THE ROLE OF MATHEMATICS AND THE BASIC SCIENCES IN POLYTECHNIC EDUCATION

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Abstract

The paper traces the history and origin of Mathematics and sciences from the rivers period to the modern world period. It evaluates the development of the teaching of science in tertiary institutions and discovered that the teaching of Mathematics and science has no strong roots at the secondary school level. This might possibly be due to the dearth of manpower and/or misappropriation of funds due to science development by heads of secondary schools. The paper also attempts the definition of science, the process and ethics of science and the relationship between scientific knowledge and other disciplines. This is done in order to note that the vulcanizing or patching of tyres by the road side vulcanizer requires simple chemical bonding in the relevant fusing materials. It also relates the problems of teaching of sciences in the Polytechnic to lack of facilities and also lack of maintenance of such facilities. Lastly, the paper elucidates on how to encourage effective teaching of science by teaching the concepts, laws and theories from first principles. It also advocates effective supervision of practicals, projects and attendance to periodic seminars, conferences, workshops in order to enable the science lecturer to be abreast of modern scientific trends.

The Origin and Brief History of Mathematics and Basic Sciences

In order to fully grasp the nitty-gritty of the subject of discourse, it is better to understand what basic Sciences and mathematics are: Basic Sciences comprises of Biology, Chemistry and Physics. Biology is a science that attempt to understand the teeming diversity of life on earth, a diversity of which we are a part. Biology therefore deals with life.

Physics is a science that deals with the behaviour of matter. Some of its branches are electromagnetic waves, optics, heat, sound and properties of matter. As a result of the study of Physics, many useful inventions and machines have been produced e.g. internal combustion engines in the 1880s, aircraft design and manufacture in 1918, colour television by John Logie Bairdin in the 1920s etc. Also in the world of electronics, the technology centering round the thermionic valve and the Cathode-ray tube was made possible by extensive research and inventions in Physics.

Chemistry is the scientific study of the structure of substances, how they react when combined or in contact with one another and how they behave under different conditions. Mathematics is the science of numbers and shapes. Some branches of mathematics include arithmetic, algebra, geometry and trigonometry. The origin of science is traceable to an attempt to search for the truth behind the universe. Human beings have been bothered about what was responsible for stability and change. The history of science can be anchored on six most significant periods:

(i) Rivers period
(ii) Greek period
(iii) Renaissance period
(iv) The period of scientific revolution
(v) The 18^{th} and 19^{th} century
(vi) The modern world period

The Rivers Period

The rivers period was the time the Egyptians, the Babylonians and Mesopotamia responded to the challenges created by the environment. The rivers involved here were Tigris, Euphrates, Nile and others in Mesopotamia. History informed us that for most part of the year these rivers overflowed

their banks and that the experience forced people around the rivers into applied science. The overflowing of the Nile led to the development of season's calendar, agriculture, art of building, writing and medicine. Abdullahi (1982; 112)

It is instructive to note that during the rivers period, science was rather mythological as well as theological, because people did not know the causes of events occurring in their environment, including the overflowing of the Nile and other rivers.

The Greek Period

The Greek period refers to sometime around 600BC. The Greek pursued wisdom or excellence in order to discover the laws and principles which governed the universe. This made them to search for explanations of life and creation through the use of pure reasoning, observation, analysis and deduction. Man was so fascinated by his very creation that of the world and other heavenly bodies that he saw. Infact, the Greek rejected the myths, legends and fantasies with which the mysteries of creation were traditionally explained. Then, there were speculations about the material nature of water which began with Thales (640 – 546BC). Thales feels water is a fundamental substance because it can exist in three states of matter: solid, liquid and gas. This implies that everything in the universe is made up of water. Budd and Ford (2003:36)

However, Aniximander (611 – 547BC), a student of Thales, speculated that the primary substance of all existing matter is not water but something infinite, eternal or ageless. For example, energy is neither magnetic nor electric, neither kinetic nor potential, neither matter nor radiation, but must be capable of manifesting itself. He therefore postulated two ideas:

(i) That matter is comprised of air or (pneuma)

(ii) That when pneuma is diluted, it is fiery; when it contracts it turns into wind, when water contracts it turns into rock

Renaissance Period

The renaissance period is the medieval period or the middle age period and it occurred in Europe between the 9^{th} and 15^{th} century. It was during this period that people became conscious that progress in the way of life was slow. This led to the feeling by the people that change in ideas, in beliefs and way of thought was necessary.

The ancient Greek and the people of other ancient civilization have written books on Mathematics, astronomy, geography etc and were learned. There was an increasing desire for knowledge and this was satisfied by translation of the Greek books into latin.

The spirit of questioning old beliefs and ideas and forming new and accepted beliefs and concepts dominated. This period was eventually described as the "Renaissance" which means revival or rebirth.

