CAI and conventional method for retention of mathematics: an experimental study

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Abstract. An experimental study was conducted to compare the effectiveness of Computer Assisted Instruction (CAI) and Conventional Method (CM) for retention of Mathematics in Higher Education. Instructional and measuring tools were developed for five units of Matrix Algebra, two units of Calculus & five units of Numerical Analysis. Pilot study was also conducted to examine reliability and validity of tools. Ninety undergraduates participated in final investigational study. Pre-test – Post-test Equivalent – Groups research design was used. SPSS v.16 was used for data analysis. Findings supported efficiency of CAI for retention of basic mathematical concepts. Administrators should encourage faculty members to develop Computer Assisted Instructional Material (CAIM) for retention of basic Concepts of Mathematics in Higher Studies.

1. Introduction
Mathematics is the queen of sciences. Physics, Chemistry and Cosmology has no existence without Mathematics. It is supreme and tolerates no mistake. Its facts drive the whole world. It is an important discipline and needs to be augmented in education to prepare learners with skills necessary for achieving higher education, research and personal satisfaction. National Education Policy 1986 emphasizes that Mathematics should be visualized as the vehicle to train a child to think, reason, analyze and articulate logically. This objective can be achieved by better understanding of the subject. For this, teacher has to improve the quality of Mathematics education. In order to strengthen the education of Mathematics, the need of hour is to setup an effective and smart Mathematics Classroom where whiteboards can be used for power point presentations, calculators for programming and screen of computer as teaching device. Now the question is how to manage such an effective and meaningful Mathematics Classroom? In this technical era, the most useful gift of Science and Technology is computer. It is playing a tremendous role in almost all walks of human life. Mode of instruction in Mathematics is not away from its effect as it has the potential to influence the learners as well as learning process. Now-a-days, it is considered as super-teaching machine. It is not just a tool like whiteboard but it is frequently used as mode of instruction named as Computer Assisted Instruction (CAI). CAI is an effective mode for maintaining the attentiveness of learners. It can be used for providing instructional material to the learners in different disciplines. It has influenced the traditional course like Mathematics and also improved the quality of instruction in creating a thrilling learning environment of mind-numbing mathematics classroom [1].
1.1. Computer Assisted Instruction (CAI)
CAI is a mode of instruction in which computer is used for presenting as well as monitoring the learner's learning up to the desired level of proficiency. In this study, CAI means providing self-learning material to the undergraduates through computer which is learnt at their own pace. The instructional material for CAI is prepared in the form of frames followed by self-evaluated questions in multiple choice formats.

1.2. Conventional Method (CM)
Conventional Method (CM) is that mode of instruction in which the teacher is the centre of teaching learning process. In India, it is known as a teacher-oriented Lecture-Method used for presentation of a textbook material with the help of chalk board. It is also known as Traditional Method or Lecture Method. In this experimental study, Conventional Method (CM) means that method of instruction where the teacher plays a major role and the lesson is also planned. Objectives are framed and stepwise evaluation is done at every stage. Same material used for CAI is utilized in the planning of CM.

1.3. Undergraduates
Students in a university or college who have not received bachelor's degree are termed as undergraduates. In this study, undergraduates are female students studying Mathematics in B.A./B.Sc. of Banasthali Vidyapith, Rajasthan, India.

1.4. Retention
Retention refers to the scores obtained by undergraduates on Retention Tests in the form of Criterion Referenced Tests (CRTs). These tests have been developed by the researcher for CAI and Conventional Method on selected subject area of Algebra, Calculus & Numerical Analysis in Mathematics.

1.5. Objectives of the study
The main objectives of the study were to

- Develop and validate the tools for CAI and Conventional Method for retention of Mathematics at undergraduate level.
- Compare the effectiveness of CAI and Conventional Method for retention of Mathematics at undergraduate level.

1.6. Hypotheses
According to the objectives of the study, the null hypotheses were framed as follows:

H01 There is no significant difference in mean retention scores of undergraduates for retention of Mathematics within experimental group using CAI and control group through Conventional Method

H02 There is no significant difference between mean scores of undergraduates in experimental group using CAI and control group through conventional method for Mathematics at Entry Level.

