ICT mediated cognitive apprenticeship model, and its effect on problem-solving skills and achievement in mathematics of upper primary school students

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Abstract : ***Despite the emphasis in the school system on the use of technology, ICT mediated learning is not always apparent in day to day use of technology throughout primary education system in Fiji. It is evident that children who use technology tend to be more engaged in learning and often attain higher levels of understanding in Mathematics. Alongside this importance, the present paper considers the engagement of mathematical software in the teaching and learning of mathematics to improve problem-solving skills and achievement in mathematics. This study aimed to design and construct instructional materials, and assessment tools using the Dynamic Geometry software (GeoGebra) to investigate the effect of ICT mediated Cognitive Apprenticeship model in the teaching and learning of Mathematics mainly Geometry in upper primary schools in Lautoka Fiji.***

The present study is providing opportunities for generating ideas to use the innovative ICT mediated Cognitive Apprenticeship model in Mathematics Classrooms. The development of ICTCAM in Mathematics would be useful to improve the problem-solving skills and achievement of students of year eight in Mathematics. The study was experimental in nature and pre-test and post-test with a 2x3 factorial design. The paper draws upon data gathered from two schools in Fiji studying the same syllabus, where ICTCAM was experimented to discover its effect on problem solving and achievement in Mathematics. The significant finding emerging from the data is that the ICT mediated Cognitive Apprenticeship model provided interesting, joyful, creative learning environment and supportive in providing a better understanding to the students, thus developing their problem-solving skills and achievement in mathematics. This model can be used as complementary activities to the regular setting, where students can get immediate feedback of their findings, in the classroom activities as well as in extra drills which are carried out as homework.

Keywords : Achievement, Geogebra, ICT Mediated Cognitive Apprenticeship Model (ICTCAM), Problem Solving

INTRODUCTION

Education is the greatest instrument which man has devised for his progress. Therefore failure in Education brings untold hardship and frustration to the individual and the society at (IIogu 2005). Using ICT marvellously in the classroom, teachers can engage students productively and facilitate better learning. Having the ability to use ICT in the classes is an advantage. It is necessary for the teachers to develop this creative skill to make learning experience of the students more closely to his or her imaginations. Today's education system owes a great deal to this discounting attitude towards the use of Technology. ICT promotes a good atmosphere in the classroom for knowledge transaction. Moreover, it helps the students and teachers to explain the difficult concepts with ease. When unpalatable facts or difficult ideas are favoured with technology, they find their way much easier into the brains. Mathematics is a compulsory subject which cut across every human facet and endeavours and plays a dominant role in the economic development of the country. The inability of students to pass mathematics at primary and secondary level is an ongoing problem, and this may serve as a barrier in furthering the education into the tertiary institutions in Fiji. Esu(2006) noted that students general fear and mathematics; a situation which results in poor performance. The goal of teaching mathematics, especially at the primary level is to prepare pupils to develop critically, problem-solving and creative outlook as they confront the challenges of daily life.

In rural India, nearly three-quarters of students class III, could not solve two-digit subtraction such as 46-17 and class V, half could still not do it says the Worlds development report (2018). Similarly in Fiji according to to the statistics of primary school year 6 and eight results it is self-evident that students have meagre achievement score in Mathematics. It is imperative to use innovative methods to improve learning in mathematics. It is evidence that poor children's cognitive skills fall well behind in the years before primary schools. According to Harris (1998), the challenge for education is to use technology as a tool to strengthen creativity and innovation in ways that conventional learning cannot. The International Society for Technology in Education (ISTE, 2000,P6)defines curriculum integration as, "the infusion of technology as a tool to enhance the learning in a content area or multidisciplinary setting" and "Effective combination of technology is achieved when students can select technology tool that helps them obtain information in a timely manner, analyse and synthesise the info and present professionally.

Furthermore, a comprehensive review of the literature indicated that integrating technology in schools/classrooms provide children with instructional, self-directed and student-centred learning opportunity which is very beneficial to the students.

The ICT mediated approach helps their ability to gain from collaborative learning through indulging in the game based and project-based learning activities which in turn leads to foster learning and developing the 21st-century skills such as critical thinking and problem-solving communication and interpersonal skills, collaboration and teamwork.

