used in the present study has the desired features to be an effective instructional tool for teaching Physical Science at secondary school level in India. This software in TCCAI and SCCAI approaches provides students with different opportunities to engage in science learning.

The results concerning the combined and individual effects of CAI environment subscales on attitude towards Physical Science showed that CAI environment subscales significantly predicted the attitude towards Physical Science for students in the TCCAI and SCCAI groups respectively. Out of the three CAI environment subscales, only cognitive subscale significantly predicted the attitude
towards Physical Science for students in the TCCAI Group, and only emotional subscale significantly predicted the attitude towards Physical Science for students in the SCCAI Group. The results concerning the combined and individual effects of CAI environment subscales on achievement in Physical Science showed that CAI environment subscales significantly predicted the achievement in Physical Science for students in the TCCAI and SCCAI groups respectively. Out of the three CAI environmental subscales, only two subscales, namely, cognitive and interaction subscales significantly predicted the achievement in Physical Science for students in the TCCAI Group. Only two subscales, namely, cognitive and emotional subscales significantly predicted the achievement in Physical Science for students in the SCCAI Group. Therefore, it can be concluded that the learning environment created for the TCCAI and SCCAI groups by making use of multimedia software is conducive for the teaching-learning process of Physical Science and satisfies the learning needs of students of each group to a large extent as indicated by their enhanced improvement in attitudes and achievement.

**Educational Implications**

Since both TCCAI and SCCAI promoted more positive attitudes toward Physical Science and also led to better achievement, therefore it is suggested that the instructors should use CAI for teaching science. For creating CAI learning environment, the instructors should be familiar with various formats or approaches of CAI (namely, TCCAI and SCCAI) and well-trained in using them appropriately, as per the available facilities in schools. If well-equipped computer labs are available in schools, then the instructors should use SCCAI approach; otherwise they would go for TCCAI approach. Before implementing SCCAI, the students should be given training on how to work on the CAI software and how to complete it by following the guidelines properly.

The findings suggested that appropriately-designed CAI can be an effective instructional tool in the classroom milieu. It also shows that the educational application of CAI as a learning tool in science classrooms can be efficacious. While a myriad of studies have examined the effects of CAI on a number of variables in developed countries, no systematic attempts previously have been made in India to
examine the effects of students’ attitude towards CAI and perceptions of CAI learning environment on their attitude and achievement in Physical Science. This study appears to be the first which involved student perceptions of the CAI learning environment in the evaluation of CAI. This study is an attempt to fill this gap and hopefully, it will serve as a catalyst for further research into the use of CAI in the classroom.