# ICT MEDIATED COGNITIVE APPRENTICESHIP MODEL, AND ITS EFFECT ON CRITICAL THINKING SKILLS AND ACHIEVEMENT IN MATHEMATICS OF YEAR EIGHT RURAL SCHOOL STUDENTS - PROMOTE HARMONY THROUGH THIS MODEL

[1] Sofia Shireen N. K. Ali, [2] Dr (Mrs.) Flosy C. R. D'Souza

[1] Ph.D. Research Scholar, (Fiji), Mangalore University [2] Associate Professor and Research Guide St. Ann's College of Education, (Autonomous) Mangalore India

**Abstract:**

This new era of modernization is all out for information and knowledge. To produce individuals and citizens who would be able to fit themselves in this present world scenario, every branch of learning and education system needs to be oriented in such a way that it develops a sense of harmony among themselves. Any subject you take, whether be Mathematics or ICT it should be taught in such a way that it can enable students to develop their capacities in creating classrooms that allow them to live in harmony with a dignified life.

Thus to promote this harmony, ICT has become a standard tool for supporting and transforming teaching and learning in mathematics classrooms. This research is carried out to examine the Effect of the ICT mediated Cognitive apprenticeship model using a free open source software called Dynamic Mathematics software (GeoGebra) on students' Critical Thinking Skills and Achievement in Mathematics to develop harmony through this model

The Cognitive Apprenticeship model encourages respect for diversity as different groups of students to work together collaboratively in trying to use the GeoGebra software on computers, laptops, or tablets.

To conduct this experiment, the researcher used an experimental design called 2x3 factorial design, which included the pre-test and post-test method. The innovative group ICT mediated CAM group was taught with the ICT mediated Cognitive Apprenticeship model (GeoGebra software) while the other group was exposed to the CI. The findings indicated that students have positive attitudes toward the use of GeoGebra with Cognitive apprenticeship model in teaching and learning of Mathematics, which in turn promotes harmony among each other while carrying out the given task.

**Keywords:** Achievement, Bloom's Taxonomy, Conventional learning, Critical Thinking skills, Dynamic Mathematics Software, GeoGebra, and ICT mediated Cognitive Apprenticeship model, Open-source Software.

## 1. Introduction

ICT has become one of the powerful resources of learning. The evolution in using technology and the learning process has grown up by heaps with restrictions. ICT allows easy access to information and other cutting-edge research to make learning easier. The school system has become part of the universal economic era. The electronic learning environment affects and shapes the available content absorbed by e-learners. Today with computers taking over, jobs that can be done with minimum education are fast diminishing. The use of technology will also promote harmony through education; "harmony is when you feel happy. Harmony is while people are all getting along together. Harmony is when people are nice to one another. Harmony is the flow of life."

ICT has revolutionized the way we work and is now set to transform education. Children cannot be useful in tomorrow's world if they are trained in yesterday's skills. Nor should teachers be denied the tools that other professionals take for granted. (Department for Education and Employment [DfEE], 1999)

This study emphasis is on the use of ICT for the harmonious world through ICT mediated Cognitive apprenticeship model in improving critical thinking skills and achievement in the mathematics of upper primary school students.

Education is significant to the improvement of harmony, is required to upgrade effectiveness among educators as well as learning efficiency among students or the leaners. Ilogu (2005) submitted that "students learn in a range of ways, and their ability to assimilate information also varies." A student's capacity to absorb is impacted by the teacher's style of conveying information, that is, the teaching methodology adopted by the teachers to facilitate a learning process that can help in developing their skills in understanding harmony.

Nowadays, it is the need to prepare our students for the 21st century. But in the conventional instructional method, the textbook as the primary tool alone is insufficient to meet the demand of the students as they find it difficult to visualize the concept and to grasp information that is presented either verbally or in the text. The use of ICT enhances active self-learning among students. The idea of theory and practice can be taught with the help of the Dynamic Geometry software in Mathematics.