H03 There is no significant difference between mean retention scores of undergraduates in experimental group using CAI and control group through conventional method for retention of Mathematics.

1.7. Rationale of the study
Lot of researchers has conducted researches on CAI as method of instruction. The researchers have found its effectiveness for teaching learning process in Mathematics from primary to higher secondary level [2–13]. But there is lack of researches on CAI in Mathematics for higher studies in Indian situations. The author has noted that nowhere in higher education has there been as much change as in the use of information technology, which may improve educational efficiency and effectiveness [14]. It can enhance traditional course and advance the quality of instruction. It is also widely believed by
university administrators and educational leaders that technology-based instruction may develop essential skills among students to survive in this technical era. It will certainly increase their knowledge, understanding and talent in learning new concepts. Students in this form of instruction can participate in the educational process anytime and anywhere in overcoming traditional barriers of time and place [15]. Researchers have also indicated that CAI can be prospective for quality instruction in Mathematics. Along with it, students learn material faster through CAI. Certainly students cannot learn the entire topics by themselves using CAI, as role of teacher is very important. So CAI can be used as a supplement for some important units of Mathematics [16]. Keeping in mind the problem of better understanding, clarity of Mathematical Concepts and maintaining the quality of Mathematics, the researcher developed and implemented the Computer Assisted Instructional Material in the Department of Mathematics & Statistics, Banasthali Vidyapith, Rajasthan, India. The effectiveness of Computer Assisted Instruction and Conventional Method for retention of Mathematics for the selected units of Algebra, Calculus and Numerical Analysis at undergraduate level was also evaluated [1, 17-18].

2. Method and procedure of experiment

2.1. Design of the study

In this study, Pre-test - Post-test Equivalent - Groups research design was used [19, p181].

2.2. Validation of tools for the data collection

The researcher herself developed Computer Assisted Instructional Material (CAIM) i.e. Software package for CAI and planned lessons for Conventional Method (CM). It included five sessions of Matrix Algebra, two sessions of Limit and Continuity & five sessions of Numerical Methods for the solution of algebraic and transcendental equations. It was developed in Microsoft Office Power Point 2007 inserting hyperlinks and actions. This material covered Introduction to Matrices; Types of Matrices; Basic Operations on Matrices; Elementary Matrix Operations and Echelon Form of a Matrix, Formal definitions of the limit of a function; Continuous functions and Classifications of discontinuity in Limit and Continuity, Introduction to Errors in Numerical Computations: Bisection Method; Regula Falsi Method; Newton Raphson Method; Order of convergence for Numerical Methods in Solving Algebraic and Transcendental Equations. CAIM resembled with a test but it was not a test. It was self-learning material. The criteria of 85% success were adapted to evaluate the efficiency of CAIM. Validity and suitability of these tools was calculated in terms of gain score for CAIM in pilot study of 33 undergraduates. Average gain scores for all specified Mathematical Concepts for whole CAIM were .86 on Attainment Tests and .87 on parallel test during parallel administration of tests. For this experimental study, three Attainment Tests & three parallel attainment tests in the form of Criterion Referenced Tests (CRTs) along with their scoring keys were also developed by the researchers. These were prepared for Matrix Algebra in Algebra, Limit & Continuity in Calculus and Numerical Methods for the solutions of algebraic and transcendental equations in Numerical Analysis i.e. MAT (Matrix Algebra Test), CAT (Calculus Attainment Test) & NAT (Numerical Analysis Test) for Algebra, Calculus and Numerical Analysis respectively. An Attainment Test MCT (Mathematical Concepts Test) was an Attainment Test by adding all test items of three Attainment Tests to measure the attainment of selected Mathematical concepts. Parallel Attainment Test PMCT was also prepared by adding PMAT, PCAT & PNAT. The items in MCT and PMCT were of various types such as Objective Type, Completion and Short Answer Type. The content validity of the MCT, PMCT and Scoring keys was determined by the subject experts. Individual and small group try-out was carried for the editing of content material. Reliability co-efficient of measurement tools was Kappa (.89) in terms of the consistency of decision - making process across as alternate forms of attainment test at mastery level. It was calculated in terms of mastered and non-mastered group in pilot study for 33 undergraduates [20].

