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Some Innovations in Teaching of Mathematics (At Under Graduate Level)

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Abstract: ***Presently, science educational approaches have resulted in a mismatch between what is taught to the students and what a student really needs. As such, many institutions are moving towards problem-based learning as a solution to produce students who are creative, can think critically, analytically and are able to solve problems. As Mathematics is one of the pillars of Basic Sciences, one of the solutions is to remove the mathematics phobia that has been cribbing into the minds of the students. In this paper, we focus on the problems, objectives, needs and on the innovative methods of teaching and attracting students to this subject. Some pedagogic tools with which a teacher should be equipped have been mentioned. A brief survey of the number of students, of some colleges in the state, opting for this subject has been done and highlighted in this paper.***

Keywords: Innovations, Mathematics, Undergraduate, Syllabus enrichment, Oral Presentation

1. Introduction

Mathematics, being an important subject and occupying a central position since the ancient period till date, has not been of interest to many students. The reason is mainly because there is aspiration but it is hard to achieve. Being highly abstract, it is concerned with ideas, which are interrelated, and with the manipulation of symbols. Teaching of mathematics is not only concerned with the computational knowhow of the subject but is also concerned with the selection of the mathematical content and communication leading to its understanding and application. So while teaching mathematics one should use the teaching methods, strategies and pedagogic resources that are much more fruitful in gaining adequate responses from the students. Teaching and learning mathematics involves complexities which can be overcome if certain rules are followed. The nature and quality of instructional material, the presentation of content, the pedagogic skills of the teacher, the learning environment, the motivation of the students are all important and must be kept in view in any effort to ensure quality in teaching-learning of mathematics. Mathematics has a role to play in many different fields: innovations in medicine, digital encryption, communication technology, modeling real life phenomena, predicting disasters, organization of enterprises, business and transport to name a few.

At the heart of mathematics education lies undergraduate mathematics education. It would be impossible to tackle any of the problems associated with mathematics education, at any level without intervention at the undergraduate level. After all, the harbingers of change, if there are to be any, will be the teachers, policy makers, the creators and imparters of curriculum and pedagogy. And each one of them will have been shaped by their undergraduate (mathematics) education. Hence it is necessary that we examine the doctrines that govern undergraduate mathematics education in India.

2. Objectives

In this paper, efforts to discuss innovations and innovative practices in teaching mathematics at the undergraduate level, under teaching methods, strategies and pedagogic resources have been made. The process of innovation is generally described as consisting of three essential steps, starting with the conception of an idea, which is then proposed and is finally adopted. Though many ideas have been conceived to bring about change in the teaching of Mathematics, it is yet to be proposed and adopted. So, the innovations discussed may not be new in terms of the idea but is new in terms of practice.

Innovations in Teaching Mathematics

This can be diversified in terms of methods and Pedagogic resources used in teaching-learning process.

3. Methods

Method is a style of presentation of content in classroom. The following are the innovative methods that can be used to make teaching-learning process of Mathematics effective.

1. Inducto-Deductive Method

Inductive method is to move from specific examples to generalization and deductive method is to move from generalization to specific examples. In classrooms, usually instructions start with the abstract concepts which are beyond the understanding of the students. Formulas, theorems, examples, results are derived, proved and used. But teacher needs to start with specific examples and concrete things and then move to generalizations and abstract things. Then teacher again needs to show how generalization can be derived and it holds true through specific examples. This method helps students for better understanding; they don't have to cram the things and will have long lasting effect.

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Example: (i) Pythagoras Theorem - In a right-angled □ □ ABC, right angled at B,

$$AB^2 + BC^2 = AC^2$$

(Considering right angle triangles of different measurements leading to generalization and then establishing it through the theoretical proof)

(ii) The sum of two sides of a triangle is greater than the third side.

(Ask the student to take any triangle, measure the sides, add any two of them, the result will always be greater than the third. The teacher can then proceed with the general proof.)

2. Analytico-Synthetic Method

Analytic is breaking down and moving from unknown to known and Synthetic is putting together known bits of information and moving from known to unknown. These methods are basically used in proving the results and solving problems. In textbooks, mostly synthetic method is used, to prove something unknown we start with a certain known thing, but that leaves doubts in minds of students as to why we have started with that step and using this particular known thing. So a teacher has to combine both in order to explain and relate each step logically.

