Annals of Science and Technology - A, Vol 8 (2): 86-91, 2023
Copyright: An Official *Journal* of the Nigerian Young Academy
ISSN: 2 544 6320

sciendo

ARTICLE

Present day changes in Mathematical Research

Daniel C. Iweobodo

Department of Mathematics, Dennis Osadebay University, Asaba
Received 21st September, 2023, Accepted 23rd November, 2023
DOI: 10.2478/ast-2023-0019

**Corresponding author*
Daniel C. Iweobodo, Email: iweobodo.daniel@dou.edu.ng; Tel: +2348031946778

Abstract

In this work, various changes and developments in the field of mathematics were considered. To achieve this, trends generally and how they have affected the subject of mathematics were discussed, with consideration on some areas of trends in mathematics in the 1990s, identifying some notable developments in mathematics today, and some of the most current areas of developments in the field of mathematics and their effect between 2010 and today. In the course of these considerations, it was discovered that the subject of mathematics has experienced a lot of changes and evolutions over the years, and the application of mathematics today has grown beyond just physics and engineering but in many other fields. Computer has been identified as very important and useful in the current day mathematics, and mathematics also has been identified as very important and useful in computer science too. Also, it has been noticed that some concepts of hybridization as a result of the combination of mathematics and other fields now exist today, thereby promoting inter-field study. At the end of the work, the study revealed some changes which have occurred in the field of mathematics over the years, reiterated some applicable areas in mathematics today which occurred as a result of trends in mathematics in the 1990s, reiterated the importance and wide presence of computer in the current day mathematics and the importance and wide presence of mathematics in core areas of computer science and also identified some hybridized concepts which erupted as a result of the combination of mathematics and other fields.

Keyword: Evolution, developments, changes, model, digital computing, hybridized concepts, artificial intelligence.

BY-NC-ND ©*Iweobodo* This work is licensed under the **Creative Commons Attribution-Non-Commercial-NoDerivs License 4.0**

1.0 Introduction

1.1 Background to the Study

Very many of our day-to-day activities contain mathematics, on a regular basis, every human on earth applies mathematical reasoning, but many hardly remember that what they are making use of is mathematical reasoning; some term it common sense, without realizing that mathematics has an integral role in it. These daily applications cut across nearly all the branches of mathematics (not only the applied mathematics) and they are done in every area of our daily life.

Mathematical activities such as research, learning, applications, experimentation, and exposition, have experienced multiple changes in recent decades. One of the multiple changes is the use of computers; it is quite understandable and widely applicable in the field of mathematics. Other activities of great importance as iterated in Dubey and Singh (2014) include algorithms and programming, problems and conjectures, mathematical experiments, modeling, exposition and popularization.

A few scholars have noticed some tremendous changes in the subject of mathematics over the years from what it was originally to what it is now; for instance, in Dieudonne (1978) some key areas of changes in mathematics were identified and discussed. In the same vein, some relevance of mathematics and its application in every aspect of life and in different career were stated in Bakthavathchalam and Gokul (2022), and the authors listed some areas of applications of mathematics in other fields. Some of the points identified include the use of Algebra in the study of symmetry (Chemistry), Networking and cryptology, the use of calculus in option price modeling (Economics), biology, hydrodynamics, rocket science, engineering, etc. Being motivated by the quest of knowing where the subject of mathematics is driving to, and considering the pace at which its application is spreading right from the days of its origin till date, this work intends to look at some notable developments in mathematics between the period of 2010 till date and how it has evolved over the years.