2.3. Sample and procedure of the final study

The sample for this experimental study was selected from Banasthali University, Rajasthan, India having smart computer lab. Purposive sampling technique was used to select groups by the researchers. In the
beginning, 100 under graduates (females), who offered Mathematics as elective subject, were selected. Raven's intelligence test was given to students for matching their level of intelligence. Both groups were also pre-tested with Mathematical Concept Test (MCT) at entry level to find out whether they have not learnt the unit beforehand. On the basis of the scores obtained in I.Q. Test and Pre-test, the undergraduates were matched and equally distributed in experimental and control group for final experiment. After controlling the effects of confounding Variables, the sample size was reduced to 90 at the time of analysis. Each group had 45 students. The experimental group was exposed to CAI and control group was instructed through Conventional Method. After seven days, PMCT (Post-test) was conducted at retention level. The scores obtained in Pre-test and Post-test were recorded for data analysis.

3. Results and discussions

3.1. Results

In order to analyze the data, SPSS v.16 was used. The effect of instructional material for CAI and Conventional Method for the retention of all the specified Mathematical Concepts within each group as well as in between the groups was evaluated. Gain Ratio in terms of learning gains were also calculated for both modes of instruction (table 1). Paired t-test was used to compare the results from Entry Level to Retention Level (table 2) for each group and Independent t-test was also used to compare experimental group and control group at Entry Level & Retention Level (table 3).

| Sr. No. | Level  | Mode | Total Average Gain Scores | Learning Gain for Entire Group on Average |
|---------|--------|------|---------------------------|------------------------------------------|
| 1.      | Retention | CAI  | .85                       | 85%                                      |
|         |         | CM   | .78                       | 78%                                      |

It is also clear from above table 1 that learning gain for experimental group using CAI was 85% whereas 78% for Conventional Method in retaining all specified Mathematical Concepts. This means that instructional material for both modes of instruction was satisfactory at the level of retention. Based on these results, material was taken as good enough for use during experimental study.

Table 2. Results of paired t-tests for experimental group and control group from Pre to Post stage in retaining all specified Mathematical Concepts.

| Area | Mode | Paired Sample Statistics | Paired Sample Test |
|------|------|--------------------------|--------------------|
|      |      | Stage | Mean | SD  | Paired Differences | T   | df  | Sig. |
|      |      | Mean | S.D. |     |                  |     |     |     |
| CAI  | Post | 222.33 | 12.224 | 165.089 | 9.33 | 118.613 | 44 | .000 |
| CM   | Pre  | 57.24  | 19.005 |        |      |        |    |     |
|      | Post | 209.04 | 11.066 | 152.02 | 11.16 | 91.32  | 44 | .000 |
|      | Pre  | 57.02  | 19.841 |        |      |        |    |     |

It can also be observed from the table 2 that there is a significant difference in the scores for Post (M = 222.33, SD = 12.224) and Pre (M = 57.24, SD = 19.005) conditions; t (44) = 118.613, p = .000 in for experimental group in retaining all specified Mathematical Concepts. Also, there is a significant difference in scores between Post (M = 209.04, SD = 11.066) and Pre (M = 57.02, SD = 19.841) conditions; t (44) = 91.32, p = .000 for Control group in retaining all specified Mathematical Concepts. Therefore, in the study, null hypothesis was rejected and alternate was accepted at Retention Level.
Mean Gain Scores form Entry Level to Retention Level supported the effectiveness of CAIM for CAI and Planning of Lessons for Conventional Method in retaining all specified Mathematical Concepts.