In a landmark study analysing a National database of students test scores, Wenglinsky (1998) determined the technology can have positive effects on students' mathematics scores. The low achievement in Mathematics has been traced to a poor method of teaching and effective using of teaching materials in teaching mathematics.

The observed poor performance lack of problem-solving ability of students in primary schools in mathematics calls for this present study which sought to examine the effect of ICT mediated Cognitive Apprenticeship model on problem-solving ability and mathematics achievement in upper primary school students in Fiji.

1.1 What is GeoGebra?

GeoGebra is dynamic mathematics software for schools that joins geometry, algebra, statistics and calculus through graphing and spreadsheets. Markus Hohenwarter created GeoGebra in 2001/2002 as part of his master's thesis in mathematics education and computer science at the University of Salzburg in Austria. Supported by a DOC scholarship from the Austrian Academy of Sciences he was able to continue the development of the software as part of his PhD project in mathematics education. Development teams work under grants to maintain and enhance the software.GeoGebra can be downloaded for free (from www.geogebra.org/download) to work on the "desktop." This version is more reliable, robust, and easy to use. There is also a web-based application that we are using today for convenience. It can be slow and quick sometimes but is still very functional.

On the one hand, GeoGebra is an interactive geometry system. You can do constructions with points, vectors, segments, lines, polygons and conic sections as well as functions while changing them dynamically afterwards.

On the other hand, equations and coordinates can be entered directly. Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances student's learning. (NCTM, 2000)GeoGebra was created to help students gain a better understanding of mathematics. You can use it for active and problem-oriented teaching; it fosters scientific experiments and discoveries both in the classroom and at home.

1.2 Why use Geogebra?

GeoGebra is currently used in 190 countries and has been translated into 52 languages. The mission of GeoGebra is straightforward: to help math learning for students worldwide. This free and multi-platform dynamic software allows students to interactively discover mathematical concepts and relationships among them. It will enable millions of children to understand algebra, geometry, calculus, statistics and many other fields of science in a more profound way.

(https://www.geogebra.org/m/xrqwxvku)

For instance, in countries like Argentina and Australia, and in the State of Maine the government decided to use GeoGebra as one of the leading mathematical software packages in the millions of laptops that were to students.

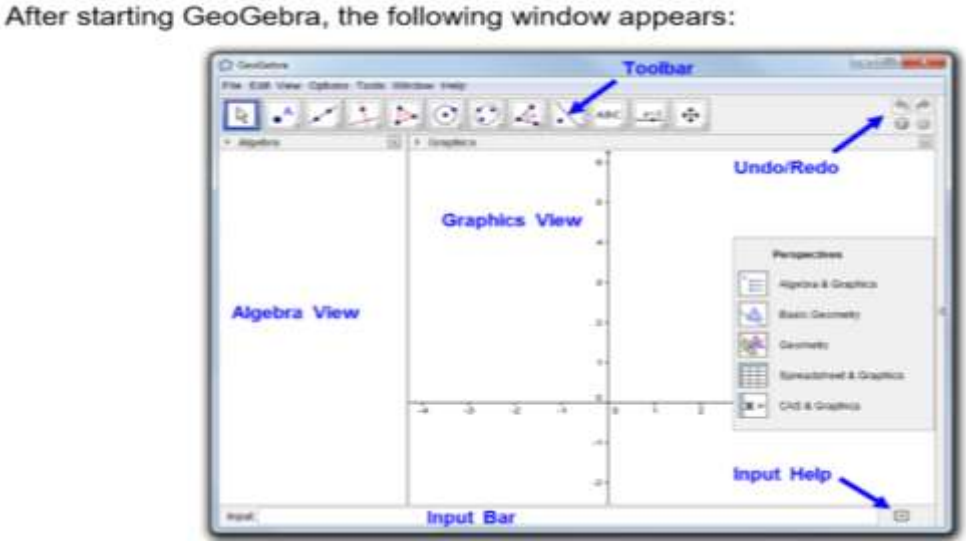
GeoGebra creates an active learning environment and is very powerful, interactive software. Also, it also helps students to learn mathematics in a way that is exciting and approachable.

Mathematics teachers are aware of commercial software for dynamic mathematics, but due to their expensive licenses and limited accessibility, commercial software packages have hindered the teachers' and students' access to these programs.

