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.

It is important to emphasize at this point that this study was done in the natural educational settings of a school, included the use of CAI within a context of intensive Physical Science study, and not an isolated experience at all, thus adding additional validity to the findings. Thus, it can be said in the light of the present study’s findings that CAI software are far from the magic bullet many look for in science education, provided that they are properly designed and applied in the appropriate contexts.
Chapter 6

SUMMARY, FINDINGS, IMPLICATIONS,
RECOMMENDATIONS, AND SUGGESTIONS

6.1 Introduction

Nowadays, the computer is generally employed in education as a facilitator, as an evaluator of student learning as well as a personal tool or ‘tool to think with’ for both students and teachers. According to Taylor (1980), “a computer can be a tool, tutor, and tutee”. Learning about the computers focuses on developing technological/computer literacy. Learning with the computer means focusing on how the computer can be the means to learning ends across the curriculum. CAI belongs to the category of learning with the computer. The most important characteristics of CAI as a teaching and learning medium are individualization, self-paced learning, self-directed learning, the exercising of various senses, and the ability to represent content in a variety of media. The most striking potential of CAI is its promise for individualizing instruction. Even with widespread optimism about the usage of CAI in the science classroom, confounding research findings on the comparative effectiveness of CAI versus traditional instruction are present in the science education literature. Some research found that CAI was effective in improving students’ science achievement or their attitudes toward science (Chang, 2001a, 2001b, 2002; Ferguson & Chapman, 1993; Levine, 1994; McCoy, 1991; Yalcinalp, Geban, & Ozkan, 1995). On the other hand, other researchers have found that the CAI approach has no significant effects on cognitive achievement or science learning (Morrell, 1992; Olugbemiro, 1991; Wainwright, 1989). The aforementioned mixing research results perhaps stemmed from some unknown factors that might have revolved around the CAI treatment and students’ perceptions of learning environment in the science classes. After reviewing meta-analyses and other studies of media’s influence on learning, Clark (1983, 1985) concluded that there are no learning benefits to be gained from employing any specific medium to deliver instruction. He went on to argue that most media or CAI comparison research, which compared CAI with conventional instruction or other media, has merely suffered from inherently flawed methodologies. He also made the claim that media are only the vehicles that deliver instruction but
that they do not influence student achievement or learning (Clark 1994). In view of that, it might be more important and appropriate to investigate the relative effectiveness of different computer assisted instructional methods and traditional teaching on students’ science learning outcomes. Furthermore, while a number of previous studies and meta-analyses have primarily focused on the comparative efficacy of computer assisted instruction versus traditional instruction in the area of science education, there are relatively fewer inquiries exploring how various teaching formats or approaches of CAI, namely, teacher-centered and student-centered CAI influence students’ science learning outcomes in the secondary classroom. Unfortunately, in India, there is not only a limited number of research studies that had focused primarily on the comparative efficacy of CAI versus traditional instruction but also hardly any research investigating how different teaching formats of CAI can influence students’ learning outcomes in the area of Physical Science at secondary school level. Therefore, this study was undertaken to compare the effects of traditional teaching, teacher-centered and student-centered CAI on secondary school students’ attitude and achievement in Physical Science with the aim of improving science instruction in the secondary school classrooms of India. 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.

6.2 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”

6.3 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.

6.4 Hypotheses of the Study

H\textsubscript{0} 1: There is no significant difference between the mean pre-test and post-test Physical Science attitude scores for students in the control group.

H\textsubscript{0} 2: There is no significant difference between the mean pre-test and post-test Physical Science attitude scores for students in the TCCAI group.

H\textsubscript{0} 3: There is no significant difference between the mean pre-test and post-test Physical Science attitude scores for students in the SCCAI group.

H\textsubscript{0} 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.

H\textsubscript{0} 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.

H\textsubscript{0} 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.

H\textsubscript{0} 5: There is no significant difference between the mean pre-test and post-test achievement scores for students in the control group.

H\textsubscript{0} 6: There is no significant difference between the mean pre-test and post-test achievement scores for students in the TCCAI group.

H\textsubscript{0} 7: There is no significant difference between the mean pre-test and post-test achievement scores for students in the SCCAI group.

H\textsubscript{0} 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.
$H_0$ 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.

$H_0$ 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.

$H_0$ 9: There is no significant difference between the mean post-test achievement 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.

$H_0$ 10: There is no significant difference between the mean post-test achievement 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.

$H_0$ 11: CAI attitude subscales do not significantly predict the attitude towards Physical Science for students in the TCCAI and SCCAI groups respectively.

$H_0$ 12: CAI attitude subscales do not significantly predict the achievement in Physical Science for students in the TCCAI and SCCAI groups respectively.

$H_0$ 13: CAI environment subscales do not significantly predict the attitude towards Physical Science for students in the TCCAI and SCCAI groups respectively.