2.0 General information about evolution in Mathematics over the years

The daily application of mathematics in many activities (e.g. trades) today has gone farther than just basic counting. Before now, mathematics is applied majorly in physics and engineering, and the applicable aspect of mathematics were analysis and differential equations. In the 20th century there was a major increase in interest in the areas of science and technology, this brought a wide spread in the application of mathematics into other areas, and the usefulness of other areas of mathematics outside analysis and differential equations. For instance, discrete mathematical structures (e.g. combinatorics) are used to study genetic codes and pattern matching in biology; also, linear programming and operations research are applied in solving problems in economics, and lots more. Currently, an important aspect of applied mathematics has been completely developed, and that is the computer science. In L´aszl´o (2013), the development of electronic computation provides a vast array of well-formulated, difficult, and important mathematical problems, raised by the study of algorithms, data bases, formal languages, cryptography and computer security, VLSI layout, and much more. Most of these have to do with discrete mathematics, formal logic, and probability.

Many mathematical scholars have continued to develop applicable models in different areas of study from areas where people never expected that their real-life applications would ever be possible, for instance, the Number Theory was studied only in the pure mathematics, but in today mathematics, a lot of areas in Number Theory are applied in computer security and mathematical cryptography. One notable achievement in recent decades is the gradual bridging of the gap between pure and applied mathematics. According to L´aszl´o (2013),

"I feel that the mutual respect of pure and applied mathematicians is increasing, along with the number of people contributing to both sides. The diversity of applications should also strengthen the flow of information across all of mathematics. No field can retreat into its ivory tower and close its doors to applications; nor can any field claim to be "the" applied mathematics any more. How to give a glimpse of the power of these new applications to our students? Perhaps some nonstandard mathematical activities like programming and modeling can be used here".

In our world today, the application of mathematics in almost every aspect of our daily living has become so visible, some areas of increment in its consideration today include science and technology, education, agriculture, social sciences, etc. Computer usage, together with other useful tools has increased the relevance of mathematics and has become a motivating factor for most students and researchers in today's world, giving room for improvement in certain social, psychological and biographical factors which may be of great effect in studying mathematics (Kushwaha et al 2014).

3.0 Research tools and activities leading to positive changes in Mathathematics

3.1 Computers and Information Technology

Computers are very important in mathematical research; they provide solution tools for proper achievement and observation of results to problems, and also help in the arrangement and organizing of the research work. They are useful in word processing and messaging, provide useful information about research events through websites, useful in carrying out useful experiments, and also used in generating and developing useful codes and programs that help in breaking down mathematical solutions. They provide access to electronic journals and databases, home pages, institutions, industries and companies, etc. The computers make available results and ideas for consumers, making research more interesting and increasing the number of researchers and learners. It was iterated in Sunghwan et al (2023) that the computers in a sense reinforce the increase in volume of research: not only are there increasingly more people doing research, but an increasingly large fraction of this information is available at our fingertips (and often increasingly loudly and aggressively: the etiquette of e-mail is far from solid).

Haven understood the immense ability of computers; the major problem is how to manipulate mathematical activities to suit the computer capability. Therefore, we must consider mathematical activities in other to achieve a successful computing. These activities are considered below.

3.2 Algorithms and programming

An algorithm is a set of rules which is to be followed in solving a problem; these rules are developed into programs and executed by a computer to produce results.

In the early era, carrying out research in mathematics involved only to state a theorem and prove it, and to develop and define notions; meanwhile, designing of algorithms has gained existence at some point then but it was not known by most mathematicians; an example of one of those designs then is the Newton's Method or the Euclidean Algorithm. Today, the introduction of computers has made designing

of algorithms known, visible and important. According to Kleinbarg and Tardos (2006), Algorithmic problems from the heart of computer science, but they rarely arrive as cleanly packaged mathematically precise questions, rather, they tend to come bundled together with lots of messy, application-specific detail, some of it essential, some of it extraneous.

In a nut shell, the mathematics of algorithm has existed from antiquity, but the emergence of computers has made it more exposed and more useful. The algorithms are programmed into the computer and results are generated.

3.3 Problems and conjectures

In situations involving only a few numbers of people, problems are easily seen, but when the situation involves a large number of persons, there should be a precise way to detect and present problems to ensure that solutions are obtained correctly, this is because inaccurate and inefficient solutions occur when problems are not stated correctly.

