Developing Country Studies
ISSN 2224-607X (Paper) ISSN 2225-0565 (Online)
Vol 2, No.9, 2012

Factors Inhibiting Acquisition of Mathematical Knowledge in Kenyan Institutions of Higher Learning

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Abstract
Kenya is a developing country which has done fairly well in terms of development. However it has developed a strategy called vision 2030 which will see it get more developed. Before this is achieved a lot has to be done in training the personnel in all areas. One important area that requires a lot of attention is level of mathematical knowledge in Kenya. Mathematics is fundamental to change in all aspects of development. In our paper we identify some factors which inhibit performance in mathematics at the Kenyan institutions of higher learning especially at the universities.
Key words: Mathematical Knowledge, Kenyan institutions of higher learning.

1. Introduction

The meaning of Mathematics as per the Oxford Advanced learner's dictionary-7th edition is that it is the (i) science of numbers and shapes and (ii) process of calculating using numbers. Our feeling is that these meanings are inadequate. In our view Mathematics is a process of calculation, analysis, deduction and making an inference arising from a problem. In other words Mathematics is a tool used to determine physical and chemical processes qualitatively and quantitatively.

Mathematics is an essential tool in all areas of development. Inadequate mathematical knowledge will result in poorly done (unfulfilled) tasks and processes. Poorly done tasks slows down (and even kill) development. Kenya as a country has decided on a roadmap to industrialization by the year 2030. This road map has been dubbed Vision 2030. It is for these reasons that we have embarked on highlighting reasons that may make the dream of vision 2030 never come. Our main concern touches on mathematical knowledge acquisition. We are certain that we are capable of highlighting issues touching on the acquisition of mathematical knowledge at the Kenyan institutions of higher learning because we have been lecturers of mathematics in these institutions for over ten years. Kenyan institutions of higher learning comprises of the universities and middle level colleges. They are the post-secondary institutions. Our duties are mainly to conduct lectures and tutorials, set end of semester examinations and marking the said examinations. We have observed over time that performance in mathematics at the universities is on the decline.

In the following sections we present and discuss factors which have led to poor performance and hence leading to low level acquisition of mathematical knowledge in Kenya. Fig. 2 (see appendix) gives a summary of why students do poorly in mathematics in secondary schools.

2. Factors affecting performance in Mathematics at the university.

2.1 Entry behavior.

By entry behavior we mean the background and the ability of a student joining the university to pursue a course in Mathematics or a course that requires mathematics. Such programs include pure and applied sciences, engineering, agriculture, business, economics and many more. Every student joining the university in Kenya must have passed with at least a mean grade of C+ in the Kenya certificate of secondary Education (KCSE) or a diploma in the course to be pursued. In addition a student who aspires to do a particular degree program must have obtained at least a prescribed grade in key subjects. In an Engineering program one must have obtained at least a grade of C+ in Mathematics and Physics. The same applies to Computer Science and all science based program which require these two subjects. Up to late 90's those with these grades demonstrated potential of pursuing science based programs. Of late this strength has diminished a lot as manifested by the way students write solutions and answers to mathematical problems. We highly feel that the grades awarded at KCSE are over exaggerated to fulfill political endevours. Our argument is supported by (Kipngetich, 2006) which reported that the mean mark in mathematics KCSE results in the years 2003 and 2004 were 16.05% for female students and 22.10% for male students, 15.39% for female students

and 21.34 for male students respectively. We believe that majority of those students who score below 50% in mathematics at KCSE cannot pursue a degree program which require sound mathematical knowledge and succeed. Koros, 2010 in his thesis did identify various reasons why students in secondary in west pokot district are ill prepared for learning mathematics at the university. He mentions inadequate material for teaching and in some cases where there are materials the teachers do not know how to use them. The same is the case for most districts in Kenya.