Thus to achieve useful instructions, the instructor needs to create an enjoyable learning environment that will develop critical thinking skills that can allow them to improve their skills in living peacefully in society. Studies conducted over the years have indicated that the use of ICT and the cognitive apprenticeship model can address different styles of learners in a classroom that can develop critical thinking skills and Achievement in Mathematics.

The investigator felt that the ICT mediated Cognitive Apprenticeship model had contributed a lot to the field of education. Thus it craved the investigator to study more about the contribution of ICT with Cognitive apprenticeship models development of critical thinking skills in students as well as improving their scores in mathematics, which as a hidden way, develops them to be a harmonious citizen in the society. Nowadays, learner-centered education is widely accepted everywhere. To make it meaningful, different subjects in the curriculum require different approaches — irrespective of the nature of the subject matter.

It is proven that upper primary school children learn more effectively when they are actively involved in the learning process. This underlines the fact that while doing mathematics, children earn more effectively when they participate, handle and manipulate the questions during the teaching-learning process.

**Theoretical Basis of the Cognitive Apprenticeship model**

Cognitive Apprenticeship Model is based on the concept of constructivism. As an instructional design, it is developed by Collins and Brown (1989). It emphasizes the teaching of cognitive skills rather than physical abilities, and learning occurs through interaction with the experienced instructor. The cognitive apprenticeship model has its origin on the Sociocultural theory of learning, Vygotsky's Zone of proximal development (ZPD), Situated Cognition, and Social Cognitive Theory.

**Cognitive Apprenticeship Model**

Cognitive Apprenticeship is a theory that endeavors to bring implicit processes out in the open. It assumes that people learn from one another through observation, imitation, and modelling.

In 1987, Collins, Brown, and Newman developed six teaching methods — modelling, coaching, scaffolding, articulation, reflection, and exploration. These methods enable students to be cognitive and metacognitive strategies for "using, managing, and discovering knowledge."

1.**Modeling**

Experts (usually educators or mentors) demonstrate a task explicitly. New students or novices shape a conceptual model of the routine at the display. For example, a math teacher might write out specific steps and work through a problem aloud, proving her heuristics and procedural knowledge.

**2.Coaching**

During Coaching, the expert gives opinions and hints to the novice.

**3. Scaffolding**

Scaffolding the practice of supporting students in their learning. Support structures are put into place. In some occurrences, the expert may have to help with aspects of the task that the student cannot do yet.

**4.Articulation**

McLellan describes articulation as (1) "separating component knowledge and skills to learn them more effectively" and, (2) more common verbalizing or demonstrating knowledge and thinking processes to expose and clarify them. " This process gets students to articulate their understanding, reasoning, or problem-solving process in a domain" (p. 482). This may include inquiry teaching (Collins & Stevens, 1982), in which teachers ask students a series of questions that allows them to refine and restate their learned knowledge and to form explicit conceptual models. Thinking aloud requires students to articulate their thoughts while solving problems. Students are assuming a critical role to monitor others in cooperative activities and draw conclusions based on problem-solving activities.

**5. Reflection**

Reflection allows students to "compare their problem-solving procedures with those of an expert, another student, and ultimately, an internal cognitive model of expertise" (p. 483). A procedure for reflection could be to examine the past performances of both expert and novice and to highlight similarities and differences. The objective of reflection is for students to look back and analyze their achievements with a desire for understanding and improvement towards the behavior of an expert.

**6.Exploration**

Exploration connects students to the opportunity to problem-solve on their own and teaching students exploration strategies. The former requires the teacher to slowly withdraw the use of supports and scaffolds not only in problem-solving methods but problem setting techniques as appropriate. It later needs the teacher to show learners how to explore, research, and develop hypotheses. Exploration allows the student to frame new problems within the domain for themselves and then take the initiative to solve these problems.

**Specification of Theory**

*(a) Goals and preconditions*

The method is intended mostly at teaching the problem-solving processes that experts use to handle complex tasks. Cognitive apprenticeships are designed to enable apprentices to learn strategies and skills in the setting of their application to realistic problems, within a culture concentrated on and well-defined by expert training.

*(b)* ***Principles***

1) Cognitive apprenticeship reassures reflection on differences between novices and expert performance.