The quest for knowledge went on from the renaissance period to the period of scientific development (600BC – 600AD) mainly, through speculations about the nature of things. The 'Greek Science' as it was then known was inadequate to support the observations around the 15^{th} and 17^{th} centuries. The Greek then began playing down on speculations for empiricism. People began to gather and treat data to verify their claims. Specifically the data were gathered in Mathematics, Physics and other Sciences to explain observed phenomena.

This period produced notable scientist who achieved some feat in their specialized field. These include:

- Isaac Newton (1642 – 1727) who made inventions in calculus and laws of motion.
- Robert Boyle (1627 – 1691) who formulated the famous law about the relationship between temperature, pressure and volume of gases in modern Chemistry.
- Galileo Galieli (1564 – 1643) who discovered astronomy and telescope and the movement of the moons around the Jupiter.
- Nicolas Copernicus (1473 – 1543) who formed hypothesis on the rotation of earth around the sun.

- Harvey (1578 – 1657) who discovered the circulation of blood.

The 18th and 19th Century

This period was that of industrialization when scientific knowledge was greatly utilized. There were tremendous progress in Galileo and Newtonian physics. Chemistry and chemical industries were improved upon while there was mechanization of biology.
However, it is instructive to note that within the stated period, scientific knowledge and discovery was restricted to Europe and America.

The Modern World Period – 20th Century

The modern world period was when science was spread across the Atlantic to other parts of the world. It was also characterized by the period of world utilization in industries.
In other words, most production, harvesting and processing were handled by mechanization. Also automation in communication, Television, telex, fax, e-mail, internet services and space communication came into being. However, these scientific developments or inventions also include production of atomic bomb, nuclear plants/reactors and other dangerous weapons for biological warfare. There was a general rapid expansion of science in every part of the universe which assisted in improving the quality of the environment and life expectancies.

According to Encanta Premium (2006) the following scientists who are among the top 25 made significant contributions in science in the 20th century:

- Einstein (1879 – 1955) made discovery on special theory of relativity.
- Enrico Fermi (1901 – 1954) made discovery on elementary particles.
- James Watson (1928) was a molecular biologist and nobel prize winner in Physiology in 1962.
- Graham Bell (1847 – 1922) invented the telephone.
- Stephen Hawking (1942) a theoretical Physicist and Mathematician who contributed to the field of relativity and quantum mechanics studied for his Doctorate degree in Cambridge.

Development of the Teaching of Science in Tertiary Institutions

Up to 1932 there was no post secondary institution for the learning and teaching of science. However, before then, the teaching of science had gained some ground in some secondary schools such as: Abeokuta Grammar School, Kings College Lagos, Eko Boys' High School Lagos, Ibadan Grammar School, Ibadan, Dennis Memorial School Onitsha, and Government Colleges at Umuahia and Ibadan in 1929. Because of the importance which the government placed on science education, it made some innovations and changes in the National Policy of Education (2004) to include that, amongst others:
…….. "Introduction of Information and Communication Technology (ICT) into the system; …… repositioning science, technical and vocational education in the scheme of national education for optimum performance"… FGN (2004:4), It is in pursuance of the above policy that government focused on some of the goals for Polytechnic education as follows:

(i) To provide full-time or part-time courses of instruction and training in engineering, other technologies, applied science, business management, leading to the production of trained manpower.

(ii) To give training and impart the necessary skills for the production of technicians, technologists and other skilled personnel who shall be enterprising and self-reliant.

(iii) Train people who can apply scientific knowledge to solve environmental problems for the convenience of man.

It is pertinent to note that inspite of the government's good intention to properly position the study of science, technological and vocational education in the Polytechnics in the country has not been able to achieve the technological development that is in consonance with its national aspiration.
Firstly, there is the dearth of manpower to teach Mathematics and the Basic Sciences at both the junior secondary secondary and senior secondary schools. From experience, it is known that the

teachers that handle these subjects are not qualified to do so. Furthermore, there are no relevant materials and laboratories (physics, Chemistry and Biology).

In order to make up for these deficiencies, some unscrupulous school principals or Heads of Science departments go out of their ways to help students cheat their ways through both in the theory and practicals during West African School Certificate (WAEC) and National Examination Council (NECO) examinations.

Eventually, secondary school science students who are either half baked or who have not seen a test tube before graduating to the polytechnic level are produced. So, in all these, there is a problem. The pertinent question is how can the problems be solved? Is it that the same government who lays emphasis on science education by policy is also not aiding development of the science teaching and learning by not funding the secondary schools science projects? OR Is it not possible that these funds were provided but were diverted into other uses?

Thirdly, most secondary school teachers and (science, social studies and arts) principals are not as committed as those of 20 – 30yrs ago. Perhaps, this is one of the reasons adduced for students not picking much interest in the learning and studying of science these days. Gega and Peters (1994). This also explains why the admission ratio of 70:30 into the technology and business courses in the Polytechnic system had been very difficult to fulfill.