There has also been a cutthroat competition by the various secondary schools to produce good results. Teachers at primary and secondary schools have employed all sorts of methods to ensure that their candidates pass the KCPE and KCSE respectively with very good marks. This has encouraged rote learning at the expense of creativity amongst primary secondary school graduates respectively. In very many cases extra curricula activities which are very necessary for brain development have been give very little or no time at all in the week. Most students who join the universities come with this kind of mentality. They then face a lot of difficulty to learn and be creative, which is a requirement at the university.

It should also be noted that in the 80s the Kenya government changed the education system from 7-4-2-3 to 8-4-4. The 7-4-2-3 (which was borrowed from Britain) prepared students joining the university in a better way than the 8-4-4 system. This is because there was a second level (2 years) at the secondary stage where students specialized in an area of study. The examination done at the advanced secondary level was called Kenya Advanced Certificate of Education (KACE). A student who passed this examination was well prepared for university education.

2.2 Pass mark

According to Macmillan Dictionary, pass mark is the level that you need to reach in order to succeed in an examination. The Oxford Dictionary online defines pass mark as the minimum mark needed to pass an examination. Danny G.P. (2009) of European Board of Ophthalmology, he defines pass mark as a special score that serves as boundary between those who perform well enough and those who do not. He also gives two main types of pass marks and their significance as follows.

Types of pass marks

1. Absolute pass mark (criterion-reference)
    - No influence of the calibre of the total candidate population
    - It is possible that all candidates pass with high distinction/ fail
    - A fair amount of experience is demanded to set the pass mark

2. Relative pass marks (norm-reference)
    - Very easy to use for examiners
    - Appropriate in large candidate populations (> 40) to be sure that the candidate population is representative.
3. Stimulates competition between candidates.

Importance of pass mark

The purpose of an examination is to select the group of candidates that perform well enough (pass) and to eliminate the group of candidates that do not perform well enough (fail)

In order to achieve this goal, a (limited) number of questions are presented to the candidates

The discriminative power of the examination will depend on the validity of the questions used.

Effects of pass mark

In Kenyan universities, the pass mark in most examinations is 40% and 50% for undergraduates and postgraduates courses respectively. Most students would work hard to attain the pass mark and end up achieving better grade. On the other hand, quite a number of students struggle just to attain the pass mark in order to avoid the supplementary examination or retaking the units they score less than the pass mark. This leads to low achievements by students who would have done better. For example, one student may score 25/30 (above 80%) in Continuous Assessment Tests (CATs) and only to score 20/70 (less than 30%) in the final examination. This may imply that having realized the good performance in CATs, such students do little in preparing for the final examination because they require little marks to attain the pass marks. This kind of situation leads to low achievement and is prevalent in mathematics.

2.3 Facilities/infrastructure

Over the recent years the student population at the public universities has grown tremendously. This has been occasioned by the Kenya government which has directed the universities to increase the yearly intake. Self sponsored students are also increasing because it is from this lot that the universities can generate some funds to supplement government's support in funding. The funding from the government has not been adequate and so some universities have resorted to admitting self sponsored students. The infrastructure has not improved in the same proportion as the increase in student number. Facilities available for use for instructions have not been adequate. Lecture halls have become inadequate. Equipment such as computers have been over used resulting in frequent breakdown. Modernization of the required facilities has not been up to date because of the inadequate funding from the government. These inadequacies results in a poorly developed mathematician, engineer, scientist etc.

2.4 Inadequate human resources

As mentioned above the number of students has increased in the recent years. Competent lecturers have not been able to meet the needs of the growing number of students. Universities have not been able to recruit competent lecturers because of the poor funding by the government. This has made the work load on lecturers and members of staff to increase. Most universities (both public and private) have resorted to using adjunct lecturers. Some lecturers have over used themselves (because of poor salaries) thus they get very fatigued and so unable to carry out their responsibilities effectively. Some lecturers have been using the same lecture notes for a very long time. Most of the adjunct lecturers hold only masters degree and have very little experience. Some of them work elsewhere and live very far and so conduct their lectures and instructions in haste. They also never have adequate time with the students and in most cases do not complete the syllabus.

