A Study on the Academic Practices in Teaching Mathematics

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Abstract: **This study investigates the academic practices employed in teaching mathematics, with a focus on identifying effective strategies that promote student engagement, understanding, and achievement. A mixed-methods approach was employed, combining survey data from 100 mathematics teachers with in-depth interviews and classroom observations. The results highlight the importance of problem-solving, critical thinking, and communication skills in mathematics education. Effective teachers were found to use a range of strategies, including technology integration, collaborative learning, and formative assessment, to create an inclusive and supportive learning environment. The study's findings have implications for mathematics teacher education, professional development, and policy, and provide insights for educators seeking to improve mathematics teaching and learning. There are three broad categories of the applications of computer technology in the field of mathematics application: Computer Assisted Instruction, student programming and general-purpose educational tools spread sheets, data bases and Computer Algebra Systems. The role of teachers is very important in order to make the effective use of available mathematical tools. We believe that mathematics teaching can be made much more interesting, inventive and exploratory using technology**

Keywords: **Technology, mathematics laboratory, mathematical software, Computer Assisted Instruction (CAI), Computer Algebra Systems (CAS), teacher.**

INTRODUCTION

In the past two decades ICT skills have become an integral part of the teaching/learning process in higher education, so students and teachers now have a much wider access to ICT than before. The present scenario shows the importance of ICT in higher education with positive outcome and enhanced impact on teaching and learning process. Teaching higher education Mathematics has a number of challenges, including the expectations that teachers cover the prescribed curriculum, help students learn difficult concepts and prepare students for future studies and increasingly they incorporate digital technologies. Students and teachers now have a wider access to ICT than before. Government have also mandated the importance of ICT in education. For using technology effectively three changes among teachers required (i)Raised expectations of pupils (ii) A more student –centered approach to teaching and (iii) Greater willingness to experiment. The availability of technology in class rooms alone does not improve student outcome, it is the teachers' decision on how to integrate ICT into the mathematics class room. For the successful integration of ICT, the role of teacher is critical because it is the teacher who decides when, where, how and whom will use ICT. It is not the technological medium itself, but the instructional method used, which supports and cause effective teaching and learning. Mathematics laboratory help them understand the practical implications of various theories and their relevance in day-to-day life.

A HISTORY OF REVISIONS IN MATHEMATICS EDUCATION

Revision can be characterized as a renewal effort that captures educators' attention for a short period of time but fails to address critical issues that are at the root of students' difficulties with mathematics. Revision perpetuates a ―quick fix‖ approach whereby new components are adapted to fit within the bounds of the accepted paradigm. Thus, revision in mathematics education leads to surface level modifications but does little to substantively alter deeply held beliefs about the nature of mathematics, how it is to be taught, the sort of learning that is valued, and

how success is determined. In contrast, reform is transformative and leads to a redefining of the epistemological position toward the field. Reform raises questions about the core beliefs of mathematics education, moving to restructure thinking about the nature of mathematics, how it is taught, how it is learned, and, ultimately, what constitutes success in learning it.

Throughout the last century, mathematics education in the United States has been a revolving door for revisions—under the guise of so-called reform movements—that failed to question traditional assumptions and beliefs about mathematics teaching and learning and, therefore, failed to change significantly the face of the mathematically successful student. Consequently, speculation exists about whether the current ―reform‖ movement will promote mathematical equity and excellence or turn out to be another trend that fails to significantly alter the status quo in mathematics education (Martin, 2003). We argue that the work currently underway is fundamentally different from past movements. In order to build a case, we will examine the motives and intentions of past revisions in mathematics education—taking care to distinguish them from actual reform. We will then examine current NCTM standards-based efforts to reform mathematics education in contrast to these past movements. A model of shifting paradigms will be offered as a way to understand what makes the current efforts distinct and why they have garnered such sharp criticism from some quarters.

THORNDIKE'S STIMULUS-RESPONSE BOND THEORY

The opening of the twentieth century saw much change in the character of the United States. It was during this time that Edward L. Thorndike, president of the nascent American Psychological Association, led a new class of educational psychologists whose work was aimed at making schools more efficient and effective in educating and stratifying the masses of children who had recently come to populate public schools (Gould, 1996; Henriques, Hollway, Urwin, Venn, & Walkerdine, 1998; Oakes, 1985; Stoskopf, 2002; Thayer, 1928) In particular, Thorndike's Stimulus-Response Bond theory (Thorndike, 1923) had a profound influence on the teaching and learning of mathematics (English & Halford, 1995; Willoughby, 2000).