Conjectures are mathematical theorems or events which have not been proven; formulating a conjecture gets increased according to research results. Achieving a perfect conjecture is not an easy task; a good conjecture brings improvement and substantial knowledge in understanding mathematics.

3.4 Experiments in Mathematics

In a normal context, mathematics is a kind of deductive science, but to a reasonable extent, the existence of computers has added some experimentation in mathematical research today, although not all aspects of mathematical research require experimentation. Some mathematical conditions that may require some forms of experimentation are described below:

i.In a situation where the needed resources are dependent on the input in a way involving some forms of complications in having a near accurate predictions, there is need to test for the accuracy and efficiency of the algorithms.

ii. Some classical questions about the supply and circulation of prime numbers, and other similar issues found in the number theory are highly needed in other to find solutions to cryptographic and some other security issues in computers. Some of the needed answers most times are found in solving relevant number theory problems such as Riemann Hypothesis and its extensions. In order to get these answers, experiments (although a practical one) must be carried out.

iii.Performing experiments in mathematics leads to the development of conjectures, for instance, Graffiti was discovered in Fajtlowicz (1998), which is the graph-theoretic conjecture generating program. Another example is the works of Gauss in propounding the theorem of prime number.

ICT and computational software packages like Maple, Mathematica, Matlab, Derive, MathCAD, etc provides many ways of performing experiments with mathematics.

3.5 Modeling

This is a process of describing real life problems in form of mathematics, it is usually in form of equations and the equations are the models. In order to achieve a perfect mathematical application, the first thing to do is to be able to formulate a good mathematical model. Hence, in L´aszl´o, L (2013) modeling was described as a typical interactive process, where the mathematician must work together with engineers, biologist, economists, and many other professionals seeking help from mathematics.

In pursuit of solutions to difficulties of life today, researchers identify the real-life problems they are facing around their place and in their course of living, they then put these problems in form of mathematical models, find and arrange necessary data, identify the algorithms in solving the equations that makes up the models and program them, then present the results. These real-life problems are so many in our environment today, they are usually in form of making useful decisions in business, making necessary efforts towards increasing production and productivity in areas like Agriculture, identifying causes and effects in medicine, etc.

3.6 Exposition and popularization

This represents the comprehensive way of describing and presenting a mathematical idea to make it known to others. This activity is on the fast increase in mathematical research, apart from the original pattern of wring monographs, people now make more request for expositions, handbooks, database, encyclopedia, surveys, seminars, courses and trainings. Today, a lot of publishing firms consider having more of survey articles than research articles, conferences and seminars are geared towards exposition and survey, and a lot of the ones that considered them ended successfully. Although most expository works are lacking complete recognition today, their significance cannot be overlooked, they are more accepted.

4.0 Areas of Development

4.1 The 1990s Achievements

A lot of trends took place between the periods of 1900-2000, there was a reconsideration of the origin of the subject of mathematics and there emerged new ways of solving mathematics. Some of the multiple trends of the aforementioned periods were the development of Banach spaces which brought a lime-light into functional analysis and later became useful in partial differential equations, topological spaces and harmonic analysis. Hilbert was one of the mathematicians who existed between 1862 and 1943, his mission was to analyze the axioms of all disciplines, and present their results and their general form. During the 1930s, he developed the axiomatic solutions of algebraic expressions.

The trends which occurred within these years brought a huge motivation that caused researchers to achieve great and applicable discoveries in many other disciplines. Because of this, L´aszl´o (2013) stated that towards the end of the 20th century, mathematicians were considering bridging the division lines within mathematics in order to open it up more for other disciplines and to support the line of inter-discipline research. With this, one can therefore say that in the course of seeking for connectivity to other fields, mathematicians of these ages made the subject of mathematics more complex, more diverse and better structured. These trends also introduced new and applicable tools into the mathematical world, and brought a more comprehensive and developed language of mathematics

4.2. Trends in Mathematics Today

(a)More areas of applications thereby reducing the difference between the pure and applied branches

This increased demand for mathematical application has appeared in two ways;

i. The science world has experienced "multiple infections". This is already obvious in the social sciences, and it has also shown its presence in today's theoretical biology.

ii. Many aspects of mathematics that were regarded by some scholars as impregnable pure are now being applied today. For example, algebraic geometry is now applicable in control theory and large-scale systems; combinatorics and graph theory are now applicable in economics; the theory of fiber bundles is now applicable in physics; algebraic invariant theory is applicable in error-correcting codes.