Tutorials have collapsed because of the high number of students and lack of space. Adjunct lecturers are paid according to prescribed contact hours. Most prescribed contact periods do not include tutorials. Research materials, facilities and infrastructure are very inadequate for lecturers. Those who want to develop themselves are not able to do so because of these shortcomings. It is not surprising that some offices used by teaching staff and instructors at some universities do not have internet installed in some universities.

Of late some senior academic members of staff are leaving the public universities because of low salaries for jobs in other countries, private universities or the private sector. This has left the public universities with thin and inexperienced academic staff (Daily Nation, August 20, 2012).

2.4 Communication in Mathematics

2.4.1 Poor knowledge of English language

From our experience (as lecturers) effective communication in mathematics is collapsing at a very high rate. A student may have a very good idea but communicating it is a big challenge. English is the language of instructions and communication. Some students and lecturers are very poor in English. Ethnic background, quality of English teacher at secondary school and sheng (language used by young people which is a hybrid of English and Kiswahili languages) have had a toll in the way students and unfortunately some lecturers communicate. Since vernacular cannot well express mathematical abstracts, students tend to shun the subject.

2.4.2 Poor communication of mathematical facts

From our experience of examining written examinations we have noted with dismay very serious problems in the way students communicate mathematical facts. We now give some few examples to demonstrate this problem:
(i) **Question**: Define an extreme point in regard to linear programming.
Answer: It is a corner point.

(ii) **Question**: Find the mass of a thin plate occupying the region between the line and the parabola $y = x^2$whose density distribution is $\sigma(x, y) = 2x + y^2$.

Part answer:

Mass (M)=$\int_0^2 \int_{x^2}^{2x} 2x + y^2$

$$\int_0^2 2xy + \frac{y^3}{3}\Big]_{x^2}^{2x}$$

$$\int_0^2 2x(2x) + \frac{(2x)^3}{3} - 2x(x^2) - \frac{x^6}{3}$$

In the first case the answer given is very inadequate or it does not reflect that which should be made by a mathematician at the university. In the second case the candidate knew how to work out the solution of the question but communication is a big problem. Note that in this case (second answer) two vital features are missing: (I) the variables under which the integral should be evaluated and (II) the required equal signs in the subsequent steps. Note also that steps are in different margins.

It is very common to see such work from a mathematics student at the university presently.

2.5 Absenteeism from lectures

The government funds some university students through the Higher Education Loans Board (HELB). Government sponsored students are advanced funds for tuition and upkeep. Over the last few years the cost of leaving has really gone up. Inflation went up to 23% in the year 2011. This was occasioned when the Kenyan currency (the shilling) was devalued. Parents or guardians or organizations fund self sponsored students. In most cases because the cost of living has gone up and the funding from whatever source is inadequate, some students have been forced to make ends meet. Some of them have resorted to working on part-time inside or outside the university. Some of them have engaged themselves in doing small businesses or work study programs. In some cases working hours coincide with lecture time occasioning the student to miss lectures. Women students are the worst affected because of the nature of their needs. Some students have ended up differing (postponing) their studies and when they come back they have forgotten basic concepts that are necessary for their progress.

Some students opt to skip classes because of frustrations experienced in the lecture hall. We earlier mentioned that the numbers of students have really grown and as such the lecture halls are often crowded. This has made some students unable to hear or write during lectures thus are unable to learn.

2.6 Drugs and Alcohol

A recent survey by the National Campaign against Drug Abuse Authority (NACADA) has revealed that that drug and substance abuse among university and college students has reached alarming levels (Daily Nation, April 23,2012). The survey indicated that students who joined universities and other institutions of higher learning with high points end up getting lower grades and re-sit very many exams due to indulgence of alcohol and other drugs. It is noted that students who engage themselves in such behavior have very little time to go to the library and even lectures.

Another survey has also shown that some students engage themselves in illicit college affairs. This has made some couples leave as a family. Family responsibilities affect studies of such students very much.