Thorndike and his colleagues contended that mathematics is best learned in a drill and practice manner and viewed mathematics as a ―hierarchy of mental habits or connections‖ (Thorndike, 1923, p. 52) that must be carefully sequenced, explicitly taught, and then practiced with much repetition in order for learning to occur.

CONSTRUCTIVIST APPROACH

Position paper national focus group on teaching of mathematics, recommended an approach in 2005 that facilitate learning of students i.e., Constructivist approach. Majority of school teachers are unaware about this approach till now. NEP (2020) also emphasized on such approach which promotes higher order thinking instead of rote memorization. Constructivist approach radically changes the process of teaching and learning mathematics, connecting it with daily life, rather than teaching only abstract formulas and using a creative approach to mathematical tasks solving (Vinetere, 2018). It is a learner centred approach in which learner is the constructor of knowledge rather mere receiver. Teacher acts as a facilitator and provides students such experiences that allow them to hypothesize, predict and manipulate mathematical facts. Under this approach, actions such as research, investigate, imagine, invent and pose questions are performed by the learner (Gray, 1997). Student's own intuitive mathematical thinking gradually becomes more abstract and powerful through interaction with mathematical tasks and other students (Clements & Battista, 2009, cited in Vintere, 2018).Constructivist approach-based classroom is distinguished from a conventional classroom by a number of identifiable qualities like learner activeness, democratic environment, interactive and student-centred activities. In the constructivist classroom, students are encouraged to construct their own ideas on the basis of their prior knowledge and experiences. This approach has positive impact on achievement in mathematics of students as well as helpful to develop a positive attitude towards mathematics (Clarke,1997 and Simon & Schifter, 1997). There are various strategies of teaching that follow the principles of constructivist approach such as Inquiry-based learning, problem-based learning, experiential

learning etc. These strategies must be utilised by the teachers to bring innovations in classroom.

INQUIRY-BASED LEARNING

Inquiry- based learning involves students' centred activities that develop confidence and ability to do mathematics on their own. It starts by posing questions rather than simply presenting established facts or portraying a smooth path to knowledge. It allows students to develop and practice critical thinking skills by providing the opportunity to explore the situation presented before them.It improved mathematical creativity of the students and develop problem solving ability among students. Problem posing and problem solving and modelling activities are core areas in inquiry-based teaching. Prior knowledge is used to start the communication that helps students to develop their own strategies. When using an inquiry-based teaching approach in mathematics, some mathematical content is more obvious than others, and students benefit from engaging in different mathematical tasks. There are two popular models viz. 5 E instructional model and 7 E instructional Model which follows the principles of constructivism and comes under inquiry-based learning. Originally these models are practiced in science subjects but many research studies have been conducted to see the effectiveness of these models on achievement in mathematics. It is evident that these models are better than conventional method in mathematics classrooms(Baser, 2008; Hiccan, 2008; Ozdal, Unlu, Catak, & Sari, 2006; Boddy, Watson & Aubusson, 2003 cited inWalia, 2016). There are five phases in 5 E Instructional model viz, engagement, exploration, explanation, elaboration and evaluation. Two additional phases i.e., elicit and extend in 7 E instructional model make itmore comprehensive and effective. Bevevino, Dengel & Adams (1999) stated that using this instructional model, teacher can create a series of activities that are meaningful for students and give opportunities to students to practice critical thinking skills.

EXPERIENTIAL LEARNING

NEP, 2020 proposed the adoption of experiential learning for all stages of school education. Experiential learning is the practice of learning through doing. It encourages the students to have first- hand experiences with the materials, rather than learning through someone's else experience in textbook and lectures. Experiential learning focuses on individual' learning. It is defined as learning through reflection on doing. It involves one more step i.e., reflection if compare with other strategies such as activity based, problem based and discovery learning. Experiential learning may be helpful in subject like mathematics where students are involve in their own understanding of mathematical concepts and practices. Introducing experiential learning activities in mathematics classroom is the way to create classroom environment innovative that help students to overcome their math anxiety. Teachers need to associate activities with the concept so that students may involve and reflect on their actions e.g., in primary school if teacher want to teach the duration and timing of rising and setting of sun. He should ask them to prepare a chart on rising and setting of sun for few days that will provide a deep understanding of duration of a day instead of telling them directly. Similarly, in middle school an activity related to selling the self-made edible items involving purchasing, measuring the ingredients and they can reflect on the process they adopted for all the activities involved. In secondary school concept of probability may be teach through experiential learning involving concrete item such as coins, cards, dices related activities.