$H_0$ 14: CAI environmental subscales do not significantly predict the achievement in Physical Science for students in the TCCAI and SCCAI groups respectively.

6.5 Research Design and Methodology

In this study, a randomized pretest-posttest control group design (Campbell and Stanley, 1966) was used as shown in Figure- 6.1, because it is a true experimental design which controls for nearly all sources of internal and external invalidity.

6.5.1 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
204 students enrolled in Class X of a Secondary School

Control Group (68 Students)
Experimental Group A (68 Students)
Experimental Group B (68 Students)

PSAS, PSAT

Traditional Teaching
Teacher – Centered CAI
Student – Centered CAI

PSAS, PSAT

2 Months Later

4 Chapters

Figure 6.1: Figural Representation of Randomized Pretest – Posttest Control Group Design

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. 204 students were included in data analysis due to missing data for 6 students.
6.6 **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.

6.7 **Data Collected for the Study**

In order to measure students’ attitude towards Physical Science and their achievement in Physical Science, PSAS and PSAT were administered as pre-tests and post-tests respectively to students in all the three groups at the beginning and end of the intervention period. CAIAS and CAIES were administered only to the students of both the experimental groups at the end of the intervention period and their respective subscales were used to predict their attitude and achievement in Physical Science.

6.8 **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

Effect size (that is, Partial Eta Squared, \( \eta^2 \)) to assess the proportion of variance in dependent variables (attitude and achievement in Physical Science at post-test stage) that is predictable from independent variables (instructional method and gender) and covariate when the variance associated with other predictors or independent variables has been partialled out or removed

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

6.9 Findings

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

6.9.1 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, $F(2, 197) = 15.21, p < .05$, 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, $F(2, 197) = 0.50, p > .05$. 
6.9.2 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, $F(2, 197) = 0.72, p > .05$.

6.9.3 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.

6.9.4 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.

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

1. CAI attitude subscales significantly predicted the attitude towards Physical Science for students in the TCCAI group, $F (5, 62) = 7.29, p < .001$. They
together accounted for 31.9% of the variance in attitude towards Physical Science ($R = .608, R^2 = .370, \text{Adjusted } R^2 = .319$).

i) 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 TCCAI group.

ii) Integration and perceived effectiveness respectively explained 14.5% and 4.5% of the variance in attitude towards Physical Science for students in the TCCAI 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 ($R = .597, R^2 = .357, \text{Adjusted } R^2 = .305$).

i) 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.

ii) 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.

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

1. CAI attitude subscales significantly predicted the achievement in Physical Science for students in the TCCAI group, $F (5, 62) = 21.49, p < .001$. They together accounted for 60.5% of the variance in achievement in Physical Science ($R = .796, R^2 = .634, \text{Adjusted } R^2 = .605$).

i) 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 TCCAI group.

**ii)** 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 ($R = .752, R^2 = .566, \text{Adjusted } R^2 = .531$).

**i)** 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.

**ii)** 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.

**6.9.7 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 ($R = .601, R^2 = .361, \text{Adjusted } R^2 = .331$).

**i)** 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.

**ii)** 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 ($R = .542, R^2 = .294$, Adjusted $R^2 = .261$).

i) 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.

ii) Emotional subscale accounted for 27.9% of the variance in attitude towards Physical Science for students in the SCCAI group.

6.9.8 Combined and Individual effect of CAI Environment Subscales on Achievement in Physical Science for students in the TCCAI and SCCAI groups

1. CAI environment subscales significantly predicted the achievement in Physical Science for students in the TCCAI group, $F (3, 64) = 22.19, p < .05$. They together accounted for 48.7% of the variance in achievement in Physical Science ($R = .714, R^2 = .510$, Adjusted $R^2 = .487$).

i) 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 TCCAI group.

ii) Cognitive and interaction subscales respectively accounted for 35.4% and 3.7% of the variance in achievement in Physical Science for students in the TCCAI 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 ($R = .583, R^2 = .340$, Adjusted $R^2 = .309$).

i) 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.

6.10 Educational Implications

The findings of the present study contribute to the existing knowledge on the effectiveness of CAI on students’ attitude and achievement in Physical Science. In addition to providing empirical data to fill in the gap in the national and international literature, this study provides useful information that may be of value to teachers and researchers in India and other developing countries. Educationists all over the world have emphasized that the quality of instruction is the most important school-related factor influencing the students’ achievement and attitudes toward various academic subjects, instructional method, and learning environment. In the light of this perspective, the observations and findings of the present study may have strong and useful educational implications in the existing school educational set-up of India, which are discussed as follows:

1. This study has evaluated the effectiveness of CAI software and also, supported the reliability and validity of CAIAS and CAILES when used specifically with a sample of secondary school students. Therefore, teachers and future researchers can use CAI software and both scales with secondary school students all over India so as to obtain a complete picture of those features of the software and those aspects of the learning environment which are most likely to promote students’ attitude and achievement.