2) Cognitive apprenticeship fosters the development of self-monitoring and correction skills required for the problem solver to alternate among different cognitive activities.

3) Sequencing: Tasks are sequenced to reflect the varying demands of learning: increasing difficulty, increasing diversity, and global before local skills

4) Sociology: With exploiting cooperation and the values of expert practice, cognitive apprenticeship extends situated learning to various settings so that students learn how to apply their skills in varied contexts with intrinsic motivation.

**Achievement In Mathematics**

Achievement in mathematics refers to the communicative evidence of cognitive effects in the discipline of mathematics, which is represented by scores obtained on the achievement test in mathematics prepared by the researcher and validated by the experts.

**Year Eight Students Of Upper Primary School**

The term upper primary in the Fiji context refers to standard or years six to eight students, including boys and girls within age limit 11-14 years studying in primary schools with a common Fiji syllabus. The year eight students are in the age group 12-14 years.

**FIJI**

Fiji officially the Republic of Fiji is an island country in Melanesia in the South Pacific Ocean about 1,100 nautical miles (2000km, 1300miles) northeast of New Zealand's north island. The closest neighbours are Vanuatu to west New Caledonia. "Fiji is an archipelago of more than 330 islands, of which 110 are permanently inhabited and more than 500 islets amounting to a total land area of about 18300 square kilometers. It has two significant islands Viti Levu and Vanua Levu, an account of 87% of the population of almost 860000."

Fiji has a total of 732 primary schools, which include government, non-government, and individual schools. Thus in this study, one district was used from which three schools were used as the samples in this context. **Fig. 1.0** below shows the map of Fiji with the identification of the area in Fiji that was as the context of the study


Figure 1.0: Map Of Fiji Islands Identifying The Context Of The Study

**The significance of the study**

Students often have difficulties in understanding the concepts in mathematics; this may be due to a lack of critical thinking skills. According to the American Philosophical Association (APA, 1990), critical thinking refers to purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference as well as an explanation. In the present study, critical thinking skills refer to a process of actively and skillfully interpreting, analyzing, inferring, evaluating, and explaining the information gathered from or generated by observation, experience, reflection, reasoning, or communication as a guide to belief and act.

This can be developed by using the cognitive apprenticeship model which has the six steps that allow in the development of this five critical thinking skills which can enhance the achievement in mathematics as well as enable students to develop an insight that as a hidden talent that can lead to good citizens of a nation.

The research on Cognitive Apprenticeship is still occasional, with bits and pieces situated in different subfields of educational research such as teacher education, adult education, school education, and multimedia-based education.

Perceptive about the increasing importance of new technologies for everyday life, several educational organizations have started to develop technology-related standards (Lawless and Pellegrino, 2007, p. 576), trying to foster the integration of new technology into teaching and learning. For example, the National Council of Teachers of Mathematics (NCTM 2000), which is the world's supreme significant association of mathematics teachers (Wikipedia, 2016), declared technology as one of their six principles for school mathematics. The review of the above studies revealed that there is not even one experimental study conducted in the area of Cognitive

Apprenticeship model on teaching upper primary school students to develop critical thinking skills that allow them to develop skills in living in peace and harmony. This motivated the investigator to select the Cognitive Apprenticeship model as the treatment variable for the present study.

The reviewed studies inspired the investigator to test the Effectiveness ICT Mediated Cognitive Apprenticeship model on the critical thinking and Achievement in Mathematics of upper primary school students in Fiji, which develops the skills in promoting harmony in a society.

**Objectives Of The Study**

1. To study the main and interaction effects of instructional Strategies (ICT Mediated CAM and Conventional Instruction CI )and Types of Learning Styles(Audio, Visual, and Kinesthetic) on the Critical Thinking skills of year eight students by taking Intelligence as Co-variate.
2. To study the main and interaction effects of Instructional Strategies ( ICT Mediated CAM and Conventional Instruction CI )and Types of Learning Styles(Audio, Visual and Kinesthetic ) on Achievement in Mathematics of year eight students of by taking Intelligence as Co-variate.

