

PEDAGOGICAL CONTENT KNOWLEDGE (PCK) AND ITS IMPACT ON IMPROVING TEACHING MATHEMATICS

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ABSTRACT

One of the most important areas of interest of the global research fraternity is the study of various pedagogical issues in a wide variety of contexts India is facing a grave problem for being short of human resource in one of the international curriculum subject i.e. Mathematics. The relevance and importance of subject is seen everywhere and has a market value. The statistics are showing poor figures which are alarming. For a country which discovered the concept of zero, where the man who knows infinity was born, we need to make mathematics interesting. It is a matter of concern that for a country of our size, the number of competent mathematicians we have is badly inadequate. Pedagogical knowledge of teachers needs to be revised and reframed. The area of pedagogical studies needs due attention of the researchers and academicians at the National and Regional levels.

Keywords: *Pedagogical Content Knowledge, Math, Effective Teachers.*

I INTRODUCTION

One of the most important issues concerning mankind since times immemorial is the ability to learn the language of mathematics. It has the power to sum up the longer versions and express in concrete forms. Mathematics is one of the languages of human life and certainly no more marvelous languages were ever created by the mind of man. Mathematics cut short the lengthy statements through its symbols and is free from verbosity. It helps in the expression of ideas in an exact form and enables to understand, appreciate precision, brevity, sharpness, and logical beauty. Mathematics is one of the most important subject which acts as a bridge for all knowledge. In the changing world of competition there is a growing demand of the subject. There is a definite need of mathematics in lifelongs and day-to-day planning. A mathematical approach is essential for any progress. Any approach devoid of mathematical considerations is likely to lead to failure. To be success in life, one must have resource of mathematics.

“Mathematics is the language in which God has written the universe” Galileo Galilee.

Mathematics is a tool of many other subjects and we can find another extension of the utilitarian aspect of the subject. Mathematics fulfils the educational values such as practical disciplinary cultural,

intellectual, more; aesthetic, social vocational, inter-disciplinary etc. in order to realize the educational values and instructional objectives of mathematics, the subject must be practiced in class rooms by utilizing the services of modern concept that is pedagogical content knowledge.

RESEARCH METHODOLOGY

The study is based on secondary data drawing support from National and International journals, Research papers, Articles, Reports from National and International newspapers, Institutions and organizations. The researchers through this research module have tried to summarize the present status of mathematics in India with special reference to concept of PCK and its importance in enhancing the teaching of mathematics.

Present Status of Mathematics in India:

Recently-declared first semester results of Anna University may seem to be one of the best in the recent years. But, on closer inspection, they reveal a worrying trend. Most students who failed have not been able to clear two subjects — mathematics and computing — considered very crucial to software development, code writing and logical reasoning. While Anna University recorded a pass percentage of 69, many self-financed colleges in the city have recorded just about 40-50 per cent pass result, with most students failing in mathematics and FOC (Fundamentals of Computing) and some in engineering graphics.

The Gujarat Board class Xth examinations reveal that Mathematics paper was once again the toughest of all papers. Around 45% students fail to clear their examination. Of the 10.47 lakh students who appeared for the examination, only 5.78 lakh failed to clear the examination. It is Mathematics that has claimed the maximum number of victims as 4.69 lakh students failed in it. Even in Science and Technology, the number of students who failed - 4.39 lakh - is pretty big. Despite fewer students taking the exam, 17,000 more students failed in Mathematics as compared to 2015. Similarly, in Science and Technology, 6,000 more students failed as compared to last year. This is for the third consecutive year that the maximum number of students failing a subject is in Mathematics.

The academic year 2015-16 saw 15 out of 20 students of Goa University's (GU) mathematics department failing their postgraduate exam. This translates into a shocking failure rate of 75%. The rate in the physics department stood at 43%. GU has presented these figures in its annual quality assurance report submitted to the National Assessment and Accreditation Council (NAAC). More than half struggle with division (3 digits by 1 digit) problems. Only 43% are able to do such problems correctly. The ability to do division – a task that is usually done in ASER, can be thought of as a proxy for the ability to do basic arithmetic operations. Even among youth in this age group who have completed eight years of schooling, a significant proportion still lack foundational skills like reading and math. Interestingly, although reading ability in regional languages and in English seems to improve slightly with

age (more 18 year-olds can read than 14 year olds), the same does not seem to apply to math. The proportion of youth who have not acquired basic math skills by age 14 is the same as that of 18 year olds.

