



Technology Transforming Mathematics Education

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Abstract-Emergence of information and communication technology has ushered a new era in modern civilization in which digitalization has almost become a useful alternative, because it has influenced every aspect of human life especially our education. Information and Communication Technologies possess an invaluable potential to alter and positively change education of children, teachers, teacher educators and others. ICT ensures innovative and reliable modes of tackling effectively the challenges downgrading the educational system of our country. In mathematics teaching and learning, teachers' beliefs about mathematics learning with or without using technology are considered to be important because it could influence teaching and learning, and curriculum reform. Mathematics education in educational institutions is witnessing dedicated reforms directed toward the integration of technology in mathematics courses at all levels. There is growing demand for sustained cooperation and collaboration amongst mathematicians, technicians, educators in the formulation, research and implementation of not only the syllabus but methodology on use of technology in mathematics education also.

Keywords: Education, e-learning, ICT policies, Mathematics software, Reforms Technology.

INTRODUCTION

Information and Communication Technologies, is the diverse set of technological tools and resources used for communication, to disseminate, to store, and to manage information, which include computers, internet, broadcast technologies such as radio and television, telephone, satellite systems, and services associated with these technologies, such as videoconferencing and electronic mail.

Information and Communication infrastructure refers to physical telecommunications systems and networks like broadband, broadcast, cable, satellite and the services that operate those like Internet, voice, mail, radio, and television while Information technology refers to the hardware and

software of information collection, storage, processing, and presentation.

ICT plays a significant role in every aspect of education by encouraging computer use to enhance learning and better teaching methods. This positively effects student achievement in knowledge, command, practical and presentation skills in subjects like mathematics, science, and social science etc. ICT uses a variety of media forms like text, graphics, animation, audio and video, to enable a rich communication.

ICT tools can be used as an opportunity to create and express. Software applications and hardware devices have become increasingly versatile and cater to a variety of learning needs. The wider the range of tools, devices, software applications and techniques that teachers are aware of, the wider will be the opportunities for developing their imagination and expression. Computers can be used to compute and have frequently been applied in Mathematics research when hand computations are difficult.

Charles Babbage, the father of computing machine, predicted in 1864 that the analytical engine would guide the further course of science because of its ability to do lengthy calculations in the shortest time[1]. Marshall hall took the help of technology to determine all simple groups of order up to one million.

George Forsythe noticed considerable impact of computations on mathematics in 1958, that influenced further mathematical research to an increasing degree. He observed,

"The most valuable acquisition in a scientific or technical education are the general purpose mental tools which remain serviceable for a lifetime."

George Forsythe rated natural language and mathematics as the most important of these tools and computer science as the third [2].

Garrett Birkhoff, an American mathematician, best known for his work in lattice theory, maintained that influence of technology on mathematics were already significant in the early Greek development of mathematics. Birkhoff, a friend of John

von Neumann, took a close interest in the rise of the electronic computer. Birkhoff's research and consulting work developed computational methods besides numerical linear algebra, notably the representation of smooth curves via cubic splines.[3]

Donald Ervin Knuth, an American computer scientist, mathematician, and professor emeritus at Stanford University, claimed that the presentation of finite groups and reduction theory of binary quadratic forms in terms of algorithms, made the purpose and meaning of the mathematical theorems transparent[3].

Derrick Henry "Dick" Lehmer, an American mathematician refined Édouard Lucas' work in the 1930s and devised the Lucas–Lehmer test for Mersenne primes. Lehmer combined computing with mathematics to prove that every set of six consecutive integers > 285 contains a multiple of prime > 43 . [4].

Hyman Bass, an American Mathematician and educationist, observed that technology can carry out quickly and more accurately, mathematical processes to perform large or complex calculations, solve equations, approximate integrals, exhibit function graphs, study effects of variation of parameters, produce vivid and accurate images of geometric figures, etc [5].

Antony Gracious, studied on "e-Training the future world of education", an easy and a faster way to learn as well as present the e -resources, e-lectures online, by visualizing, interacting through video conferencing and with a facility to share the resources through email. ICT and its components would replace the future teacher education and in service programs with e-training. Anil Ambasana conducted a research on "Utilization of computer technology in remedial instruction", showing that computer assisted instruction programme in remediation task was successful as the students were able to overcome the difficult points in the content and to increase their achievement significantly. [6]

Indian Government Initiatives to Promote ICT in Education

Multiple action plans aimed at promoting, implementing and integrating ICT into education at various levels of primary schools, secondary schools, colleges and universities are being developed worldwide. Government of India is also taking various steps to promote use of ICT in education. In recognition of the importance of role of ICT in education, the Computer Literacy and Studies in Schools (CLASS) Project was introduced as a pilot project in 1984-85 and its scope was widened to provide financial grants to educational institutions and also to cover new Government and Government aided secondary and higher secondary schools during the 8th FYP (1993-98).