2.7 Career choice

Students and parents look forward for formal employment immediately after completion of a university degree. Stake holders have spoken publicly of the need for the universities to offer marketable programs. In this respect marketable programs are those which enable a graduate to be employed formally. Science oriented programs offer better chances of attaining formal employment. Students joining the university would prefer then to enroll in the so called “marketable programs” many of whom just meet the lower border line of qualifications. Many then do not care much how they perform and are only interested in passing. Majority of the candidates pass marginally. It has also been reported that many students are unhappy with the degree programs they enroll in. The Joint Admission Board (JAB) enrolls government sponsored students to degree programs according to the performance of the student at KCSE and number of available vacancies (Daily Nation, August 22, 2012). This has caused a lot of apathy in the student community and they take the courses just for the sake of attaining a university degree. This is corroborated by the fact that after completion of the university degree graduates enroll in other short term courses to enable them attain their dreams.

2.8 Peer Influence

Students' reluctance to choose science courses and mathematics in particular, in their final years of formal education has important implications not only for the continuity of the scientific endeavour but also for the scientific literacy of future generations. As a result, development of positive attitudes towards Mathematics, Mathematicians and learning science which has always been a component of education is increasingly a subject of concern.

To help in mitigating the negative trend, this paper seeks to establish the factors affecting poor understanding of Mathematical concepts by learners in Kenyan schools; particularly those related to peer influence or stemming from age set interactions.

Mathematics is offered to all students joining formal school in Kenyan, both public and private. But vast majorities of learners do not do well in the subject. Statistics from the KCSE marking paint a grim picture for the subject. This trend greatly reduces the pool of students, who then pursue Mathematics courses and careers.

Kenya proposes to be industrialized by the year 2030. The government has predicated part of its planning and resources on ensuring that the economy will have substantially shifted from being an agricultural based one to an industrial production and value adding one. Industrial production and systems require scientists and mathematicians; people who are well versed and trained in the natural and physical sciences and how to employ mathematics in planning and managing of the economy. The country needs people who can undertake research and generate new ideas and working systems.

To nurture such people, the education system needs to be geared towards training learners to equip them with functional skills and a good grasp of the natural sciences, particularly Mathematics. As many learners as have the aptitude for the subject should be able to pursue it, in an environment that promotes quality, personal expression and research in relevant areas. Learners must be made to have passion of mathematics by all means. It is now a known fact (Kipngetich,2006) that curiosity, talent, freshness, passion, guidance are the ingredients of learning mathematics.

A recent survey in the newly created Navakholo District established the following reasons why students do not excel in mathematics in Mathematics as an examinable subject at KCSE level. Table 1(see appendix/0 gives a summary of the reasons advanced by students.

According to six (6) teachers sampled, there are also several reasons why students do not excel in Mathematics when they have the chance in form four.

Of particular interest is the fact that many learners demonstrated a preconceived idea about mathematics even before they had personal experience with the subject. It can be summarized that students fail at the concept formation stage in learning mathematics. This in turn is influenced the fact that many learners have a negative attitude towards the subject. They view it as being "difficult" and taxing. That it requires so much effort just to scratch the surface as it were.

- The casual and sometimes comical jokes made about the subject. Even including the acronyms learners come up with (DHAFU – Death Has Actually Followed Us!) This becomes the "cool" thing to say and slowly the apathy sinks.
- Remarks and the wide berth given to it by some teachers, starting from primary school. It builds an idea that the subject is for the select few.
- Language of communication. Some learners are basically not able to communicate in English, the primary language of instruction for Mathematics. A poor foundation at lower school level makes it difficult even for teachers to enunciate ideas.
- Unfavorable publicity given for the subject by the senior students in schools to those who are just joining. "Wait until you start learning …" is a heavy club the juniors are beaten with.
- Poor results by those who have done the National exams earlier in some schools.
- Lack of positive traditions in schools. Where the school has a history of good performance, those joining are encouraged from the first day and usually end up doing well.
- Uninspiring teaching methods. The old lecture is becoming obsolete, or so they young ones say. But in many instances, uptake of innovative methods in Mathematics has been slow.