Mathematics is an important subject with broad applicability to everyday life, yet mathematics is often considered as a difficult subject in schools. Fajemidagba, Salman & Ayinla (2012), have described Mathematics as a core science subject and tool for the development of any science-based discipline. These include; Technology, Astronomy, Graphics, Industry and Analytical reasoning in daily living. Ayinla (2011) also posited that mathematics is the pillar of all knowledge, showing its relevance to all disciplines. Onwuachu & Nwakonobi (2009) noted that mathematics is the foundation on which the whole essence of living revolves and the platform for scientific and technological innovation. The Prime Minister reminded parents and students that mathematics was “the mother science, however, he regretted that the country did not have enough competent mathematicians. “It is a matter of concern that for a country of our size, the number of competent mathematicians we have is badly inadequate. Unfortunately, today mathematics talent is not encouraged and cultivated as much in India, compared to the US and Europe. The sheer amount of mathematics talent in India is incredible, but most students talented in mathematics are encouraged to move to engineering or other fields. Over more than the last three decades, many of our young men and women with natural ability in mathematics have not pursued the discipline at advanced levels.” This resulted in a decline in the quality of math teachers in schools and colleges. Dr. Singh said the perception that mathematics did not provide attractive career options might have been valid until some years ago, “but, today, there are many new career opportunities and the teaching profession itself has become much more attractive in recent years.” But still the number of students opting for math subject is meager. The mathematical community had a duty to address the shortage of top quality mathematicians in the country and must reach out to the public, especially in the modern context wherein mathematics had a tremendous influence on every kind of human Endeavour. John Mack points out that the rising numbers of students with no math means that some 50% of the entire HSC cohort is now ill-prepared to understand any argument resented to them that depends on an understanding of rates of change in scientific data. The problem is also broader and deeper.

Pedagogical development in mathematical understanding through problem solving still remains as a challenge for teachers. Mathematics pedagogy focuses on the ways in which teachers help their students come to understand and be able to use mathematics in different areas. What does an efficient mathematics teacher mean? What should be the qualities for him or her? There is a common belief that those who learn more mathematics and familiar with higher difficulty level problems they are good. But, which is not necessarily true. In the research report, no co-relation between teacher’s content knowledge in mathematics and their student’s success in mathematics was found. Many researchers already reported various effective descriptions on teacher’s role during the classroom session about motivation, interaction, uses of models, problem solving devices etc. All these can be considered as mainly two types of knowledge—firstly, mathematical content knowledge which enhances capability to explain and interact to student’s doubts; secondly, pedagogical content knowledge

through which students achieve knowledge with proper understanding and applicability. Pedagogical content knowledge asserts that knowing what and knowing how are inseparable in the business of effective teaching. Pedagogical knowledge in mathematics is the device of transition from contents to its applicability. In pedagogical point of view, teachers in mathematics have a very critical role to play in facilitating students for effective learn.

It is an undisputable fact that an adequate supply of Mathematics teachers is an essential ingredient for Mathematics teaching (Odili, 2006). Such teachers if supplied are supposed to be with substantial amount of knowledge that is capable of making them successful in the process of their delivery in the classroom. This was further noted by Adedoyin (2011) that one of the characteristics of good teachers is that they possess a substantial amount of specialized knowledge which is referred to as pedagogical content knowledge. Pedagogical content knowledge is the knowledge of how to transform formal subject matter knowledge into meaningful learning outcomes for students and it also involves an understanding of a particular topic and how teachers explained the topic or concepts to make sense to the students in the classroom. The persistent failure and lack of proper understanding of Mathematics by its learners has always been of an interest to the scholars. According to Ball (2003) a teacher with good mathematical pedagogical content knowledge can break down mathematical knowledge into less polished and abstract forms, thereby, making it accessible to students who are at different cognitive levels. A teacher with good pedagogical content knowledge can unpack the Mathematics into its discrete elements and can explain a concept or procedure at a level that includes the steps necessary for the students to make sense of reasoning. Teachers with good mathematical pedagogical content knowledge understands where students may have trouble learning the subject and should be able to represent mathematical concepts in a way that their students can comprehend its structure and avoid these difficulties. Since the aim of Mathematics' teacher pedagogical content knowledge is essential in teaching process, pedagogical knowledge as well as mathematical content knowledge is needed in order to construct mathematical concepts in students' mind. According to Shulman (1986) mathematical content knowledge and pedagogical content knowledge are integrated parts of the effective mathematical instruction.