In order to ameliorate the situation, the National Board for Technical Education (NBTE) has, in its wisdom designed the preliminary National Diploma in Science and technology courses to upgrade the General Certificate of Education (GCE) or the West African School Certificate candidates to credit levels as a prerequisite for admission to National Diploma Science and Technology Programmes offered by the Polytechnics and similar level institutions in Nigeria.

Nature and Processes of Science

Definitions of Science

There are lots of definitions of science; the simplest is that in which 'science' is derived from Latin word "Scientia" which means knowledge.

Oxford Advanced Learner's Dictionary (2001 edition) defines science as knowledge about the structure and behaviour of the natural and physical world based on facts that you can prove, for example by experiments and new development in science and technology.

Encanta Premium (2006) defines science as:

(i) The study of the physical and natural world and phenomena, especially by using systematic observation and experiment.

(ii) A systematically organized body of knowledge about a particular subject.

(iii) An activity that is the object of careful study or that is carried out according to a developed method.

(iv) Mathematics is the study of the relationships amongst numbers, shapes and quantities. It uses signs, symbols and proofs and includes arithmetic, algebra, calculus, geometry and trigonometry.

Abdullahi (1982) defined science as activities culminating into a testable, falsifiable, and verifiable body of knowledge.

From the above definitions, it can be easily seen that none of them is adequate enough for a comprehensive definition of science. However, we can look at science as business participated in by human beings, concerned with the study and parsimonious explanation of the materials and forces of nature. In effect, science deals with the desire for knowledge, ability to use systematic and verifiable methods for experimentation and acceptance of a new order (concept) based on falsifiableness of an old order using descriptive, comparative and quantitative concepts.

Deductive and Inductive Science

The scientific approach is grounded on a set of fundamental assumptions that are unproved and unproveable. They are necessary prerequisites for the conduct of scientific discourse and

represent those issues in the area of the philosophy of science that is termed epistemology-the study of the foundations of knowledge.

The basic assumption of the scientific approach is that there exists a definite regularity and order in the natural world: events do not occur haphazardly.

Nachmias and Nachmias (1981) averred that in science, nature denotes all those empirically observable objects, conductions and phenomena that exist independently of human intervention but include the human being as a biological system. The laws of nature do not prescribe, but rather describes, what actually is happening. Furthermore, order and regularity in nature are not necessarily inherent in the phenomena. Deductive Science involves generating knowledge from generalization to observation.

Deductive science is based on logic or reason and to that extent, it thrives best in an atmosphere of freedom of thought. It is a process of using science information at your disposal in order to understand a particular situation or to find solution to problem. Deductive science usually describes, explains or predicts natural phenomena by setting up a hypothesis and testing its validity on the basis of experiments. On the other hand, inductive science involves generating knowledge from observation to generalization. This kind of scientific investigation starts from particular facts. For example, the physics of electromagnetic induction involves the movement of magnet near a stationary coil to produce an electric current or an e.m.f. in the opposite direction. In logic, reaching conclusion is based on observation to generalization to produce a universal claim or principle. It should be here stated that the two views of science are complimentary episodes of thought involved in scientific investigation.

Process and Ethics of Science

Scientific knowledge is knowledge proveable by both reason and experience (observation). Logical validity and empirical verification are the criteria employed by scientists to evaluate claims for knowledge. These two criteria are translated into the activities of scientist through the scientific process which can be viewed as the overall scheme of scientific activities in which scientists engage to produce knowledge; it is the paradigm of seven principal stages:

- Problem recognition
- Hypothesis formulation
- Experimental design
- Measurement/Data collection
- Data analysis
- Acceptance, modification, or rejection of hypothesis.

Ethics of Science

Ethics is the study of morality effect on conduct. The ethics of science include objectivity, curiosity, sceptism, willingness to change opinion, humility, precision, open mindedness etc. For example, it is morally incongruous for a scientist to ‘cook up’ or ‘adjust’ a result in order to prove a point or conform to a preconceived idea. It is generally agreed that there is no particular way of acquiring the right attitudes to science.

The scientific attitudes emerge through constant practice and rational decision. Keeping to regulation is one of the conventions of science. These include: careful and honest recording of observation, careful reporting, interaction with colleagues. Attendance to learned conferences, journals etc. will keep scientist informed, current and up to date in scientific knowledge.

Relationship between Scientific Knowledge and Other Disciplines

(i) Technology and Engineering:

Mathematics and basic sciences serve as prerequisites for the study of Engineering and technologically related disciplines. Usually, most intending students for these areas of study do not meet up with the basic requirements through JAMB, WASC, NECO and GCE.