Problem based learning is another learner centred strategy that begin with the problems. Problem drives the learning when it is taken from real world. Problem based learning environment helps students for constructing a deep understanding of mathematical ideas and process by engaging them. Problems are solved by creating, conjecturing, exploring, testing and verifying the mathematical situations (Lester et.al., 1994 cited in Benjamin, E., 2011). Traditionally, math textbooks often just provide fixed examples without providing rich experiences in problem solving. Problems should be presented before the students so it can arouse students' interest and they become motivated to solve it. In this approach, teacher provide meaningful instructions and learners work on these instructions by following steps such as identifying the problem, devise a plan to solve a problem, implementing and reflecting on the plan. It stimulates critical and creative thinking among students that help to develop problem solving skills that will be helpful in their life as well.

TECHNOLOGY ENABLED LEARNING

Technology reduces the effort of human being and increase the efficiency in all sphere of life. Education is not the exception where technology entered and contributing in increasing the efficiency of teaching learning process. There are various type of technology enabled learning strategies which can be categorised on the basis of hardware, software and utility purpose. Web quest learning, m- learning and blended learning are few of them that must be practiced in mathematics classrooms to make learning interesting and joyful.

WEB QUEST LEARNING

Web Quest learning is the outcome in the form of construction of knowledge with the help of internet resources. A Web Quest is an inquiry-oriented activity/lesson in which all or most of the information that learners use comes from resources on the Internet. It is designed to ensure meaningful learning by combining technology with a constructivist approach in classroom (Yenmez, Ozpinar & Gokce,2017). Teacher can create Web quest using different programs, but the most common and simple form is to create a word processing document that includes links to websites. "Web Quests were created by Dodge in1995, during the early stages of widespread Internet access. It includes group work, prior knowledge and cooperative learning.

BLENDED LEARNING

Blended learning is the combination of e-learning and face to face learning environment. It combines online educational material and opportunities for interaction online with traditional classroom methods. Thousands of videos on trigonometry, statistics, algebra and arithmetic are available freely on Khan academy and youtube. This online material is frequently used by the teachers for blended learning environment. Lin, Tseng and Chiang (2016) conducted an experimental study to see the effectiveness of blended learning on high school mathematics students in Taiwan. They found not only positive effect on learning outcome but also attitudinal change towards mathematics. Awodeyi, Akpan &Udo (2014) & Abramovitz, Berezina (2012) found the result in favor of blended learning in mathematics classroom with reference to achievement and attitude. Generally, Moodle Learning platform is utilized for such learning environment. Teacher can conduct interactive activities for online group discussion, examination and assessment. This strategy provides flexibility in context of time and space.

M-LEARNING

M-Learning is the technique where learning occurs in multiple contexts, through technological, social and content interactions. M-Learning Technologies are available by using personal electronic devices such as handheld computers, notebooks, mobile phones and tablets. Supandi et.al. (2017)and Etcuban & Pantinople (2018) found that mathematics teaching supported by mobile phone application improves school student's achievement. Apart from web-based learning, many mobile applications such as Socratic, Photo Math, ‗My script Calculator Two' etc are used commonly by the students.

‗Socratic' is a photo based free software which provides step by step solution of math problem. ‗My script Calculator Two' is an app which is more than a calculator. It converts the handwriting into text and then solve the problem. The app includes support for basic operations like addition and subtraction, powers, roots, exponents, trigonometry, logarithms, constants (like pi), and more. Apart from that various learning management software such as Google classroom, Moodle, EDMODO are popular now a days to connect with students anytime anywhere.

Apart from paradigm shift in approach and strategies of teaching some innovations may be bringing real classroom teaching by merging two methods such as Inducto-Deductive Method and Analytico- Synthetic Method. Inducto-Deductive method is the combination of inductive and deductive method of teaching in which number of examples are presented and students generalized the things on the basis of observation of example and later use the formula directly to solve the problems. This method promotes construction of knowledge by observation and discourages rote memorisation. Analytico- Synthetic method is the merger of two separate method of teaching mathematics i.e., analytic and synthetic method. This method must be utilised by teachers for proving the results and solving problems. Teacher must start with analytic method and then utilised synthetic method.