**Hypothesis Of The Study**

$H_0$(1)There is no significant difference in the main and interaction effects of Instructional Strategies(ICT Mediated CAM and Conventional Instruction CI ) and Types of Learning Styles(Audio, Visual, and kinesthetic ) on the Critical Thinking Skills of year eight students by taking Intelligence as Co-variate.

$H_0$(2) There is no significant difference in the main and interaction effects of Instructional Strategies (ICT Mediated CAM and Conventional Instruction CI) and Types of Learning Styles(Audio, Visual, and Kinesthetic) on the Achievement in Mathematics of year eight students by taking Intelligence as Co-variate.

**The Methodology Of The Study**

In the present study, two by Three (2x3) Factorial design was utilized with co-variate as (Intelligence). The model was structured so that every level of the one independent variable was coordinated or associated with the other. The variables of the study and the factorial design are summarised in **Table 1.0,** given below.

**Table 1.0: The variables of the study and the factorial design**

| Instructional Strategies (A) / Types of Learning Styles (B) | | Audio Learners ($b_1$) | Visual Learners ($b_2$) | Kinesthetic learners ($b_3$) |
|---|---|---|---|---|
| 1 | ICTMEDIATED CAM ($a_1$) | $a_1, b_1$ $Y_1, Y_2, Y_3$ X | $a_1, b_2$ $Y_1, Y_2, Y_3$ X | $a_1, b_3$ $Y_1, Y_2, Y_3$ X |
| 2 | CONVENTIONAL INSTRUCTION (CI) ($a_2$) | $a_2, b_1$ $Y_1, Y_2, Y_3$ X | $a_2, b_2$ $Y_1, Y_2, Y_3$ X | $a_2, b_3$ $Y_1, Y_2, Y_3$ X |