As per ICT Policy in School Education - 2009 developed by Department of School Education and Literacy Ministry of Human Resource Development, the National Policy on Education revised in march 2012, stressed upon employing educational technology to improve the quality of education paving the way for a more comprehensive centrally sponsored scheme – Information and Communication Technology @ Schools in 2004 [7].

Educational technology found a significant place in the National Curriculum Framework 2005 (NCF) 2005. It also figures in Government of India's flagship programme on education, Sarva Shiksha Abhiyan (SSA) and comprehensively in the norm of schooling recommended by Central Advisory Board of Education (CABE), in 2005 [8].

SSA endeavours to provide guidelines to assist the States in optimizing the use of ICT in school education within a national policy framework. It aims to promote universal, equitable, open and free access to the state of the art ICT as well as ICT enabled tools and resources to all students and teachers. It encourages research, evaluation and experimentation in ICT tools and practices in order to inform, guide and utilise the potentials of ICT in school education.

National Assessment and Accreditation Council (NAAC) was established by the UGC in 1994. NAAC's mandate includes the task of performance evaluation, assessment and accreditation of universities and colleges in the country and to bring higher educational institutions on par with international institutions. All the higher educational institutions have to enrich the learning experiences of their students by providing them with State of the Art educational technologies, have to use ICT for resource sharing and networking, as well as adopting ICT-enabled administrative processes. [9].

The NCERT, being apex organisation in school education, has constantly been engaged in improving the quality of education through various academic programmes such as development of curriculum, textbooks, supplementary books, educational kits, teachers' handbooks, manuals, e-resources and capacity building of Key Resource Teachers, Teacher Educators, State Functionaries. It is contributing significantly in Sarva Shiksha Abhiyan (SSA), Rashtriya Madhyamik Shiksha Abhiyan (RMSA), Information and Communication Technology (ICT) in schools, National Skills Qualifications Framework (NSQF) and Right of Children to Free and Compulsory Education (RTE).

The National Repository of Open Educational Resources (NROER) launched in 2013 makes available digital resources as educational videos, concept maps, audio clips, interactive objects, photographs, diagrams, charts, images, articles, learning objects, talking books, textbook pages and documents in multiple languages for teachers and students. The Curricula for ICT in Education for the school system have been developed to realise the goals of the National Policy on ICT in Schools Education and the National Curriculum Framework [10].

The National Policy on ICT in school education has set the goal of preparing youth to participate creatively in the establishment, sustenance and growth of a knowledge laden society leading to the all round socio-economic development of the nation and striving to be geared for global competitiveness. The teachers' curriculum is a significant vehicle for the realisation of the goals of the National Curriculum Framework. The ICT curriculum broadly attempts to equip teachers with ICT competencies to strengthen their own professional capabilities and to effectively use ICT tools and devices in their teaching-learning [11].

Guided by the National Policy on ICT in School Education, the curriculum for students is designed to promote creativity, problem solving, and introduce students to the world of information and communication technologies with the specific purpose of widening their horizons and better informing them of choices in their career pursuits. MHRD constituted an Institutional consortium to undertake activities viz., online resources available at NCERT, NROER, UNESCO, and others working for promoting science-math teacher education and to contribute e-Books, in the country [12].

ICT Practice in Mathematics Learning and Education

ICT enables Mathematics learners to manipulate diagrams dynamically and support them to imagine the geometry. It support students to make their own conjectures and to test out and modify their ideas. Computers help students to work with real data, represented in variety of ways to support its interpretation and analysis. They form link between graphs and observed values. Mathematical softwares include graphics software, numerical analysis software, numerical libraries, statistical packages etc.

A computer algebra system software, 'Mathematica', is used in manipulation of mathematical formulae includes facilities for graphing equations and provides a programming language for the users' own procedures. It uses symbolic mathematics to solve classical algebra equations and problems in human readable notation. ensures the availability of arbitrary precision arithmetic which can provide more accurate results. 'Axiom' is a general-purpose, strongly typed, computer algebra system. 'CoCoA' is a computer algebra system for doing computations in Commutative Algebra. 'Fermat' is a computer algebra system oriented towards polynomial and matrix algebra over the rationals and finite fields.