Play way method is another useful method which produce joyful learning and help to create interest in

the subject for lower grades. Mathematical puzzles, riddles and jigsaw are the ways to teach the students through play. This method is very useful in foundational and preparatory stages of school education (NEP, 2020). NCF (2005) pointed out that making mathematics a part of children's life experience is the best mathematics education. Project Based Method is a way to connect classroom learning to life outside the school. It is ideal to arouse curiosity, promoting creativity and inculcating the spirit of enquiry among the students. Students handle the problems in natural setting. A sense of confidence may be brought though engagement in projects involved mathematical concepts. Above discussed approaches, strategies and methods are learner centred and facilitate the learning of students in one hand but require flexible curriculum, well trained teachers and resources in other hand. There may be some constraints behind less utilization of these pedagogical practices in real

LABORATORY METHOD OF TEACHING MATHEMATICS

In Mathematics laboratory all essential technology based equipment concerning the learning activities in mathematics are kept. The Mathematics laboratory provides an opportunity for the students to discover mathematics through doing. It is a space to explore and design new mathematical activities. It helps students in making clear and in understanding abstract concepts. It enables the students to apply mathematical facts and principles in an actual life. The students develop love for the subject and arousing their interest in mathematics. It is multi-sensory approach to learning. So, the maths lab should not be used to assess students' knowledge of mathematics. Often mathematics lab teaches students knowledge beyond the curriculum.

In this method practical work is emphasized. It is activity centered, students work in the laboratory and verify mathematical truths. The use manipulative aids are often assumed to be an integral part of mathematics laboratory. Mathematics laboratory is a supplemental, mathematics program enriches mathematics curriculum.

OBJECTIVES OF MATHEMATICS LABORATORY

To emphasis on ―learning by doing‖ and develop an attitude of enquiry and needed confidence g by students. Make the students divergent thinkers and to generate interest in the subject. Remove the weakness of present day mathematics education which the mathematics laboratory alone can do it to generate interest in the subject

MATHEMATICAL SOFTWARE FOR TEACHING AND LEARNING MATHEMATICS

Free/Libre Open-Source Software (FOSS or FLOSS)

Free and Open Source Software (FOSS), also called just Open Source or Free Software, allows users and programmers to free to use, edit, modify or reuse the software's source code. The developers get the opportunity to improve program functionality by modifying it. The term ―free‖ indicates that the software does not have constraints on copy rights. The term ―Open Source‖ indicates the software is in its project form. Open source software developed and released with the source code with limited or no restrictions. The open source community of a database where educational institutions can tap the full potential of software available in the open source domain. This software which is available free of cost is developed, tested and upgraded by programmers and the users on a regular basis. With the help of FOSS different courses in the universities can be make easily available in the higher education. FOSS can be use in higher education for research and development or to the improvement of the equipment of the laboratories.

Commercial Open Source Software(COSS) can obtain Free Open Source Software Components, however limits availability of key functionality to closed proprietary software and therefore is discussed only on the COSS page

―Computer Assisted Instruction‖ (CAI) , is the use of a computer to provide instruction. CAI is a self-learning interactive instructional technique where by a computer is used to present the instructional material and monitor the learning that takes place. CAI uses a combination of text, graphics, sound and video in enhancing the learning process. With self –directed learning, learners can decide what they want to learn and in what order.

Software applications that perform symbolic calculations are called Computer Algebra Systems (CAS).CAS is widely used to experiment in mathematics and to design the formulas in the

numerical programs. When numerical methods fail, it is used for complete scientific computations.

LIST OF SOME FREE MATHEMATICAL SOFTWARE

Software	Year of Start	Utility
GP/PARI	1985	Number Theory
GAP	1986	Group Theory, Discrete Math
Gnuplot	1986	Plotting Software
R	1993	Statistics
SciLab	1994	General Purpose CAS
CoCoA	1995	Polynomial Calculation
Macaulay2	1995	Commutative Algebra, Algebraic Geometry
Maxima	1998	General Purpose CAS(Computer Algebra System)
YACAS	1999	General Purpose CAS(Computer Algebra System)
Dynamic Solver	2002	Differential Equation
SAGE	2005	Algebra and Geometry Experimentation
Kash/Kant	2005	Algebraic Number Theory

LIST OF SOME COMMERCIAL MATHEMATICAL SOFTWARE

Software	Year of Start	Utility
MatLab	Late 1970	General Purpose CAS(Computer Algebra System)
MathCAD	1985	General Purpose CAS (Computer Algebra System)
Maple	1985	General Purpose CAS(Computer Algebra System)
MuPAD	1993	General Purpose CAS(Computer Algebra System)
Magma	1993	Arithmetic Geometry, Number Theory
Mathematica	1998	General Purpose CAS(Computer Algebra System)

ADVANTAGES OF FOSS

Cut-off the cost in ICT implementation by using freely available software. Provide reliability, security and performance in available products. It is created by skilful and talented people. FOSS provide an opportunity to examine and modify the programs this enables the learners to studying high-quality real-time problems.