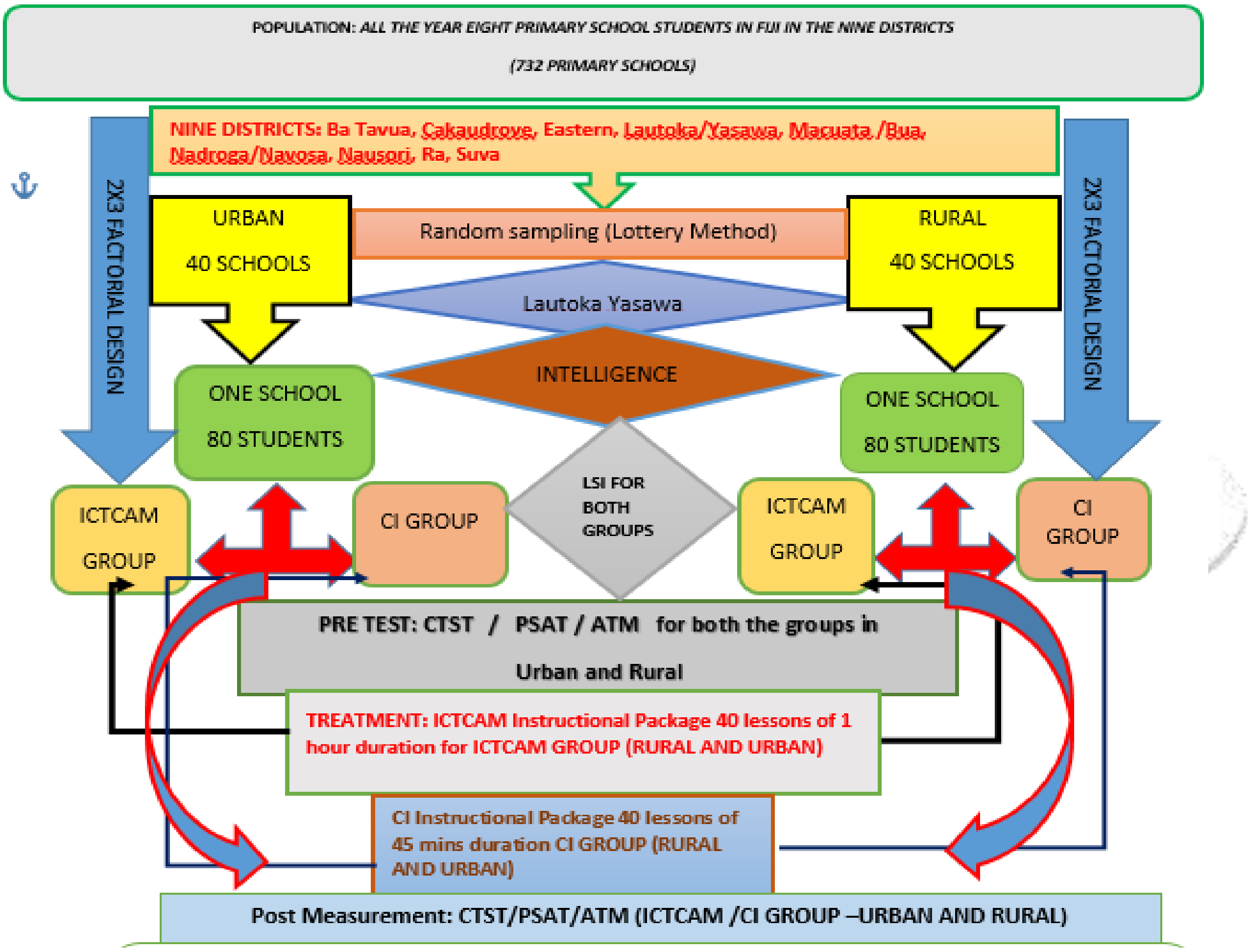
**Population and Sample**

The Annual Plan, 2014 statistics provide data that there are 732 primary schools in Fiji, of which 714 are non-government, 16 as private, and two as government schools. All the students of year eight studying in 732 upper primary schools in Fiji constitute the population of this study.

The present study consisted of one randomly selected district from one of the nine districts of Fiji, namely Lautoka /Yasawa which included a total of 87 primary schools of which 40 schools were for urban and forty schools were as rural, from the forty rural schools one school was randomly selected from the Lautoka /Yasawas group.

The schools chosen from the population of selected schools that have internet and computer, laptop or tablets in schools from the mentioned district was considered as the sample from which they were randomly divided into ICTMediated CAM group and the other as a Conventional Teaching group. The phases of the experimental design is shown in Figure 2.0 below.

**Figure 2.0: The phases of the experimental design**




**Tools used in the present study:**

To measure the selected variables, the covariate (Intelligence Test, the investigator used the following means.

1. A standardized Group Intelligence Test (GGTI-A) by Dr. DC Ahuja was used.
2. Achievement Test in Mathematics (ATM) was constructed by the researcher based on the new revised Bloom's Taxonomy of Instructional Objectives and validated by experts by content selected for the experiment.
3. Instructional Material using ICT Mediated CAM developed by the investigator for the training of students of year eight.
4. The Critical Thinking Skills Test (CTST) was developed by the researcher and validated by experts.

Critical thinking skills Test (CTST) was designed to measure the skills, namely interpretation, analysis, evaluation, inference, and explanation based on the five critical thinking skills adapted from "The Delphi Report" (Facione, Peter, 1990). CT is an essential tool of inquiry in the teaching and learning process

**Statistical Techniques Used In The Present Studies.**

In this present study, the data collected was analyzed by using descriptive statistics and inferential statistics concerning the objectives and hypotheses.

1. Descriptive statistics: Mean Standard deviation &Graphical representations.
2. Inferential Statistics: ANCOVA, whereby Intelligence was kept as covariance

(In statistical analysis and interpretation of data, the hypothesis will be tested at 0.05 level of significance).

**Results And Findings**

The pre-tests of Critical thinking skills Test (CTST) and Achievement Tests in Mathematics (ATM) were given to students to check whether the background knowledge and Critical Thinking skills of students before the use of ICTMCAM were different. The comparison of students gain scores in pre-test and post-test revealed that the two groups had significant differences in their performance CTST and ATM.

A 2x3 repeated measures of ANCOVA with one within-subject factor and one between subject groups were conducted to evaluate the effect of group on students' performance. **Table 2.0** presents pre-test and post-test measures of the scores and change scores for the two groups.