2.9 Mathematical knowledge acquisition

Mathematical knowledge is a very vital tool in nearly all sectors and spheres of development. The following is a schematic representation of how mathematics knowledge is built and how it plays a role in development:

The above figure depicts how mathematics knowledge is built and used.

Note

(i) that there is more than one peak represented by the letters A, B, C, D, E, etc. These peaks are actually imaginary (they are never attained) but narrowing down in an area of specialty and it occurs as one advances in mathematical knowledge (for instance an engineering program may require a more advanced knowledge-level C than one in medicine-level E in mathematics),

(ii) all the areas of specialty have one common base- that is basic knowledge (level P) and (iii) most areas a have common base up to some level.

As an example a program in Engineering require all areas of mathematical knowledge ranging from statistics to differential equations.

The different peaks represent the different areas of specialty or the various sectors of development. The figure suggests that different advanced level knowledge in mathematics is required to accomplish the tasks required in each professional sector. Some sectors require nearly the same mathematical knowledge. It is therefore imperative that all areas of mathematics be developed so as to enable one carry out tasks effectively.

In Fig. 4, R is the current Kenya Certificate of Primary Education (KCPE) where the children sit their first national examination. It is a very basic level and the knowledge acquired so far cannot enable one to work professionally. Broadness is necessary but specialization is critical. In Fig. 4, Q is the current mandatory level every student reaches in pursuit of mathematical knowledge. This level is currently the Kenya Certificate of Secondary Education (KCSE). We feel that mathematical knowledge at this level is still very inadequate to enable one work efficiently. We want to suggest that it is necessary for a student whose interest is to pursue a profession at the university level which requires mathematical knowledge study it up to the level P. Up to level P students will have acquired basic knowledge in mathematical analysis, algebra and statistics. Level P is equivalent to the current second year at Kenyan universities. In the next section we suggest (using our experience as lecturers for mathematics at the university) how mathematical knowledge should be effectively instilled at Kenyan universities at the undergraduate level.

3.0 Process of acquiring mathematical knowledge.

Acquisition of mathematical knowledge at the university involves a process. This process when followed drives facts home. Fig. 5 is a schematic diagram that shows steps a good lecturer of mathematics in Kenya should take in order to make his/her teaching effective:

It is very necessary that a correct sequence of imparting mathematical knowledge be adopted to bring a meaningful build up. The process shown in Fig. 4 serves to sequentially build up mathematical facts leading to acquisition of sound mathematical knowledge.

Conclusion

Unless the government addresses the problems discussed that hinders good level acquisition of mathematical knowledge the vision 2030 may not come true. Universities must help the Kenyan government to understand these problems and to provide ways of alleviating them since they are in charge of developing the professionals. Professionals too must develop themselves by seeing to it that they have acquired the necessary working tools.

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Appendix

Table 1. Students' reasons for not doing well in mathematicsFig 2: Bar graph showing reasons why students fail in Mathematics and the relative frequency for each reason

Reason	Frequency (out of 120)	Percentage
Peer influence	79	66
It's not important	50	42
It's difficult and taxing	80	67
Contains a lot of calculations	118	98
The teacher and teaching methods	63	51
Its technical(not interesting)	40	33
Does not fit career interests	41	34
Shortage of teachers	16	1
Poor performance in exams	10	8

Table 2. Teachers' reasons why students do not excel in mathematics

Reason	Frequency (out of 6)	Percentage
Influence by peers	5	83
Lack of facilities	3	50
Subject content	3	50
Career requirements	2	33
Poor grounding in prerequisite subjects	4	67