These massive applications are therefore making the difference between the pure and the applied branches of mathematics now not

measured on the basis of their content but on the character and inspiration of the mathematician. Because of this, some mathematicians have gone farther towards bridging the distinctions between the pure and applied branches of mathematics. For instance, Dubey and Singh (2014) argued that there should be no sharp distinction between the methods of pure and applied mathematics, and they stated that such a distinction should certainly not consist of a greater attention to rigidity in the pure community, their reason is because they believe that the applied mathematician should have an understanding of the domain of validity of the methods he is applying, be able to analyze the stability of his results and the extent of modification they can do to suit a situation.

Because of the fact that many or almost all areas are now being applicable today, it will be kind of impartial to still classify the pure mathematics as inapplicable.

(b)Rejoining of Sub-Disciplines

Among the features which existed in mathematics before 10 years ago, the most characteristic feature was the emanation of other autonomous disciplines; most of them came into existence just recently. Therefore, other disciplines having the same interest were calved out of mathematics, and their existence was in one way or the other, broadly or slightly dependent on certain mathematical areas like algebraic geometry, algebraic topology, homological algebra, commutative ring theory, real analysis, complex analysis, set theory, and lots more. Some scholars still argue that real mathematicians never really existed because scholars in different fields were not able to communicate with each other so easily, that was the existing system, and its appearance in the history was not out of place, but today, the story is turning around as the autonomous disciplines are now getting directly linked together with mathematics in such a way that the subject matter is being rejoined as one, making the subject of mathematics broader and breaking down the artificial barriers surrounding its understanding.

(c)The Role of Computer

Another trend to consider is the general existence and importance of the computer system and the different roles they play in achieving results and changing the face of the subject matter. The computer plays enormous and versatile roles in our life and in the evolution of mathematics today. Many branches of mathematics have been brought into greater prominence today by the computer, and the process is still on, another new change the computer has caused in mathematics is the development of new branches, some of these new branches include, the theory of automata, mathematical cryptology, the theory of computational complexity, and lots more. Also, its capacity and ability to perform some mathematical task so easily, faster and accurately has caused a great relief to mathematicians of the difficulty and tediousness of executing some certain traditional mathematical task, and the computer performs the tasks faster and more accurately. In buttressing this, Patel (2019) emphasized that the computer does all numerical tasks easily, painlessly and faster; making the analytical tasks of many real life and mathematical problems by many mathematicians achievable.

(d) Connection between Mathematics and Other Fields

A lot of efforts are being encouraged today in order to actualize collaboration across many different traditional academic fields in research, and also to develop and train interdisciplinary scientists and mathematicians. Many fields which never felt the presence of mathematics before now, now involves many knowledge of mathematics in their studies and researches, For instance, some Curricula for some social science programming now include some serious mathematics more than the traditional descriptive statistics. Also, some universities and tertiary institutions of some developed countries now have some interdisciplinary programs in their curricula, causing some students to get involved with mathematics students and other science students in some joint projects. Today, experiments and discoveries have shown that the subject of mathematics is not only useful in physics and engineering, but also in other disciplines like medicine, biomedicals, economics and lots more. Its interdisciplinary connection has also been useful in many certain real practical situations like predicting patterns in the stock market, denoising, image compression, speeding the flow of traffic on the internet, sharpening the transmission of digitized images, and feeding the entertainment industry through its contributions to digital technology.