Synthetic method	*Analytic method*
$\int \tan x dx = \int \frac{\tan x \sec x}{\sec x} dx$ $= \log\lvert\sec x\rvert + c$	$\frac{d(\log\lvert\sec x\rvert + c)}{dx} = \frac{1}{\sec x} \sec x \tan x$ $= \tan x$

3. Play-Way Method

This method includes play and fun activities that are related to numbers.

Example: (i) checking of divisibility of one number by another number,

123456712345688 is divisible by 4

Example: (ii) generation of Pythagorean triplets (3,4,5), (6,8,10), (5,12,13)

Example: (iii) formation of Pascal's triangle in solving $(1+x)^n$

Students don't realize that they are learning but in a way they are gaining knowledge through participating in these activities.

4. Laboratory Method

With the advent of computers, many of the colleges are well equipped with computer laboratories. The availability of computing softwares can be utilized in complementing classroom mathematical teaching to promote students´ active engaging and learning; to exchange long and difficult numerical and algebraic manipulations by communication of supporting reasoning when answering mathematical questions; to make experimental activities easier to handle; to develop problem resolution skills dealing with more interesting and difficult problems in so far as numerical, algebraic graphical and programming resources are available; to encourage discussion of different solutions or strategies as one works with multiple representations of the same mathematical object or process; to motivate the development of paired notions like discrete/continuous and finite/infinite. The pedagogical work needed to construct and implement learning situations to actualize these potentialities constitutes a major challenge to teachers.

Some mathematical problems can be solved through Computer programs such as Maple, Mathematica, Matlab, Group algorithm program (GAP), which are powerful software programs used to solve general-purpose mathematical problems. Problems in the areas of mathematics, science and engineering (and many more) can be investigated using in-built commands of these programs or by utilizing these programming languages to create one's own personalized programs. They can be used for solving problems in Calculus, Algebra, Solution of Differential Equations, Linear Programming, Statistics, plotting of points in two and three dimensions and also to create a three dimensional view of an object and many more.

Hence, introduction of laboratory component, in mathematics teaching, at the under graduate level, may enhance a better understanding of the subject for all papers for which there is feasibility of working in a laboratory environment.

5. Oral Presentation in Mathematics Learning

Anne B D'Arcy-Warmington(2008) mentioned that " it is important to consider the merits of oral presentations in mathematics service units as students' educational needs are diverse. Reaching parts of the brain that usual educational methods don't reach may be the answer to those poor students who do not have a 'mathematical brain'. The theory of multiple intelligences and brain-based learning may be the tool that will aid these students to be more confident about their mathematical ability. Oral presentations provide all students with a chance to display their knowledge in fun and creative ways. The interest aroused when researching the topic may give rise to a new curiosity about mathematics. With the declining numbers of students wishing to study mathematics perhaps, an injection of creativity in service units may spark an interest in mathematics in these and other students".

A study done by Lianghuo and Shu Mei (2007) showed that both teachers and students overall developed positive views about the benefits and usefulness of using oral presentation tasks into their daily mathematics teaching and learning. Oral presentation is an activity of sharing ideas and clarifying understanding verbally. Firstly, this method is regarded as an alternative mode of assessment for teachers to gather information about their students' learning of mathematics and hence make relevant instructional decisions. Secondly, it is also viewed as a tool for developing students' communication skills. One general purpose of oral presentation is to allow teacher to hear what students think about mathematics, and how they express it

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and their understanding of mathematics in their own words. Furthermore, teachers using oral presentation tasks must provide opportunity for students to think through questions and problems; express their ideas; demonstrate and explain what they have learnt; justify their own opinion; and reflect on their own understanding and on the ideas of others.

Thus, in the existing syllabus, changes can be made so as to include oral presentation as a process of mathematics learning by allocating some grades/marks to every paper. This incorporation may induce a better understanding of the subject.