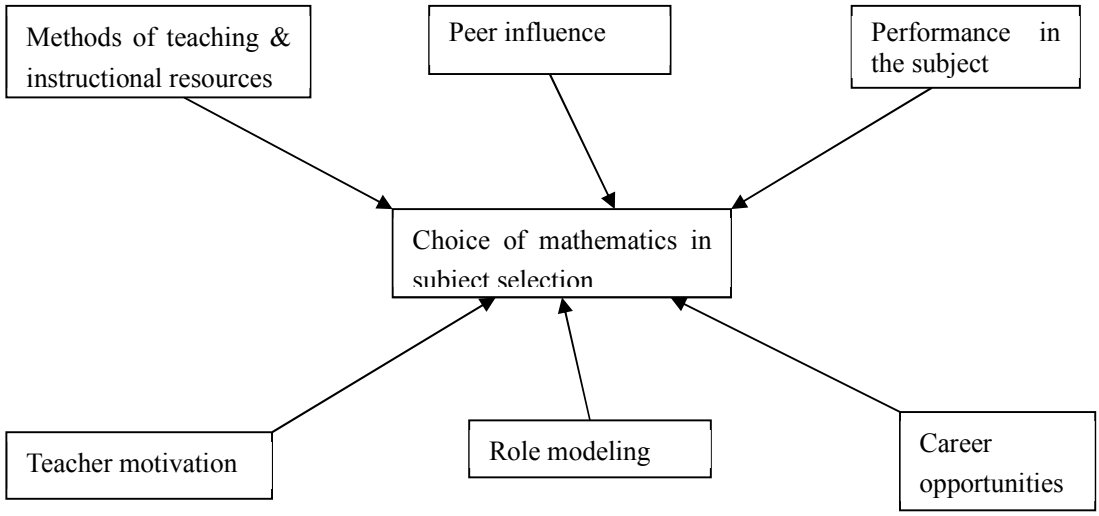

Fig. 1: Conceptual framework showing factors affecting students' understanding of mathematics.