SINGULAR is a Computer Algebra System for polynomial computations with special emphasis on the needs of commutative algebra, algebraic geometry, and singularity theory. PARI/GP is a computer algebra system designed for the fast computations in number theory. 'Felix' is a special computer algebra system used for the computation in commutative and non-commutative rings and modules.

GRAPE is a GAP package for constructing and analysing graphs related to groups, finite geometries, and designs. GUAVA is a GAP package for computing with error-correcting codes. LiDIA is C++ Library for Computational Number Theory. LiE is a Computer algebra package for Lie group computations. SONATA is a system for the construction and the analysis of finite near-rings [13].

Spreadsheet software are used to solve simple problems relating to numerical analysis. GAMS, Guide to Available Mathematical Software from NIST, is a cross-index and virtual repository of mathematical and statistical software components of use in computational science and engineering.

GAP (Groups, Algorithms, Programming), is a system for computational discrete algebra, with particular emphasis on Computational Group Theory. GAP is used in research and teaching for studying groups and their representations, rings, vector spaces, algebras, combinatorial structures, and more. 'Magma' is designed to solve computationally hard problems in algebra, number theory, geometry and combinatorics, providing a mathematically rigorous environment for computing with algebraic, number-theoretic, combinatorics and geometric objects [14].

MATLAB mathematics software is used for performing mathematical calculations, analysing and visualizing data, and writing new software programs. MAXIMA, mathematics software, is a system for the manipulation of symbolic and numerical expressions, including differentiation, integration, Taylor series, Laplace transforms, ordinary differential equations, systems of linear equations, polynomials, and sets, lists, vectors, matrices, and tensors. Maxima yields high precision numeric results by using exact fractions, arbitrary precision integers, and variable precision floating point numbers. Maxima can plot functions and data in two and three dimensions [14].

REDUCE mathematics software is a system for doing scalar, vector and matrix algebra by computer, which also supports arbitrary precision numerical approximation. SAGE is free open-source mathematics software system for Algebra and Geometry Experimentation. By an experimental design it was found that working with the software did foster an active, exploring and investigative style of learning resulting in improved knowledge in arithmetic and geometry [14].

Discrete mathematics has been given an added boost by the rise of technology. Symbolic, numerical and graphical representations of functions in algebra are easily understood with an increased ability to visualize manipulations through software packages of 3-dimensional objects like solids of revolution as an aid in developing spatial visualization skills.

Calculus students use computer algebra system to perform numerical integration as one step in a multistep applied problem which enhances the ability to focus on the process of problem

solving instead of the computational aspect. Graphic calculators, computer-aided instructions are used by algebra students having difficulty with factoring for individualized and customized diagnosis, remediation and evaluation.

ICT helps to estimate the probability of quadratic equation having real roots under varying conditions on the coefficients. Word processors can be used to write reports which include mathematical symbols, tables and graphs and use of multimedia programs to communicate mathematical ideas.

CHALLENGES

Science and Technology has resulted in many dramatic developments and advantages of using modern tools and technological innovations life. The use of new technologies for teaching, learning and governance of higher educational institutions, is missing. Our education system, still uncomfortable with new technology, is expected to use of easily available technological advancements. Traditional methods of imparting higher education are inadequate, insufficient to produce required results.

The advancements in other spheres of human endeavour, demand the fast emerging technological developments which enrich and quantify the learning experiences of students. Conscious, dedicated efforts to invest in hardware, resource allocation to train the faculty suitably, to overcome its inherent deficiency, to eradicate the initial reluctance in using the things that are new and gadget-oriented, is required.

Education program in India should invariably integrate ICT component to change the process of teaching and learning, to prepare the students to adjust themselves in the modern society. There are almost negligible, inadequate curriculum regularity measures, mostly outdated assessment frameworks leading to evident poor articulation, stagnant dogma and beliefs among teachers on the use of technology in education, scant and insufficient proficiency skills in the use of ICT.

There is a strong and immediate need for uninterrupted collaboration amongst mathematicians, technicians, educators in the thinking, modulation, formulation, research and implementation of syllabus as well as methodology, on the use of technology in mathematics education. In particular, educators have to urgently grab the opportunity rather challenge, if they are to remain relevant within the rapid revolution in educational courseware.

CONCLUSION

Technology can be used to transmit, perhaps interactively, instruction and course materials that are conceptually of a traditional genre like lectures, demonstrations, problem sets, assessments, which thus would fundamentally support distance

learning. The current activities and practices with the continued use and development of ICTs within education will have a strong impact on Mathematics education, essential today. Using technology as a learning resource, managing the activities of the institution in a technology-enabled way, will cultivate effective institutional functioning.

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