Figure 1.0 showing the views and Perspectives of GeoGebra

1.3 GeoGebra Interface

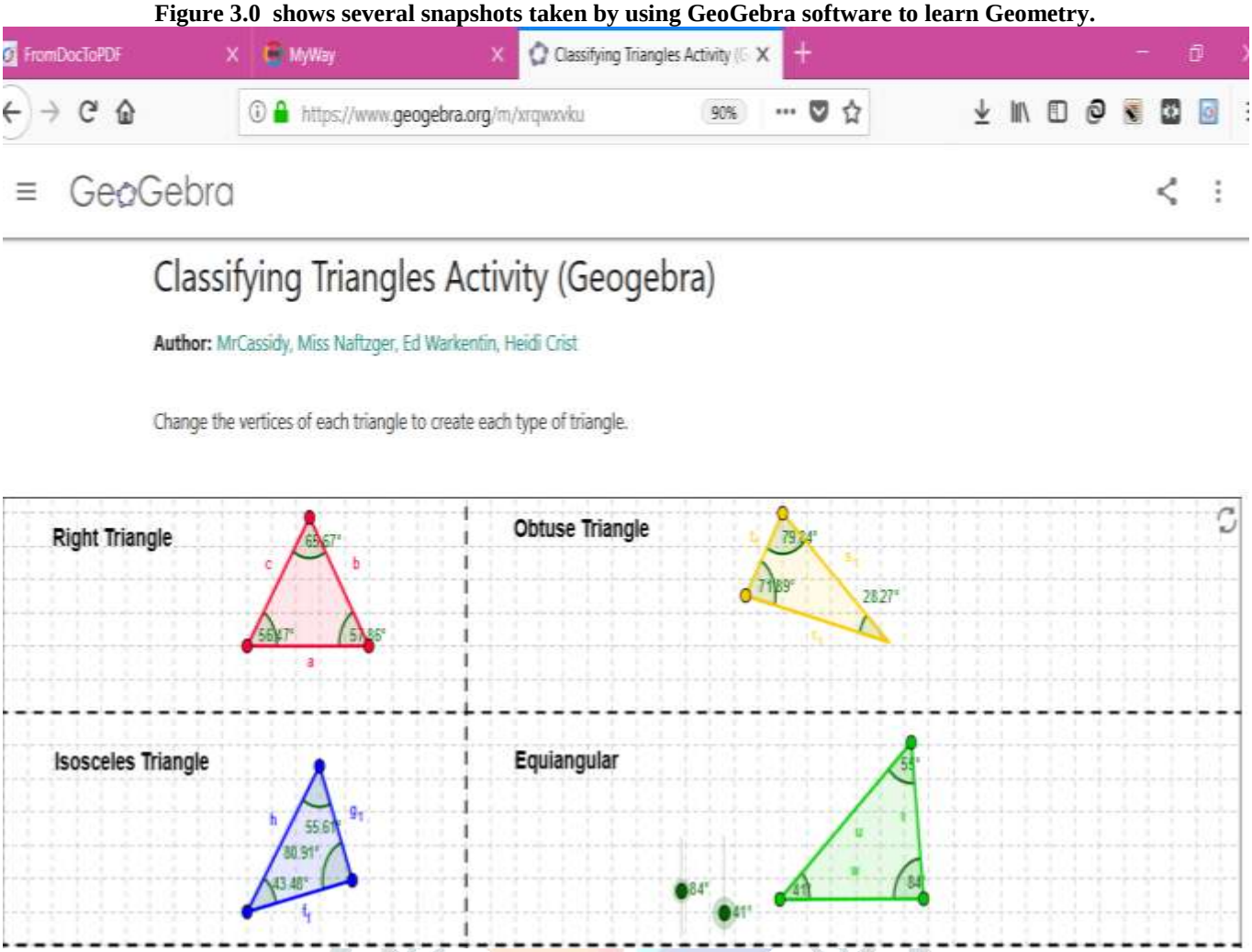
Figure 2.0 showing the GeoGebra Interface



You may also customise Menu-perspectives.SVG GeoGebra Classic's user interface to match your personal needs by changing the default Perspectives and adding other com