**Table:2.0 The main and interaction effect of Instructional Strategies (ICTMCAM) and CI on Critical thinking skills of year eight students by taking intelligence as Co-Variate**.

| Component | Source Of Variation | Type III Sum of Squares | df | MSS | F- ratio | P Value | Results |
|---|---|---|---|---|---|---|---|
| Critical Thinking Skills | Instructional Strategies Group (A) | 221.437 | 1 | 221.437 | 46.754 | 0.000 | S |
| | Types of learning styles (B) | 12.827 | 2 | 6.414 | 1.354 | 0.265 | NS |
| | (A)x(B)<br>Group x Types of learning styles | 4.331 | 2 | 2.165 | 0.457 | 0.635 | NS |
| | Adjusted Error | 345.744 | 73 | 4.736 | | | |
| | Total | 811.000 | 80 | | | | |

From **Table 2.0,** it is observed that the F value for Instructional Strategies is 46.754, with the p-value that is equal to 0.000, which is less than 0.01 shows a significant effect for degrees of freedom 1 and 73 at 0.05 level of significance. Thus it is evident that the value is significant in developing Critical Thinking skills among upper primary rural school students who have been taught through different instructional strategies.

To determine which instructional strategy is significantly more effective in developing the CTS adjusted mean and standard deviation of Instructional Strategies were calculated. The details are shown in **Table 3.0,** given below.

**Table 3.0: Adjusted mean and standard deviation**

| COMPONENT: CRITICAL THINKING SKILLS (CTST) RURAL SCHOOLS | | |
|---|---|---|
| **GROUP** | ADJUSTED MEAN | STANDARD DEVIATION |
| **ICTCAM** | 3.33 | 2.786 |
| **CI** | 0.05 | 1.300 |
| **TOTAL** | 1.69 | 2.043 |

From **Table 3.0,** it is observed that the adjusted mean of the Instructional Strategies (ICTCAM and CI) is 3.33, which is higher than the adjusted mean of that is 0.05. Hence it is evident that ICTCAM is more effective than CI in developing CTS among year eight upper primary rural school students.

Hence the null hypothesis $H_0$ (1*) "There is no significant difference in the effects of Instructional Strategies (ICT Mediated CAM and Conventional Instruction CI)) on the Critical Thinking Skills of year eight rural school students by taking Intelligence as Co-variate*" is rejected and

Alternate Hypothesis *"There is a significant difference in the main and interaction effects of Instructional Strategies (ICT Mediated CAM and Conventional Instruction CI) on the Critical Thinking Skills of year eight rural school students by taking Intelligence as Co-variate"* was accepted.

The main and interaction effect of Instructional Strategies (ICTMCAM) and CI on Achievement in Mathematics of year eight students of upper primary school by taking intelligence as Co-Variate.

The summary of 2x3 factorial design Ancova for Achievement in Mathematics of rural schools by taking Intelligence as a covariate is shown in **Table 4.0** below

**Table 4.0: The summary of 2x3 factorial design Ancova for Achievement in Mathematics of rural schools**

| COMPONENTS | Source | Type III Sum of Squares | df | Mean Squares | F-ratio | p- ratio | Results |
|---|---|---|---|---|---|---|---|
| Achievement in Mathematics | Instructional Strategies Group (A) | 210.584 | 1 | 210.584 | 47.566 | 0.000 | S |
| | Types of learning styles (B) | 0.874 | 2 | 0.437 | 0.099 | 0.906 | NS |
| | (A)x(B)Group x Types of learning styles | 9.737 | 2 | 4.869 | 1.100 | 0.338 | NS |
| | Adjusted Error | 323.186 | 73 | 4.427 | | | |
| | Total | 1011.000 | 80 | | | | |

From **Table 4.0,** it is observed that the F value for Instructional Strategies is 47.566 with the p-value that is equal to 0.000, which is less than 0.01 shows significant for degrees of freedom 1 and 73 at 0.05 level of significance. Thus it is evident that the value is significant in increasing the scores in Achievement in Mathematics among upper primary year eight rural school students who have been taught through different instructional strategies.