Teachers with pedagogical content knowledge have a good grasp about their subjects, they know which topics are easy for students and which are typically more difficult. With the content knowledge, they can create lesson plans that move through the easier material quickly and provide more time for the difficult subjects. This will help students grasp fully the difficult topics. The pedagogical content knowledge is a type of knowledge which is unique to teachers, and is based on how teacher relates their pedagogical knowledge (how to teach) to their subject matter (what to teach). Grouws and Schultz (1996) stated 'pedagogical content knowledge includes, useful representations, unifying ideas, clarifying examples and counter examples, helpful analogies, important relationships, and connections among ideas (Grouws and Schultz, 1996: 443)

Pedagogical concept can be well used to develop interest among students towards mathematics. In the view of Roger Bacon, “Mathematics is the gate and key of sciences. Neglected of mathematics works injury to all knowledge, since he who is ignorant of it common now the other sciences or the things of the world and what is worse, men who are thus ignorant are unable to perceive their own ignorance and so do not seek a remedy”. Pandit Jawaharlal Nehru also has expressed his view related to mathematical aspects as: “mathematics is supposed to be a dull subject, but is increasingly recognized that it is of high importance in scientific developments today. Indeed, mathematical research has evidenced the horizon of the human mind tenuously and has helped in the understanding, to some extent, of nature and the physical world. It is a vehicle of exact scientific thought”.

Hence, mathematics, which is a science by any criterion and which rightly belongs to this group has not been accepted and emphasized as a science. Math is a science of digits or numbers as well as it is an art of computing.

Aims of Pedagogical Content Knowledge (PCK) to Develop Mathematics as a Life Skill:

Mathematics develops practical value, disciplinary value and cultural values among the students, addition, subtractions, multiplication, division, weighing, measuring, selling, buying and many more simple and fundamental processes of mathematics which have got an immense practical value in life. The knowledge and skill in these processes can be provided in an effective and systematic manner with the help of PCK. The greater stress should be laid down on the teaching of the subject that can be helpful in practical life.

The aim of pedagogical content knowledge is to teach modern mathematical theories, law and rules by understanding and observations of the daily and life current practices and problems. Students should be trained to apply laws, theories and rules in day to day activities. Mathematics is very much helpful in solving the problems and practical problems of management of life, as life is full of complex problems.

Artistic aspects of Mathematics:

Beauty of a piece of art depends on the manner in which it expresses truth mathematics in knowledge of truth and realities. It is in itself a piece of fine art. It is a thing of beauty and for many it is a joy forever especially when they do not study it for examination purposes. In the artistic view by Helmholtz – “The manipulations of artistic’ genius are but the unconscious expression of a mysteriously acting rationally”.

According to Bertland Russell – “mathematics, rightly viewed, possesses not only truth, but supreme beauty – a beauty, cold and austere, like that of sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure and capable of a stern perfection such as a only the greatest art can show.” Hence mathematics provides a basis and background for aesthetic appreciation. Appreciation of rhythm, proportion, balance and symmetry postulates a mathematical mind. But the systematic study of these designs and orders of rhythms is fully the knowledge aspects of mathematics. We cannot separate

mathematics from our daily life for every person. All the effects of nature are the mathematical results of unmovable or unchangeable laws of a small numbers. So we can say that even metaphysics numbers also required full knowledge of mathematics.

Mathematics Pedagogical Knowledge: A Tool for effective teaching of Mathematics:

Some series of questions has on various occasions been posed regarding mathematical pedagogical knowledge of mathematics teachers. Some of these questions are: How does one become a better Mathematics teacher? How does one improve his/her teaching skills in Mathematics? How can teachers help students learn Mathematics the best way? For the foregoing question raised to be answered, a lot has been said and various hypothesized by scholars ranging from Psychologists, Mathematics Educators, Curriculum experts e.t.c. Teachers 'mathematical knowledge, pedagogical competence and insight into the development of students' mathematical ideas and reasoning are key to improving students' mathematical achievement (Arthur & Evelyn, 2006). High quality standards, curriculum, instructional materials and assessment are also important but not enough to improve students' learning of Mathematics. As Ball, Hill and Bass (2005) argue that little improvement is possible without direct attention to the practice of teaching; that how well teachers know Mathematics is central, which explains why recently there has been a considerable discussion and research on teachers' subject matter knowledge, pedagogical content knowledge and mathematical knowledge for teaching. The perspective of some Mathematics Educators is that to teach a school subject like Mathematics effectively, necessitate knowledge of Mathematics that goes beyond the subject matter per se to the dimension of subject matter knowledge for teaching or what Ball (2000) term as mathematical knowledge for teaching. Effective teaching requires teacher to attend and endeavor to understand the mathematical ideas and reasoning of their students. However, studies conducted in the past have not adequately taken into account mathematical problems which arose in daily mathematical learning situations when analyzing teachers' pedagogical content knowledge. On the contrary, some studies found and revealed that some teachers who acquired more mathematical knowledge facilitated their students' learning and thereby improve problem solving performance (Carpenter, Fenema&Franke, 1996). In this regard, conception of mathematical knowledge is a critical aspect of teachers 'knowledge before they are able to help students learn (Swafford et al, 1997).

Recommendations:

Pedagogical knowledge in teaching Mathematics is indispensable and teachers should try and make the teaching appreciable to learners through the following ways:

1. Translate curriculum content into knowledge so that students should be able integrate what they are learning in Mathematics with other parts of their learning knowledge.
2. Mathematics laboratories should be well equipped with teaching apparatus so that teachers can use their pedagogical skills in the process of imparting the knowledge.

3. Teachers of Mathematics should try to be attending mathematical conferences both at local and international level so that they keep abreast of the latest teaching approaches in Mathematics.
4. At local level, conferences such as Mathematical Association of Nigeria (MAN), National Mathematical Society (NMS) are recommended while at international level, conferences such as that of American Mathematical Society (AMS) and National Council of Teachers of Mathematics (NCTM) are recommended. The impact of Teachers' in-depth pedagogical mathematical content knowledge on academic performance:

Based on Schulman's (1987) notion of pedagogical content knowledge, effective teachers can possess an in-depth knowledge of how to represent the subject matter to learners (Parker & Heywood, 2000). Shulman (1987) also stated that pedagogical content knowledge must include the knowledge of learners and their characteristics, knowledge of educational contexts, knowledge of educational ends, purposes and values, and their philosophical and historical bases. Additionally, pedagogical content knowledge refers to the ability of the teacher to transform content into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students (Shulman, 1987, cited in An, Kulm and Wu, 2004). According to Ann, Kulm, and Wu (2004) pedagogical content knowledge has three components:

- Knowledge of content
- Knowledge of curriculum
- Knowledge of teaching.

An, Kulm and Wu (2004) point out the importance of knowledge of teaching and they accept it as the core component of pedagogical content knowledge. Researchers have been focusing on many aspects of teaching, but very less attention has been given on how teachers need to understand the subject they teach. In the mid-1980s, a major breakthrough initiated a new wave of interest in the conceptualization of teacher content knowledge. In his 1985 AERA presidential address, Lee Shulman identified a special domain of teacher knowledge, which he referred to as pedagogical content knowledge. He distinguished between content as it is studied and learned in disciplinary settings and the "special amalgam of content and pedagogy" needed for teaching the subject. These ideas had a major impact on the research community, immediately focusing attention on the foundational importance of content knowledge in teaching and on pedagogical content knowledge in particular. In 1986, Lee Shulman, an educator and researcher, noticed that all students need a teacher who is more than knowledgeable about their subjects. They also need one who can teach their specific subjects clearly and effectively. He called this combination of content and teaching knowledge, pedagogical content knowledge. The foundation of pedagogical content knowledge is the combination of both content and pedagogy.

CONCLUSION

At the heart of effective content teaching is the teachers' pedagogical content knowledge. If we are to improve the quality of teaching and learning in critical core content areas, we need to resist some old traditions in

professional learning. Instead, we should acknowledge and expand the insights of experts who develop competence in subject matter teaching. We should additionally commit to high quality professional development targeted to develop this expertise. When we do this, we support the growth of the teacher as a person and a professional who can expertly lead a student to academic success. Concurrently, we will contribute to the realization of the goals and priorities of the classroom and the school system as a whole.

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