Menubar/ Input Bar/ Style Bar/ Navigation Bar/Context Men/ Virtual Keyboard

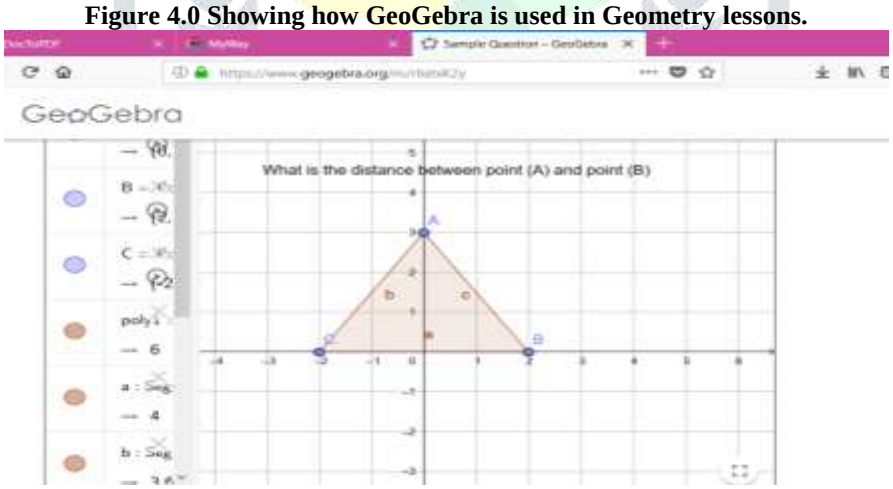
Figure 3.0 shows several snapshots taken by using GeoGebra software to learn Geometry.



Source(https://www.geogebra.org/m/r8atxK2y)

Sample Question to show how GeoGebra is used in Geometry Lessons.

Figure 4.0 Showing how GeoGebra is used in Geometry lessons.



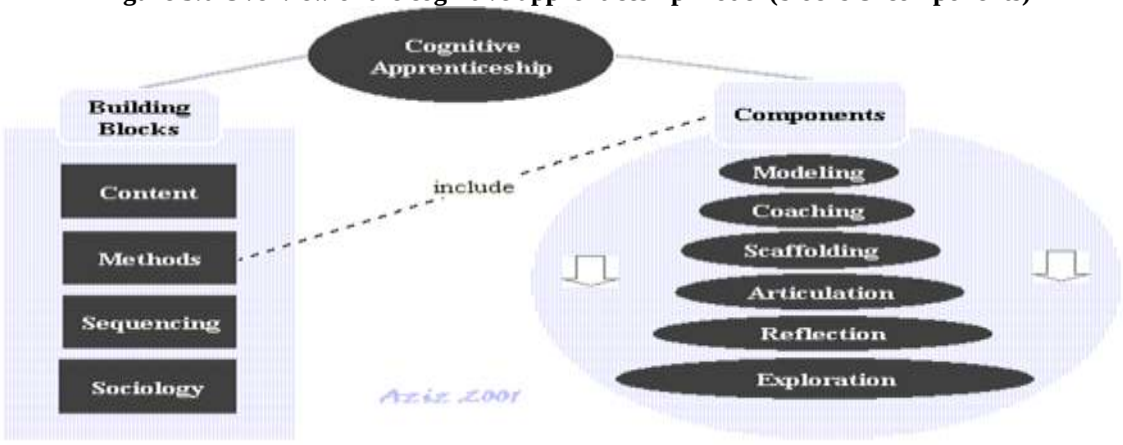
1.4 What is Cognitive apprenticeship model?

Cognitive Apprenticeship is a model developed by Collins Brown and Newman in (1989). This particular model is relevant to different subjects. According to Collins, Brown and Newman (1989), Cognitive Apprenticeship emphasises the solving of real-world problems under expert guidance that fosters Cognitive and Metacognitive skills and processes. To put Cognitive Apprenticeship into practice, Collins et al. (1991) offered six instructional methods of Cognitive Apprenticeship - modelling, coaching, scaffolding, articulation, reflection, and exploration.

Based on the innovative work of Tharp (1990) and Tharp and Gallimore (1990) related to assisting in the learning process, Thus for the present study, this model was used with the six different strategies mentioned below.

The original six methods are summarised in figure 4.0.