Hence the null hypothesis $H_0$ (2.0*) "There is no significant difference in the effects of Instructional Strategies (ICT Mediated CAM and Conventional Instruction CI) on the Achievement test of year eight upper primary rural school students by taking Intelligence as Co-variate"* is rejected and

Alternate Hypothesis *"There is a significant difference in the main and interaction effects of Instructional Strategies (ICT Mediated CAM and CI) on Achievement Test of year eight upper primary rural school students by taking Intelligence as Co-variate"* was accepted.

To determine which instructional strategy is significantly more active on the Achievement in Mathematics adjusted mean and standard deviation of Instructional Strategies were calculated. The details are shown in **Table 5.0,** given below.

**Table 5.0: Adjusted mean and Standard Deviation**

| Component: Critical Thinking Skills (CTST) RURAL SCHOOLS | | |
|---|---|---|
| **GROUP** | ADJUSTED MEAN | STANDARD DEVIATION |
| **ICTCAM** | 28.05 | 12.47 |
| **CI** | 19.48 | 9.357 |
| **TOTAL** | 23.77 | 10.91 |

From **Table 5.0,** it is observed that the adjusted mean of the Instructional Strategies (ICTCAM ) is 28.05, which is higher than the adjusted mean of CI that is 19.48. Hence it is evident that ICTCAM is more effective than CI in the scores of Achievement Test in Mathematics among year eight upper primary rural school students.

- There is a significant effect of ICTCAM on Critical Thinking Skills in Mathematics of year eight upper primary rural school students
- There is a significant effect of ICTCAM on Critical Thinking Skills in Mathematics of year eight upper primary rural school students.
- There is a significant effect of ICTCAM on Achievement in Mathematics of year eight upper primary rural school students.

**Conclusion**

ICTCAM learning processes develop the cognitive competence of learners by providing chances to work on real problems that challenge their current thinking levels. In general classrooms, students often solve problems which have no bearing too on real situations. Therefore activities that promote Critical Thinking as well as the articulation, reflection, and exploration from the CA model, will allow students to deal with situations in a manner that will encourage harmony in the classroom as well in the society, through these students who will be skillful future leaders of tomorrow.

However, (CT) cannot be separated from each other if meaningful learning of Mathematics is sought after (Innabi & Sheikh, 2006; Aizikovitsh & Amit, 2010).

Hence, teaching CT in Mathematics classes should be a goal of Mathematics educators. Garrison, Anderson, and Archer (2001) and Schrire (2006) rightly say that CT is both a process and an outcome.

Also, CT skills were reported by Kosiak (2004), to be correlated with Mathematics examination scores, in her study on online Problem-solving sessions for college algebra.

CT skills and academic achievement are significantly related to the findings of Semerci (2005). The relationship between CT skills and Mathematical Achievement has not received much attention in literature; hence, a detailed discussion is not possible.

Given such varied results on the connection between academic achievement and CT, it was worth examining the relationship between academic performance in Mathematics, and CT skills.

Moreover, the study of CT must continue research to facilitate CT in teaching and learning, which could be an area to blow in further for Mathematics and non-mathematics educators and researchers.

The current study gave a genuine insight into the development of Critical Thinking Skills with ICT CAM, the teacher initially models the essential strategies, allows students to try them out independently, and coaches students accordingly. The steps of ICTCAM demands learners to articulate their reasoning or methods to solve a problem and are encouraged to reflect on and learn from other's approaches as CAM is regarded as a collaborative effort wherein each step the students are helped by each other and they learn through each other during scaffolding, articulation, and reflection.

Thus ICTCAM is very useful in developing Critical Thinking Skills to solve problems in a very harmonious manner. It also creates a social climate in the classroom and will produce students who can utilize these skills to promote harmony at the school as well as in society. Therefore, there should be provision for activities, enriching ICTCAM in schools as well as teacher training curricula that can produce students who can use these skills to promote harmony in the classroom a well in the nation.

*'We Cannot Change the World Alone, but If We Each Cast a Pebble across the Water,*
*We can Create Many Ripples."*

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