2. One of the study’s major contributions was that a new CAI attitude scale was developed and validated specifically for the CAI software developed and used in this study and unique setting of computer assisted instruction in secondary school science classroom. The subscales in this instrument were found to display adequate internal consistency reliability. It is likely that other researchers will find this new instrument useful in future evaluations of CAI software.
3. The present study provides teachers with guidelines and step-wise procedure for developing multimedia CAI software and evaluating its effectiveness in a regular school setting. The teachers could also use these guidelines for testing the effectiveness of a number of commercial educational software available in India which can be accessed online as well as offline and are designed for school education and different educational boards in India.

4. 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.

5. The major outcomes from this part of the study suggested that the interaction with CAI software provides students of SCCAI group with enhanced opportunities to learn, practise, and master science concepts at their own pace. Overall, the different aspects of the study provided complementary insights into learning in a context which was designed to emphasize the integration of CAI into science teaching-learning process.

6. 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.

7. The findings of the present study, regarding the effects of different features of multimedia CAI software and different aspects of CAI learning environment, have a number of implications for instructors or teachers and instructional designers. These findings clearly indicate the sets of characteristics and features that students perceived as strengths and weaknesses of CAI software. This information can subsequently be used to modify and fine-tune the CAI software and other existing commercial software if they are to be used with future groups of students. This information can also be used for the development of future CAI software.

8. This study also provides science teachers with information about important aspects of the learning environment that, if altered, could lead to increases in students’ attitudinal and achievement gains. This study has indicated that many aspects of learning environment are associated with students’ attitudinal outcomes. For example, favourable attitudes were found to be associated with students’ positive perceptions of the cognitive, emotional, and interaction dimensions. Associations between students’ perceptions of the learning environment and achievement outcomes reported in this study suggest that the provision of a learning environment that is suitably sound on its cognitive, emotional, and interactive dimensions is more likely to promote achievement.

9. In the present study, the students’ attitude towards CAI and their perceptions of the computer assisted learning environment significantly influence their attitude and achievement in Physical Science. This means, of course, that the factors which influence the success of CAI and the implementation of computer use in school must be carefully handled. The students’ attitudes are of crucial importance to the success or failure of educational approaches and media, for a negative reaction will inhibit learning whereas a positive one will make students more receptive to the learning activity.
6.11 Recommendations for Practice

The study results do not call for immediate and widespread change in the teaching of science. However, a discussion should begin among the science teachers in Aligarh district and other states of India concerning the use of CAI. Some schools have the equipment and are not using it. Others would like to use the equipment but do not have access to it. Many teachers have never been introduced to CAI, and could find it useful in their classrooms. Since the findings of this study revealed the positive outcomes of the effectiveness of CAI on achievement and attitude scores of secondary school students, the following recommendations for integration of CAI in science lessons should be followed in order to get effective results in the Indian school educational system:

1. Since TCCAI was found to be more effective than SCCAI and traditional instruction in enhancing students’ attitude and achievement in Physical Science, therefore science teachers of Indian schools can incorporate CAI into science teaching.

2. Since CAI software used in this study led to students’ positive attitudes toward CAI and positive perceptions of CAI learning environment, therefore it can be concluded that students are ready for the integration of computer technologies into science lessons. Hence, it is recommended that computers and educational software must be integrated into science curriculum in Indian school educational system. For more fruitful results, students should be introduced to the use of technology in their learning process prior to secondary school. As students need some time to get familiar with CAI and other educational software, therefore students should be given enough number of opportunities to use software so that they would be able to gain the knowledge and skills needed for using them appropriately.

3. One of the possible reasons for the positive effects of CAI on students’ attitude and achievement in this study was that the participating teachers were properly trained in using and integrating CAI software into science teaching. Since teacher's abilities and skills play a crucial role on the effectiveness of CAI, therefore teachers’ training for successful integration of educational
software should be given due importance. In order for teachers to use CAI effectively in the science classroom, they need to receive sufficient training in order to be comfortable using this technology with students. Student teachers in the education departments, pre-service and in-service teachers should be trained in computer-based education. For this purpose, NCERT and DIETs (District Institute of Educational Technology) should start and provide a certification course on CAI for school teachers.

4. Pre-service teacher training programs such as B.Ed. conducted by education departments or teachers’ training institutions should also involve a course to inform prospective teachers about the benefits of CAI and how to integrate computers into science teaching. Suitable arrangements should be made by departments or institutions for prospective teachers to teach at least two lessons using CAI during their teaching practice, so that they can integrate computers into their teaching more easily when they will become professional teachers.