6. Syllabus enrichment

Generally the Mathematics courses of both BSc and BA programmes (with Honours/ Major in Mathematics) are the same as indicated in the NEHU syllabus curriculum to be followed at the undergraduate level in all affiliating colleges in Meghalaya; the two programmes differ in the nature of the stream, a student chooses from, in addition to mathematics, that is, whether from science or social sciences stream. The BA/ BSc (Honours/ Major in Mathematics) curriculum of most of the universities include the following as compulsory courses:

Algebra (Classical and Linear Algebra) and Trigonometry
Calculus (Differential and Integral Calculus, Advanced Calculus)
Differential Equations (*Ordinary Differential Equations and Partial Differential equations)*
Vector Analysis
Analytic Geometry of two and three dimensions
Analysis (Real and Complex analysis, Metric Spaces)
Modern/Abstract Algebra
Mechanics
List of Optional papers
Principles of Computer Science-Theory and Practical
Differential geometry
Discrete Mathematics
Mathematical Modeling
Applications of Mathematics in Finance and Insurance
Special theory of Relativity
Combinatorial Number Theory
Computational Mathematics Laboratory
Numerical Analysis
Operational Research
Astronomy
Complex function Theory and Real Analysis

With new ways of improvement in the teaching-learning process, the Syllabus may also be modified keeping pace with the all round development of the society. Some of the above mentioned optional papers in many of the colleges are options made by the teachers and college authorities and not by the students themselves and as a result the purpose of an optional paper at undergraduate gets defeated in many cases. Thus in order to eliminate such practices, some of the vital optional papers mentioned above can be included into core courses. The courses that can be incorporated into the core courses, to name a few, are topics from Computer Science (Data storage, Data Manipulations, Operating system and network, algorithm, Programming languages, Software Engineering, Data Structures), Discrete Mathematics (Propositional logic, Relations, Lattices, Boolean algebra, Graphs, Combinatorics) Mathematical Statistics (Probability theory, Descriptive Statistics , Statistical Methods (Sampling, Statistical Tests), Distributions, Sampling theory, Correlation and Regression and multivariate analysis) Differential Geometry (Curves, Surfaces, Manifolds, tensor Analysis) Cryptography (Classical and Modern techniques, Elliptic curves Cryptography)

The inclusion of the above topics to the present syllabus can prove beneficial for the students in enhancing their employability.

This is an exploratory research paper and the above recommended syllabus enrichment is not a technique, but rather a suggestive approach which when followed may prove beneficial for the students studying mathematics in enhancing their employability.

Pedagogic Resources

These are resources that a teacher may integrate in a method for the transaction of a particular content and draw upon to advance the students' learning.

7. Programmed Learning Material (PLM) – As internet usage by the students is increasing day by day, colleges can provide soft copies of important textbooks/learning materials and make them available to students through the colleges/ institutions websites. *An interactive environment by the use of web 2.0 can also be created by every department of a college/Institution so as to encourage students-teachers interaction as a PLM through which a learner can proceed his self study at his own pace.* It has the characteristics of all sequential steps, learner's response, self-pacing, immediate feedback, reinforcement and self-evaluation. It is helpful in acquisition of concepts like fractions, number systems, etc. and can be used as a remedy for slow learners for a specific content.

Tablet- This is essentially an interactive whiteboard (IWB) or EWB that enables the lecturer to write with a special pen on the screen of a tablet that is connected to a data projector. Any work done on the tablet is then simultaneously (real time) broadcast to the whole class. The tablet enables the lecturer to, inter alia, annotate notes, make comments and use colour schemes to highlight important points in a lecture.

4. Activities

Activities here include works wherein students play active roles, interact with different resources and generate knowledge. Some activities are listed below.

