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REVIEW ARTICLE

RESEARCH IN MATHEMATICAL SCIENCES

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ABSTRACT

Technology in various branches of science, business and marketing is changing rapidly. As a result, Mathematics is undergoing a revolution, Computational as well as conceptual. A major issue that needs to be addressed when thinking about impact of technology on Mathematics is the research in Mathematics. In this paper, an attempt has been made to review some basic issues about Mathematics research which comes in the mind of newcomers such as 'How one goes about doing mathematical research? 'and 'What are its most important achievements? ' Some recent trends in mathematical research and worldwide challenges for the future of research in the mathematical sciences are also briefly discussed.

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INTRODUCTION

The Advanced Learner's Dictionary of Current English lays down the meaning of research as "a careful investigation or inquiry specially through search for new facts in any branch of knowledge." (**The Advanced Learner's Dictionary of Current English, Oxford, 1952**). The research in mathematics lies at the heart of the way, science shapes contemporary society. Mathematics, by which we mean pure and applied mathematics as well as statistics, is a discipline in itself, but it also provides the universal language and an indispensable source of intellectual tools for describing, analyzing, and solving problems in other fields. Mathematics has influenced and continues to influence new and far-flung areas of science engineering and technologies, ranging from system biology to national security, prediction of human behavior and recently the 'big bang theory of fundamental particles'. The need for new techniques in applications leads to the development of new research, not only in Mathematics, but in Mathematical Sciences. Steven G. Krantz writes in "The Proof is in the Pudding. A Look at the Changing Nature of Mathematical Proof": (**Steven G. Krantz, 2008**) "It is becoming increasingly evident that the delineations among "engineer" and "mathematician" and "physicist" are becoming ever more vague. It seems plausible that in coming years we will no longer speak of mathematicians as such but rather of mathematical scientists.

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Mathematical research - A people-intensive activity

Mathematics is without any doubt a part of science, but its mode of operation has intrinsic special features. Symbols, Abstraction, Generalisation and extension, theorems, Proofs, concepts, rules, abstract patterns and structures, Infinity are the particular features of mathematics. Mathematics is a key ingredient in science and technology and thus vital to the understanding, control and development of the resources of the high–take world around us. In the mathematical sciences viewed as a whole, new fields continue to emerge that blend two or more classical fields. Even, there is no sharp distinction between the two aspects of mathematics, often referred to as pure mathematics and applied mathematics. For ex. Number theory is being applied to cryptography; Algebraic geometry is being applied to control theory; combinatorics and graph theory are applied to economics; algebraic invariant theory is applied to the study of error-correcting codes and many others. Today's challenges faced by science and technology are so complex that all three approaches to science, 'observation and experiment, theory, and modeling' are needed to understand the complex phenomena and each approach requires the mathematical sciences.

The enormous applications, a new unity in the mathematical sciences, and the ubiquitous presence of the computer are the principal broad trends in Mathematics. The paper "Experimental Mathematics: Recent Developments and Future Outlook" (**Bailey *et al.*, 2001**) describes expected increases in computer capabilities: better hardware in terms of speed and memory capacity; better software in terms of increasing sophistication of algorithms; more advanced visualization facilities; the mixing of numerical and symbolic methods.

Computer is changing mathematics by bringing certain topics (e.g. the method of successive approximation (iteration theory)) into greater prominence. It is even causing mathematicians to create new areas of mathematics such as the theory of computational complexity, the theory of automata, mathematical cryptology. It carry out numerical work faster and more accurately than we can. The influence of computer software is one of the main reason why the young generation want to contribute mathematical research.

How one goes about doing mathematical research?

The first question that comes in the mind of newcomer in research field is 'Where do you get the idea ?' There are several places. Theory of one's own interest, Day- to-day problems, Rapid technological changes in various branches of science, business and marketing, topic of current interest or recent trends, Unexplored areas, hot problems or open end questions, Discussion with experts are some sources of identification of a research topic. Once the research problem is identified, things that help researcher most consistently is Polya's dictum: "Inside every problem you can't solve, lies a smaller problem you can solve." Find it! Then work on this problem, a related problem, a broader or a more specific problem, Generalise or extend it. Often, the good problems come from errors in continuous work. We write a proof of something which at that time, we may think is obvious and later we find a counter-example. The problem is then non-trivial and become a source for research. Another method to do mathematical research is "Starting with a standard problem, apply a standard method or find new simple methods." Indeed, a common method is to reduce a problem to one already considered. If the original problem is too difficult, then a standard strategy is to simplify the problem, using skills and knowledge, so that it does become of standard type, easy to solve, no one else has considered till now, and this leads to new and important research problem.

"Attacking a well-known problem at the frontiers of knowledge" seems to be the most ambitious method and requires more ideas, concentration, deep knowledge, techniques and strategy plans. The popular strategy is 'Relate different areas of knowledge or interrelate different fields'. In this method, one learn about the beginnings of different areas, find relations between them, and fill in the gaps between the peaks. This method advances the general unity of mathematics. Fractional differential equations, fractional linear programming problems are recent examples of this type. Generalisation and extension is one of the beauty of Mathematics which help a researcher. For ex. Pythagoras ' Theorem is the generalisation of the (**Mikhail Gromov, 1998; National Environment Research Council, 2007; New Trends in Mathematical Physics**) right angled triangle, while Fermat's Last Theorem is an extension, resulting in new concepts. Some mathematical scientists, through collaborative efforts in research, will discover new and challenging problems. In turn, these problems will open whole new areas of research of interest and challenge to all mathematical scientists. The fundamental mathematical development of these new areas will naturally cycle back and provide new and substantial tools for attacking scientific and engineering problems.