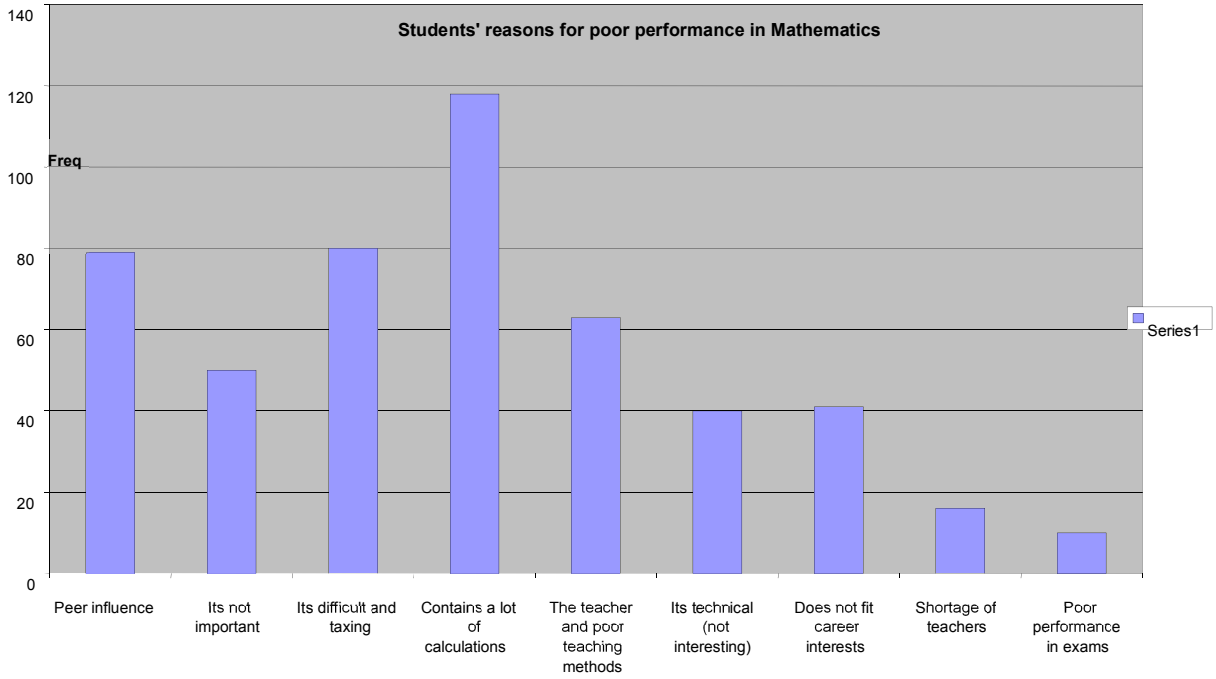

Fig 2: Bar graph showing reasons why students fail in Mathematics and the relative frequency for each reason