5. Teachers should have knowledge of how technology can influence their students’ understanding of the science concepts, achievement, and attitudes; they also should understand how to use technology and how to select appropriate software. There is a need to provide teachers with opportunities to develop teaching methods for computer integration. Courses for teachers might be designed to help them gain competency of “teaching with computers”.

6. Science curriculum and textbooks should be revised based on the novelties in educational technologies and computer technologies. Curriculum developers should take the effectiveness of CAI into consideration during curriculum development process. The involvement of computers in science curriculum will accordingly make teachers give more importance to CAI. The textbooks published by NCERT and most of the publishers in India have not taken into consideration the benefits of CAI. It’s high time for them that they should supplement their books with educational CDs designed and developed on the pattern of CAI and its various modes.
7. All schools in India should have a computer laboratory that can be used to support the conventional teaching methods for the subject matter presentation. Teachers should consider CAI as a supplement rather than a substitute for traditional instruction and make use of TCCAI and SCCAI as per the available facilities and requirements of the subject matter to be taught.

8. The government should provide schools, education departments, and other teachers’ training institutions with larger technology budgets. Technology resources (hardware, software, and Internet access) should be provided in every school and department. In this context, it can be suggested that each school and department should have one computer lab and one multimedia room. Moreover, at least one computer with Internet access should be made available in computer lab and multimedia room. In addition to the supply of resources, technical support should be provided to schools and teachers to use these resources effectively.

6.12 Suggestions for Further Research

Based on the results and findings revealed from the study, recommendations for future research on this topic are as follows:

1. This study was limited to class X students enrolled in Ayesha Tarin Modern Public School in Aligarh, and it can be replicated with a larger sample size for generalization to a bigger population. Future research should be undertaken with bigger and broader samples to improve confidence in the findings. Such studies could include samples from primary, secondary and college levels in India to examine whether the findings of the present study can be generalized to other states within India by including more grade levels in order to investigate the effectiveness of CAI in science education.

2. CAI can be administrated to different topics and branches of science.
3. Since this study evaluated the effectiveness of CAI software for teaching four chapters of Physical Science, therefore further study would be required to determine what effects the CAI software, if used for the entire syllabus, would have on students’ attitude and achievement.

4. Since this study was conducted for a period of eight weeks, therefore further study would be required to determine what effects the CAI software, if used for the entire one semester or for the entire session, would have on students’ attitude and achievement.

5. Future researchers should undertake studies to determine the effectiveness of various types of CAI for different subject areas and at different grade levels. For instance, further research studies should be conducted for different subject matters such as Mathematics and foreign languages.

6. Different kinds of educational software can be developed and utilized in order to assess the attribution of a particular software type.

7. Researchers can carry out research studies to provide the effectiveness of CAI not only on attitudes but also on motivation.

8. Further research needs to be conducted which address the effectiveness of CAI among different periods of instructional time in terms of weeks.

9. If random assignment is not possible for sampling, a quasi-experimental method can be used for this type of research study.

10. Further studies should be conducted with the students with different levels of science achievement and with different amounts of CAI activities. Results would indicate how the variance of students’ achievement level interacts with different amounts of CAI.

11. Further research studies can be carried out to examine whether or not gender differences is related to the effectiveness of CAI. Future researchers testing
interaction between instructional method and gender may improve the strength of their studies’ findings by using a large sample size having proportionately equal male and female groups.

12. Further research studies should be conducted to investigate the teacher’s readiness, attitudes and knowledge about computer-assisted science teachers.

13. This study should be replicated in other school settings such as colleges, universities and private schools. This would provide the effectiveness of computer-assisted instruction for different population in India.

14. Future researchers should also aim at exploring the different ways in which male and female students view the different features of multimedia CAI software and different aspects of CAI learning environment and the use of computers in their science courses at different school levels in India. This would help them not only in identifying the general trends concerning students’ perceptions of the effectiveness of CAI in science courses at different school levels but also in finding out the differences in perceptions, if any, between male and female students.

15. It is very important to carry out longitudinal studies to study the effects of the inclusion of CAI in science teaching at schools. For such studies, computers should be included during earlier grades in order to determine what effect the inclusion of CAI in the lower grades would have on students’ achievement, attitudes toward science and CAI, and perceptions of CAI learning environment as they move to higher grades. For instance, follow-up studies should be conducted to assess the students’ gains after the second and third years of CAI implementation.

16. Future studies should employ qualitative data collection methods (such as, interviewing procedure or focus-group interviews) to explore the students’ perceptions toward CAI software and CAI learning environment.
CAIAS and CAILES respectively could be used by future researchers to assess the teachers’ attitude towards CAI and their perceptions of CAI learning environment, as well as to compare the teachers’ attitude and perceptions with those of their students. This would help in investigating the extent to which there is a correspondence between the two groups’ attitudes and perceptions.