Figure 5.0 Overview of the cognitive apprenticeship model (blocks & components)



(Source: Ghefaili (2003);http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.331.1704&rep=rep1&type=pdf)
This model is supported by Albert Bandura's (1997) theory of modelling, which posits that for modelling to be successful, the learner must be attentive, access and retain the information presented, be motivated to learn and be able to copy the desired skill

1.6 What is ICT Mediated Cognitive Apprenticeship Model?
Table 1.0 A summary of roles of Cognitive Educators and Students and target outcomes for the Cognitive Apprenticeship six teaching methods using GeoGebra.

Component	Cognitive Educator's Role	Students' Role	Target	Use of GeoGebra
1.Modelling	Show students how to do tasks. Build a conceptual model of the processes Explain the reasons why things happen that way. Provide rationale for procedures.	Observe Watch/listen Conceptualise.	Receptive Meaningful learning (Declarative & Heuristic Knowledge)	Expert communicates with the student via digitised video. Expert shows how things work and how things are done. Using DGS Watching and observing built-in movies and voice. Narration. Expert reifies cause-and-effect relationships; presents goals before actions. Online expert examples of case solutions and Online problem-solving samples,
2.Coaching	Observe students attempt a task. Given by the teacher in as stated in the lesson plan .Provide assistance as needed. Offer hints feedback, and guidance.	Perform a task. Engage in problem- solving activities given in the worksheets as per the lesson plan.		Students work on programming/ multimedia/ hypermedia/online tasks of increasing difficulty as stated in the lesson plan. Highly situated feedback is given in response to student errors and actions. Expert helps the students as the need arises.
3.Scaffolding "fading"	Offer little support, Guidance and reminders. Assists students to manage complex task performance If necessary, complete those parts of the task that students have not yet mastered Gradual removal of support(fading)	Perform a more complex task. Work independently Engage in the legitimate peripheral. Participation	Metacognition	Student-initiated help system available through the specific button. Students can replay movies to review instructional. Materials. Help system provides a "Show Me" button as last recourse Feedback dialogues are generalised when errors of the same type are made. Recourse to more detailed information remains available Online testing Online diagnosis Online instructions, Online coaching if required.
4.Articulation	Require their students to explain what they are doing. Encourage students to demonstrate their	Explain the knowledge and skills achieved Discuss their plan Thinking Aloud		System poses conceptual questions to articulate the answers to the questions either to themselves or a friend. More profound theoretical significance raised to students Online

	knowledge, reasoning, and problem-solving strategies			questioning and answering. Online discussion via e-mail, list servers, chat rooms, and forums.Hypermedia representations of problem-solving solutions
5.Reflection	Encourage students to reflect on their tasks. Provoke students to compare their work with educators', other students, and with an internal cognitive model of the relevant expertise	Reflect on work they have already performed and analyse or deconstruct it. Compare what they know with what others Know. Contrast their actions with that of others.		Play Movie button plays a digitised movie of an expert expressing his view on the reflection.question. And a comparison of one's solutions with expert and.peer solutions. Using evaluative judgment on web-based resources Book-marking feature saves and retrieves entries for future reference. Developing computer-based portfolios.
6.Exploration	Encourage students to solve new, but similar, tasks. Drive students to be independent learners. Strengthen students to engage in research.	Solve new, but Similar, tasks. Frame and explore exciting questions. Make independent discoveries. Identify personal interests and pursue personal goals	Application/ Transfer	Explore button so students can further explore the system/task on their own and pursue their purposes, Online exploration strategies Multiple representations of a problem/Hypermedia representations. Constant availability of tools and instructional library.Multiple search options including browse Using available technologies to represent data in new ways.

2.Purpose of the study

The purpose of the present study is to find effects of ICT (DMS Geogebra) mediated Cognitive Apprenticeship Model on student's problem solving and achievements in Mathematics (geometry) which is organised as the fourth strand in the teaching of mathematics in the Fiji Primary schools Mathematics syllabi of years 7&8. (Ministry of Education, heritage revised version 2016)

3.Research Objectives

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 Problem Solving skills of year eight students of urban schools 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 urban schools by taking Intelligence as Co-variate.

4.Methodology

4.1 Research Model

The research was conducted in the pre-test, and post-test control grouped experimental design.