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Activity	*Situations related to Activity*
Quiz competition	Mathematical rules, results, formulae, Properties of numbers
Projects	Contribution by Mathematicians
Seminars	Applications of Mathematics, talks on Ancient Mathematics etc.
Discussion	Concept of Pi , Golden ratio, Presence of Mathematics in real world viz, nature and music
Mathematics Clubs	Preparing models , Paper folding
Assignments	Solving problems, proving of theorems
Field trips	Visit to banks, Insurance companies
Self study	Library, internet, resource centers
Scholarship exams	Mathematics Olympiads, Mathematics Training and Talent Search (MTTS), Advanced Training in Mathematics etc, all funded by NBHM (National Board for Higher Mathematics)

5. Explorative Study

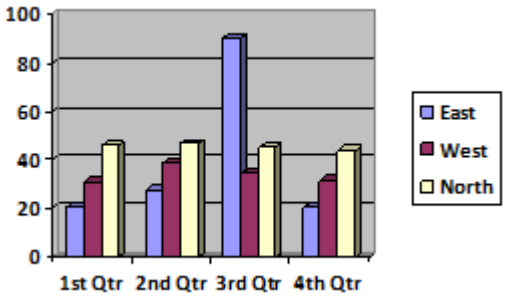
A brief explorative study is done in connection with mathematics performances of the students in the state by using the data obtained from Meghalaya Board of School Education and North Eastern Hill University, Shillong. One can draw a clear picture (Table 1) that the percentage of students failing in Mathematics in class X is increasing.

Data from Table 2 reveals a marginal decline on the percentage of students failing in Mathematics for class XII in the year 2011. However, it may not be authentic to draw a definite conclusion about this percentage as it again shows an increase in the following year. But an overall study reveals that more than 50% of the students are not able to stand to the subject and as a result few of them may continue with higher studies related to the subject

The figures from Table 3 are inconsistent and do not show an increase or a decrease in the trend .The previous data revealed that approximately 3000 students appeared for the class XII exams in Meghalaya. However, in spite of this, only a handful of students opt for Mathematics as an Honours paper.

Mathematics is believed to be the key for all other subjects but it is surprising that most students fail and yet pass in other subjects. Some of the reasons may be because there is a negative attitude towards mathematics, fear due to pressure from friends that the subject is tough, limited or even lack of learning materials or lack of enough practice by the students.

The present exploratory example is simply an attempt to quantify crudely the success level of students at different level of education in the subject mathematics, and this failure rate may not have a connection to the methods of teaching and curriculum of the subject. However this study is simply an attempt to bring out new ideas for making the subject more interesting and appealing to the learners, which in the process can also benefit the students in enhancing employability by the choices of optional papers listed above.



6. Conclusion

At present, we are in the growing needs of our society and the needs of the discipline itself, unless we take strong ameliorative steps, the rate at which we are improving is just not going to be enough. If we take a closer look we can see many gaps and lacunae that require immediate healing. There is a requirement to both work out long-term strategies and at the same time to also have good achievable short-term goals.

To sum up, the curriculum in most of the high weightage undergraduate mathematics Programmes seem to be focused on fast-tracking young men and women to be research Mathematicians. On average, however, much less than a fourth of undergraduate Mathematics students actually decide to pursue an academic career in mathematics. Further the pedagogy and assessment patterns followed actually do not do much to foster or enhance the ability to think originally or to critically analyze and solve unseen questions. Thus on average the undergraduate programmes in mathematics fail in at least two important ways: firstly, they are not really equipping and training the minority that plan to take up a career in mathematics in the manner they should; secondly, the majority are neither gaining any understanding of the role of mathematics in society nor are they learning the skills required by all in terms of communication, presentation, or the use of modern computer technology.

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Table 1: Number and percentage of students who failed in Mathematics at the Secondary School Leaving Certificate (Std X) Examination conducted by Meghalaya Board of School Education.

Year	*Number Appeared*	*Number Failed in Mathematics*	*Percentage Failed*
2010	36153	14027	38.79
2011	36122	17874	49.48
2012	38942	38942	54.93

Source: MBOSE

Table 2: Number and percentage of students who failed in Mathematics at the Higher Secondary School Leaving Certificate (std XII), Science Examination conducted by the Meghalaya Board of School Education.

Year	*Number Appeared*	*Number Failed in Mathematics*	*Percentage Failed*
2010	2946	1941	65.89
2011	3058	1708	55.8
2012	3072	1803	58.69

Source: MBOSE

Table 3: Number of students who appeared as Mathematics Major Students at the First year Bachelor of Science Examination conducted by North Eastern Hill University

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Number Appeared	65	57	99	72	40	59	45	51	66

Source: NEHU

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