Blue skies research (also called blue sky science) is scientific research in domains where "real-world" applications are not immediately apparent. It has been defined as "research without a clear goal" (**Bailey *et al.*, 2001**) and "Excellent curiosity-driven science, free from boundaries" (**National Environment Research Council, 2007**). Bertrand Russell has defined mathematics as "the science in which we never know what we are talking about or whether what we are saying is true". Hence, blue sky research is the main important method in Mathematics research, mainly for basic research in pure Mathematics.

Some recent substantial contributions of mathematical research to society

The mathematical sciences are increasingly playing a more central role in the development of advanced modern societies because frequently advanced technology relies on sophisticated mathematical content. Some recent research in mathematical science are

i) The mathematical theory of *wavelets* enables very efficient signal compression, with applications ranging from the video entertainment industry to fingerprint analysis, iris recognition, image transmission and to many new areas of science and technology.
ii) Game theory, with roots in mathematics, statistics, and economics, is routinely applied today to understand and predict human behavior. Game theory recently played a vital role in the design of auctions for third-generation mobile telephone licences.
iii) Numerical methods for partial differential equations have advanced in both accuracy and speed based on innovations in theory, matrix computations and adaptive algorithms. A notable application is the design of extraordinarily efficient airfoils.
iv) The protection of data or information is now everybody's concern, in contexts ranging from bank accounts, credit cards to national security, which are benefits of research in *cryptography* and security.
v) Data mining, the extraction of patterns and anomalies in data, combines statistics with pure and applied mathematics as well as computer science. Modeling, analyzing and updating from data will be of increasing importance because the sheer volume of data associated with numerous applications in areas of science and engineering, such as bioinformatics, genetics, medicine, education, electrical power engineering, is growing rapidly.
vi) In the applications of probability, recent research is on the analysis of probabilistic models of communications networks and internet traffic, coalescent methods in population genetics, randomized algorithms and particle methods for nonlinear filtering.
vii) Research in Fluid Mechanics has been transformed in recent years because of the new dimension taken by massive computer simulation, to the point of giving rise to a new field, Computational Fluid Dynamics (CFD).
viii) Research in scientific computing and computational science:

Computing had a profound impact on research across the mathematical sciences. Computation is widely seen as a new partner that has joined the two classical elements of the scientific method, theory and experiment, as a strategy for doing science. The research in this domain both addresses the challenges of specific research areas and the need for common tools and methods in areas such as parallel computation.

ix) Mathematical biology is a relatively new addition to the mathematical community, Several areas of mathematical biology in which research is going on include pattern formation in developmental biology and more generally in chemically-reacting systems; biological fluid dynamics, including blood flow and swimming microorganisms; tissue dynamics, including wound healing, tumour growth and angiogenesis; mathematical and theoretical ecology; theoretical immunology and in epidemiology.

x) Financial mathematics brings together methods of PDE, stochastic analysis, statistics, probability, and numerical analysis to develop methodologies for the investment-banking industry including optimal investment strategies, risk-management tools and pricing methodologies.

Recent trends in Mathematical research

Biomathematics, Mathematical methods involving Material Design, Prediction Analysis, Safety and Precaution areas, Cryptography, Coding Theory, Sensor *Analysis* in Espionage, Mathematics of the DNA, Fuzzy Mathematics, Fractional calculus, Application of Mathematics in Voting, Actuary Work – Finance, Pension and Insurance, Security and related features in Networks, Image Compression, Financial decision making, Mathematics for storage of Finger Prints, thermo elasticity, Smarandache Notions are some of the recent trends in mathematical research.

Worldwide challenges for the future of research in the mathematical sciences are to advance the core of mathematics, to Strengthen the linkages within mathematics, between mathematics and other disciplines, mainly science and technology; between mathematics and industry and organizations; mainly between research and education.

Conclusion

The connections between the biological sciences, and the physical sciences, mathematics and computer science are rapidly becoming deeper and more extensive. Fields such as physics and electrical engineering that have always been mathematical are becoming even more so. Sciences that have not been heavily mathematical in the past, for example, biology, physiology, and medicine, are moving from description and taxonomy to analysis and explanation; Outside the traditional spheres of science and engineering, mathematics is being called upon to analyze and solve a widening array of problems in communication, finance, manufacturing, and business. Progress in science, in all its branches, requires close involvement and strengthening of the mathematical enterprise.
More precisely, the artifacts of mathematics are results, insights, algorithms, techniques, and software. These forms of knowledge permit very rapid introduction of the latest research in the mathematical sciences to applied fields of science and technology. Hence, the need of research in mathematical sciences is not only for the growth of mathematics but also for the health of an increasingly large part of the high-tech world.

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