Experimental and Control group

The pre-test results showed that there was not any statistical difference between the groups. Therefore one group was selected as an experiment and the other as Control group.

The groups were divided into different types of learning styles of each student, through the 30 questions based on learning style inventory prepared by the researcher, primarily Audio, Visual and Kinesthetic learners. The experimental group was subjected to the lessons arranged with the ICT-mediated Cognitive Apprenticeship model using the GeoGebra, while the control group was submitted to the experiences shaped with conventional instruction. Instructional materials were developed by the researcher using ICTCAM for taking the lessons.

4.2 Process

A five-week course which contained 15 main GeoGebra activities and many other practices about the achievement had been planned by the official mathematics curriculum of Fiji primary schools. Then the activities were constructed with GeoGebra for the experiment group. The GeoGebra prepared activities aimed to make the subject more dynamic, concrete and visual. The worksheets were developed from the textbook questions and designed and constructed using GeoGebra following the six steps in a Cognitive apprenticeship model.

5.Tools used in the present Study:

There is an abundant number of tools and techniques available for the collection of data for the research. To measure the selected variables of the present study, the investigator administered the following tools.

Table 2.0 Shows the details of Evaluation tools used in the study

Tool No	Name of the tool	Name of the Author of the tool	Variables/Validity and reliability
1.	Problem Solving Ability Test-PSAT-D	L.N.Dubey.	Standardised test

2.	Group Test Of Intelligence – GGTI-A	Dr G.C.Ahuja	Standardised test Co-variate
3	Achievement Test in Mathematics-ATM-S	Ali, Sofia & D'souza, Flosy- Constructed the tools and validated by Experts	Validation and Item Analysis
4	Learning Style Inventory LSI-S	Ali, Sofia & D'souza, Flosy- Constructed the tools and validated by Experts	Validity Types of Learning Styles
5	Instructional Material using ICT Mediated CAM	Ali, Sofia & D'souza, Flosy- developed the Instructional materials using the six steps involved in Cognitive apprenticeship model and validated by Experts.	Lesson plans and worksheets ICT(GeoGebra)mediatedCognitive Apprenticeship Model(six steps- Modelling, coaching, scaffolding,

5.Statistical techniques

The investigator used t-test and analysis of covariance (ANCOVA) for the study analysis of the data about the study.

7.Major Findings

Based on the analysis and data interpretation, the following are the findings of the study.

- ICT mediated. Cognitive apprenticeship model has a significant effect on the problem-solving ability among the upper primary school students in Fiji.
- The use of instructional materials have a significant effect on mathematics achievement among upper primary school students in Fiji.
- Teachers have a positive attitude to the usage of ICTCAM instructional materials Aand this, in turn, have a positive effect on mathematics achievement among upper primary school students in Fiji.
- ICTCAM instructional strategy is useful when compared with the conventional instruction in improving achievement in Mathematics among the upper primary school students in Fiji.
- ICTCAM is a supplement to conventional classroom instructions, and it is evident through the findings that it is more effective.

8.Conclusion

The present investigation opens doors and paves for further research in the area of ICT mediated cognitive apprenticeship model in learning and teaching of mathematics. The findings of the study will lead to better ways of teaching, learning process and will help the students to learn excitingly and creatively. Consequently, the curriculum developers can design new framework including more exciting and innovative methods to motivate teachers and students to teach and learn in a stress-free atmosphere. The fifteen per cent fee-free grant given to schools for computer and IT should be utilised in setting up the ICT mediated environment, whereby this free software can be used for upper primary as well as lower primary students especially for years four to six. Students can download this software and also use it at home or outside the school. This model can be used as complementary activities to the regular setting, where students can get immediate feedback of their findings, in the classroom activities as well as in extra drills which are carried out as homework. Cost is usually the determining factor in acquiring new teaching and learning aids in schools, so OSS(GeoGebra) can solve the problems the findings demonstrate that ICTCAM gives an alternative to the teachers to utilise OSS mathematics Software as a tool of instruction with the use of six steps of the cognitive apprenticeship model. Cognitive Apprenticeship is a theory that combats to bring tacit practices out in the open. It assumes that people learn from one another, through observation, imitation and modelling.

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