Mathematics has contributed greatly in many fields through mathematical modeling, analytical studies and numerical analysis and experiments, its numerous contributions has been greatly seen in areas like human genes, geometric motions and finances, etc. for instance, there is a huge body of genetic information in science now, and scholars have to apply mathematical formula and algorithms, clustering methods and computer models to search and to interpret them. Mathematics plays an important role in finance, finance deals with derivatives, risk management, portfolio management and stock options. They are modeled mathematically; therefore, mathematicians are fully involved in the financial businesses today. The convergence of mathematics and the life sciences, which was not foreseen a generation ago, is a remarkable opportunity for application.

5.0 The most current areas of changes in Mathematics between 2010 till date

Since the last 10 years, many research areas requiring mathematical applications have emanated, some of these areas include- the need for reliable software in situations requiring mathematics for computer language, architecture, etc.; System Security (mathematics for Information and Communication, Mathematics for sensors, mobile communication as well as network security and protection); Mathematics for materials; Future systems (lighter vehicles, smaller satellites, ICBM Interceptors, Hit before being Hit, secured wireless communication systems, super-efficient energy/power sources, modeling and simulations, robotics and automation; and requirements for automated decision making (probability, stochastic analysis, mathematics of sensing, pattern analysis, and spectral analysis). Let us consider some examples of these trends.

5.1 Material Sciences

The study of material sciences was originally considered important only in metallurgy, ceramics, and plastics, but today; its wide presence has appeared in typical areas of sciences, engineering, and mathematics. Material sciences deal with the combinations of components of materials, modification of materials, predicting the characteristics of materials, studying the evolution and control of the characteristics of materials within a period of time, understanding materials, and manufacturing of new materials. For instance, mathematical models have shown reliability in synthesizing and manufacturing polymers. Most of the reliable mathematical models applicable in this are traceable to statistics, mechanics, and diffusion equation. Another important mathematical concept which is very useful in material sciences is the singularity and stability of solutions.

5.2 Composites

Between the periods of 2010 till date, mathematicians have developed some new mathematical tools which are useful in numerical analysis, functional analysis, and PDEs; these new tools have been very useful in computing and estimating effective characteristics of composites. Composites are useful in very many industries; they are used as lightweight alternative to steel (composites of silicon-carbon grains and composites of aluminum), also, they are applicable in enhancing brake fluid and shock absorbers (Fluid with magnetic and electrically charged particles). Many new materials and their composites are on the increase in recent days, this means that there is going to be more mathematical application in this area as time progresses.

5.3 Digital Computing

A lot of research areas are involved in the mathematics of digital technology, so many areas of digital technology have been affected positively by mathematics, some of these areas include- signal processing, image compression, speech recognition, computer display, networking, CAD, image processing, etc. some applicable mathematical tools which are useful in these areas include- wavelets, PDEs, stochastic process, graph theory, numerical analysis, Markov chain, statistical pattern, operations research, optimization, etc. A fast growing and powerful tool for many firms and institutes today is the CAD (Computer Aided Design), research in mathematics flourishes more with this technological tool. In Dubey and Singh (2014), it was stated that

"The future of the World Wide Web will depend on the development of many new mathematical ideas and algorithms, and mathematicians will have to develop ever more secure cryptographic schemes and thus new developments from number theory, discrete mathematics, algebraic geometry, and dynamical systems, as well as other fields".

Thus, multimedia computing has a great potential for research in mathematics as many mathematical tools keep being useful in the areas, and results are being evidently visible and applicable in many industries.

5.4 Artificial Intelligence

This is an advanced area of the digital technology today, it is the theory and the development of computer systems to perform certain tasks which require human intelligence, these tasks include- visual display, speech recognition, signal processing, decision making, translation between languages, etc. In very magical and unexpected way, the Artificial Intelligence has spread into our lives and existence today; In Kutyniok (2023) it was asserted that Artificial Intelligence tools are already at the point of having a breakthrough in the fast-evolving level of digital technology.

The whole brain behind thinking machines and their ability to behave like humans is all mathematics. An article online described Artificial Intelligence and mathematics as two branches of the same tree, therefore, one cannot excel in the field of artificial intelligence without an in-depth knowledge of mathematics.