DISADVANTAGES OF FOSS

Vulnerable to malicious users. It relies on its online community network to deliver learning support through forums and blog. FOSS might not be as user-friendly as commercial versions.

MERITS OF MATHEMATICS LABORATORY

Teacher can provide various kinds of learning experience to the students. This is a natural way of making discoveries and considered to be the psychological method of teaching as the individual different and interest of all the students are taken into consideration. It is based on the principle of ―learning by doing‖. It brings the application of mathematics into prominence. Various kinds of practical skills and proficiency get developed in them to considerable extent, with the help of which they prove to be successful in earning their livelihood in future. Student learns to perform their work on their own. Habit of team work develops in the students as they are in team. It helps in develop visual or geometrical understanding of the subject. We can observe the increase in the value of the knowledge and degree of interest of students. Students can explore concepts before hard skills to do so are available. Help to increase student motivation and improve student's attitudes towards mathematics. Allows students to concentrate on writing problem formulation and solution analysis.

DEMERITS OF MATHEMATICS LABORATORY

Even if the technology were available there is a limited use of ICT in mathematics class room due to infrastructure, large class sizes and lack of teacher

knowledge. This method of teaching requires well – equipped mathematics laboratory which most of the colleges do not possess. Many colleges, especially those in rural areas, do not have electricity and so computers can't be used. Large class sizes, in such cases a data projector so that all learners might see what is on the computer screen. Lack of teacher knowledge on how to use ICT in teaching mathematics. Limited applicability method as it can't be applied to all the topics of the subject. Shortage of resources as all the students can't get separate equipment. A huge amount of funds is required for essential materials and facilities. Students feel heavy burden on themselves as every student expected to learn by performing experiments. Difficult for the teacher to provide timely help and guidance to them. Teacher should be experienced and well qualified otherwise probabilities of getting failure may increase. Used by the teacher when students have strong theoretical base

DRAWBACKS OF USING TECHNOLOGY IN MATHEMATICS LABORATORY

In spite of so many benefits of using technology there are some drawback, that is why many people advocate against its use. Students tend to use technology blindly and they don't bother about the validity of answer obtained through technology. Most often students try to use technology as an advanced calculator and refuse to learn concepts. Decline of students' paper and pencil skills and find difficulties in evaluation of a course taught using technology. Greater time needed for class preparation lack of familiarity with the computer and technology. Lack of awareness about IT. Technology potentially prevents students from making the proper connections between the techniques used and their mental approach to mathematics.

CHALLENGES AND DIFFICULTIES

Un availability of innovative and exploratory teaching module. Many teachers are not willing to move from traditional teaching style to technology based teaching whenever necessary. Teacher's training in order to integrate technology in teaching and learning. Class rooms are not equipped with relevant hardware which is required integrate teaching in technology. Teachers and students can't affordable some of the Mathematical software, which are too costly. Some colleges don't have proper computer lab. Before using the technology students must be allowed to learn the language and features of technology to enhance their learning. Class rooms and mathematics laboratory should be equipped with relevant data. Sufficient furniture should be provided in the laboratory to do experiments and at the same time for displaying the working models and other means of taking observations to carry out experiments and make a clear understanding about the use of procedural tools.

CONCLUSION

The present era is changing from class rooms to smart rooms, seminar to webinar, traditional class room to virtual class room, academic course to online course. The teaching and learning methods are unlimited as the creativity has no end. Information and Communication Technology has no doubt brought about tremendous change in education, but we are yet to achieve the desired level of IT adaptation in higher education in the country. Teachers are the greatest assets of any education system. Mathematical software is a tool not a self-contained learning package or encyclopedia of mathematical knowledge. It is the way in which it is presented to and used by students that determines its ability to influence learning. Much emphasis these days is placed on student-cantered learning and less on the teaching but teaching and learning are equally important. Computer tools which are easy to use and useful in both pure and applied mathematics courses.

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