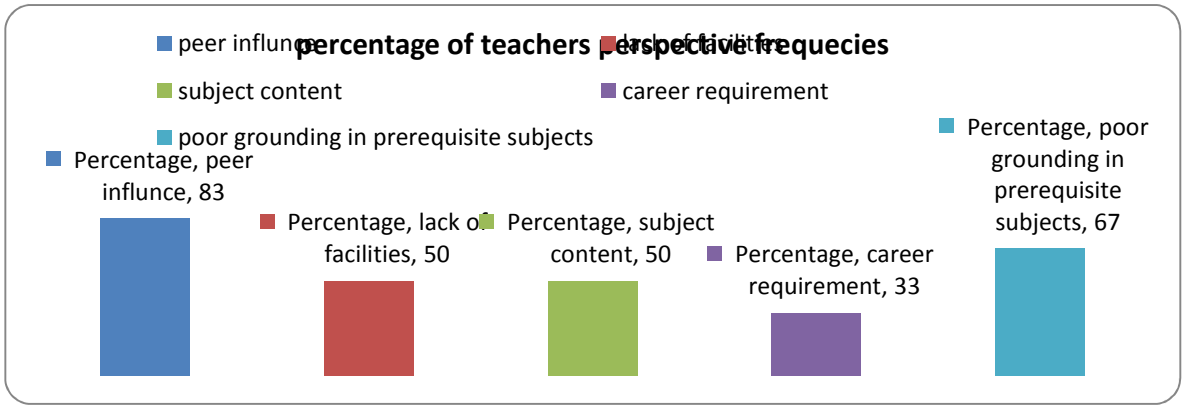

Fig 3: A bar graph showing teacher's perspective

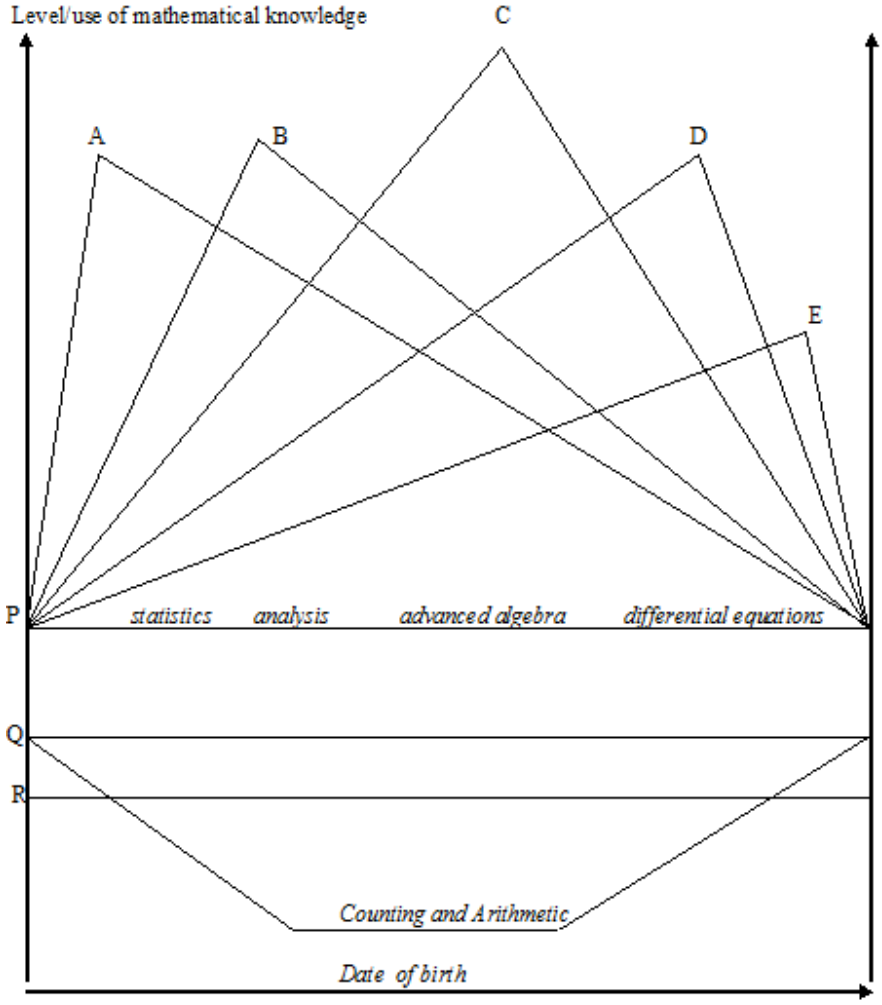

Fig. 4: Diagram showing acquisition and application of Mathematical knowledge.

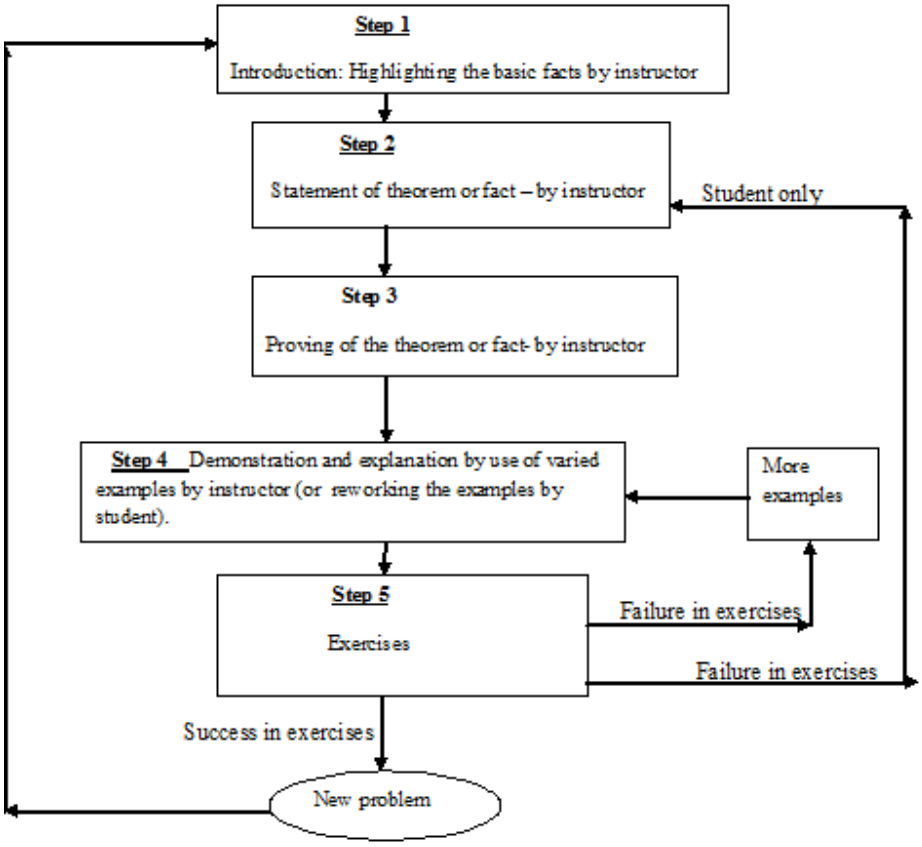

Fig. 5: Sequence of building a Mathematical fact.

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