5.4.1 How the Artificial Intelligence connects with Mathematics

The first aspect of the connection is problem formulation, there are two classes of problems which make up the Artificial intelligence, these are- search and representations problems. The next areas of their connection are the tools, nets, models, algorithms, frames, and logics; all these are major areas of study in mathematics. The major reason why artificial intelligence is developed is to develop an acceptable model for human understanding; these models are developed with mathematical ideas and concepts. For instance, the goal of a self-driving car in a video clip is to identify people and objects, there is a mathematical model with minimization procedure and back propagation that helps in achieving the goal of the car. Therefore, mathematics brings solution to difficult and abstract problems in artificial intelligence with the normally known mathematical methods and tools, some of the applicable aspects of mathematics useful in artificial intelligence include- Linear algebra, Calculus, game theory, probability theory, advanced logical reasoning, regression analysis, statistics, gradient descent, and more.

6.0 Conclusion

All aspects of mathematics have the ability to be applicable and useful in other disciplines and in solving the problems of the world today, recent trends in mathematics from 2010 till date have shown the effort of scholars in combining mathematics with other fields, thereby bringing about some hybridized concepts in fields of study today, thereby promoting inter-field study for the benefit of solving real life problems.

The involvement of mathematics in the analysis and proffering of solutions to very many problems of life today cannot be over emphasized. Many different areas of mathematics today now have significant roles and applications in other areas, thereby bringing positive and exciting changes in the attitude of people towards the subject of mathematics. The mathematics of today has continued gearing towards providing solutions to real life problems as it is evident in artificial intelligence, data analytics, business analytics, etc. Also, the art of combining mathematics with other disciplines has brought about hybridized concepts capable of bringing more positive changes to situations of the world today.

Conflict of interest

No conflict of interest

Author's contribution

This work has been solely designed and developed by D. C. Iweobodo

References

Bakthavathchalam A. K. and Gokul R. (2022). Emerging Trends in Application of Mathematics in Current Engineering Field. Department of Civil Engineering, Monroe Community College. https://www.studocu.com/en-us/document/monroe-community-college/civil-engineering/emerging-trends-in-application-of-mathematics-in-current-engineering-field/17021968

Dieudonne, J. (1978). Present Trends in Pure Mathematics. Advances in Mathematics, 27(3);235-255, https://doi.org/10.1016/0001-8708(78)90100-7.

Dubey, M. and Singh, B. K. (2014). Recent Trends in Mathematics and Potential Contributiontoother Disciplines. International Journal of Innovation and Research in Educational Sciences, 1(2);115-118. ISSN (Online): 2349–5219.

Fajtlowicz S. (1998). On Conjectures of Graffiti. Anals of Discrete Mathematics. 38;113-118. https://doi.org/10.1016/S0167-5060(08)70776-3

Kleinbarg, J. and Tardos, E. (2006). Algorithm Design. Pearson Addison Wesley. ISBN 0-321-29535-8.

Kushwaha R. C., Chaurasia P. K. and Singhal A. (2014) Impact on Students' Achievement in Teaching Mathematics using Geogebra. IEEE Sixth International Conference on Technology for Education. 134-137. DOI 10.1109/T4E.2014.54

Kutyniok, G. (2023). An introduction to the mathematics of deep learning, EMS Press, DOI 10.4171/8ECM/30

L´aszl´o, L. (2013). Trends in Mathematics: How they could Change Education, Notices of the ICCM, 1(2); 79-84.

Patel, S. (2019). Modern Trends and Perspective in Mathematics. Journal of Emerging Technologies and Innovative Research, 6(3):545-547. ISSN-2349-5162.

Sunghwan H., Eunhye F. and Ji-Eun L. (2023). Exploring research trends of technology use in mathematics education: A scoping review using topic modeling. Educ Info Technol, 28:10753–10780, Doi:10.1007/s10639-023-11603-0. PMID: 36779196.