Table 3. Results of independent t-test between experimental group & control group for Retention of Mathematics.

| Group      | Statistics | Independent Sample Test for equality of mean |
|------------|------------|---------------------------------------------|
|            |            | t   | d. f. | Sig.(2-tailed) |
| Stage      | Mode       | N   | Mean  | S.D    |               |
| Pre        | CAI        | 45  | 57.24 | 19.005 | .054          | 88  | .957          |
|            | CM         | 45  | 57.02 | 19.841 |               |     |               |
| Post       | CAI        | 45  | 222.33| 12.424 | 5.358         | 88  | .000          |
|            | CM         | 45  | 209.04| 11.066 |               |     |               |

It can be observed from the table 3 (Pre stage) that Comparison of Pre-test Score for CAI (M = 57.24, SD = 19.005) and Conventional Method (M = 57.02, SD = 19.841) revealed no significant differences between Groups t (88) = .054, p= .957. Thus null hypothesis was accepted at Entry Level. This also indicates that entry level for both the groups were similar in the study. It is also clear from the table3 (Post stage) also reveals that experimental group using CAI recalled significantly more scores (M = 222.33, SD = 12.424) than the control group using Conventional Method (M = 209.04, SD = 11.066), t (88) = 5.358, p = .000. Hence null hypothesis was rejected at retention level and alternate hypothesis accepted. It means that CAI was found better for retention of Mathematics.

3.2. Discussions

At the commencement of the study, both experimental group and control group were matched on the basis of intelligence test and pre-test scores. Paired t-test was used to compare Pre-test and Post-test results within each group. Also Independent t-test was used to compare Pre-test and Post-test results of CAI and Conventional Method in between experimental group and control group for all specified Mathematical Concepts. Performances of the undergraduates form Entry Level to Retention Level showed significant difference within both groups for all specified Mathematical Concepts (table 2 & table 3). These results indicated the efficiency of instructional material in both experimental group and control group for retention of all specified Mathematical Concepts at undergraduate level. Gain Ratio in terms of Learning Gains Scores at Retention Level also supported the effectiveness of instructional material for both modes of instruction (table 1). It meant that CAI offered a valuable means for improving mathematical knowledge at undergraduate level. These results were also supported by the results of [21] in Chemistry and [22] in Physics for effective use of CAI. The obtained results also indicated that both the groups did not differ significantly at Pre stage for all specified Mathematical Concepts (Pre stage of table 3). It also pointed out that Entry Level behavior of undergraduates for both the groups were similar. The reason might be that undergraduates had not read the particular Mathematical Concepts before the treatments. These results were supported by the findings of [3] and [11]. Comparison between experimental group using CAI and control group using Conventional Method was also done in retaining specified Mathematical Concepts. The results indicated the significant difference between the mean retention scores of experimental group and control group (Post stage of table 3) The probable reason for such results might be that Computer Assisted Instruction provided freedom to the undergraduates to learn at their own pace. Undergraduates were not compelled to follow the speed of teacher as in case of Conventional Method of Instruction. Moreover, when learner learned at own speed then the concepts could be revised till mastery level. Another feasible reason of better retention through CAI was that in this mode of instruction, content was made available to the undergraduate in the form of frames. Each frame had its own number and multiple choice questions in the end for recapitulation of the concept. If correct option was chosen, next frame appeared after getting feedback. In case of wrong response, learner had to read the frame again until the correct option was selected. These questions prepared students to revise content again and again. That is why; the undergraduates retained more in CAI than Conventional Method. These results were supported by the
results of [3] in terms of effective influence of CAI in retention of Mathematical Concepts. On the basis of these discussions, it may be resolved that CAI being an auto instructional mode of instruction helped in improving the retention of Mathematical Concepts at undergraduate Level. It was also observed during the experiment that CAI developed the self-confidence and reduced the Math Phobia among the undergraduates through self-instruction.

4. Conclusion
On the basis of above discussions, it may be resolved that CAI being an auto instructional mode of instruction helped in improving retention of Mathematics at undergraduate Level. This study may help the mathematicians to choose CAI as mode of instruction for teaching learning process of Mathematics at undergraduate level. The use of CAI can improve academic achievements of undergraduates in mathematics at their own pace. Therefore, Administrators should motivate faculty members to develop Computer Assisted Instructional Material (CAIM) for Mathematics in Higher Education. Moreover, CAIM for different levels of learners in different subjects can also be prepared and analyzed for effective teaching learning process.

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