(ii) Also, it is instructive to note that a vocational and entrepreneurial study requires basic scientific knowledge. For example, the road side mechanic, the panel beater and the vulcanizer may inadvertently have been using simple mechanics of machines, simple

chemical bonding in the welding of materials and simple fusion in vulcanizing or in patching tyres.

(iii) Arts and Social Studies:

For the time past, the author has carefully noted the scholarship displayed by science students in other disciplines. For example in the days of Kennedy essays (1960's and 1970s), the school, zonal and regional winners have always in most cases, been science students.

Similarly, students with science background have excelled in other unrelated disciplines e.g courses in management, economics, sociology have been undertaken by scientist relatively successfully. For example Engineers and Scientists have done well in the banking sector where they've worked.

Initial studies carried out by the author on random samples of Engineering and Accountancy students had been revealing. The studies showed a high correlation between the scores in science courses (Physics, Chemistry, Mathematics) and English, Economics, Citizenship, Law, etc.

While it might prove difficult to offer plausible explanations for the above trends, the reasons are not far fetched. Scientist have attitudes of enquiry, objectivity, curiosity coupled with a lot of practice and rational decision in their interaction in whatever they find themselves doing. This may be the reason they have been doing well in almost all fields of endeavour. It is also noted that the scientific process is a research process and all scientist with rational and enquiry mind will always succeed in all areas they delve into.

Problems of Teaching of Science in the Polytechnic

One of the most prevalent of the problems in the teaching of science in higher institutions is that of lack of facilities and consequent lack of maintenance of such facilities so as to stand the test of time.

It is reasonable to understand that provision and maintenance of facilities need adequate funding. Although it can be argued that most higher institutions suffer from inadequate funding, but to what judicious use have the meager funding being put?

Some unscrupulous institutional heads in conduction with some principal officers collude to divert the meager funds meant for science to other uses or their own pockets.

However, the most precarious of the problems facing the teaching of science in Polytechnics is the dearth of adequate manpower for the various science subjects: - Mathematics, Physics, Chemistry and Biology. Further, there is lack of adequately equipped laboratories, which should be properly maintained to contain up-to-date and modern equipment.

Lastly there is need for science lecturers to continually update their skills and knowledge by attending conferences, workshops, seminars and training.

How to Encourage Effective Teaching of Science

One of the most effective ways of teaching science subjects is to teach the concepts, laws and theories from first principles. This becomes necessary because since all scientific laws and theories have basis, it is expected that students may understand the theories from first principles.

Secondly, where two or three students are paired up in the process of performing an experiment the teacher should ensure effective supervision. This is necessary because where two or three students are paired up per experiment because of insufficiency of the necessary apparatus/equipment, there is the tendency of the dominant attitude by one student on the other to the extent that one or two of the students may "complete" the experiment without actually understanding it.

Thirdly, there should be periodic seminars, conferences, workshops where modern scientific trends are discussed and deliberated. Attendance to these conferences is a must for teachers to improve their performance. According to Budd and Ford (2003): "One of the most effective ways of both teaching and learning Maths and Science to young people is through hands on workshop". (Budd and Ford, 2003:5). Budd and Ford are part of the "Visions of Maths and Science Project" which has

made extensive use of Mathematics workshops, and related workshop in Physics into series of half hour videos. The project concentrated on people in the videos, making sure that the presentations of lecturers were recorded, the reactions of the young people (and their parents) and the views of the teachers after the event were also recorded. It is instructive to note that the video which were accompanied by notes have a supporting web-site linked to the NRICH internet magazine. This process of workshop ending up with recordings where notes are being taken is a form of feed back for the lecturers to have a grip on their areas of weaknessess for improvement.

Lastly, but not finally, it is necessary and pertinent that science teachers need to be motivated through enhanced salary and conditions of service. It is then that they can give their best.

Conclusion

From the discussion so far, it is evident that the role of Mathematics and the Sciences in moving any nation from the shackles of poverty to national wealth and prosperity cannot be overemphasized. Mathematics and Sciences are the basic foundation for producing the Engineers and the Technologists. Science is a means of understanding the natural environment while engineering and technology are means of harnessing and exploiting it ……. (Ngoddy, 2006:33).

The problem of technological development has been with Nigeria from time immemorial. Inspite of our fifty-two years of independence, and oil wealth, Nigeria has not been able to fashion its own technology. The country is so import dependent that virtually all items for consumption, jewellery, cars and households, plus building materials are imported.

As a nation, Nigeria needs to be an export-oriented country and before it can do this, its needs to go back to the drawing board, reorganize the teaching and learning of science, by adequate funding, commitment and provision of facilities and infrastructure at all levels including secondary and tertiary institutions. Furthermore, vocational studies e.g. welding, soap making, agriculture in the tertiary institutions etc. must be given priority attention in the scheme of things.

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