



Review article

Teacher pedagogical knowledge in mathematics: a tool for addressing learning problems

A.K. Tsafe

Department of Science & Vocational Education, Usmanu Danfodiyo University, Sokoto-Nigeria.

^{*}Corresponding author; Department of Science & Vocational Education, Usmanu Danfodiyo University, Sokoto-Nigeria.

ARTICLE INFO

Article history:

Received 03 December 2012

Accepted 28 December 2012

Available online 29 January 2013

Keywords:

Pedagogical role

Teacher

Mathematic

Learning problems

ABSTRACT

This paper attempts to give a pedagogical role a classroom teacher is suppose to play in disseminating and imparting of mathematical knowledge. To achieve this, the paper focuses on the concept of teacher pedagogy, pedagogical knowledge and pedagogical content knowledge (PCK) and mathematical pedagogical knowledge. Problems encountered by teachers as a consequence of mathematical pedagogy have been closely looked at, and possible solutions offered.

© 2013 Sjournals. All rights reserved.

1. Introduction

In any profession, there is a specialized professional knowledge that makes it unique and distinct with striking features entirely different from other professions. One of the characteristics of good teachers is that they possess a substantial amount of specialized knowledge for teachers known as pedagogical content knowledge. According to Grossman (1990) pedagogy has been the focus of most teaching researches between the 1960s and 1980s; which consist of general knowledge, beliefs and skills related to teaching. It includes knowledge of principle of instruction such as small group instruction (Cohen, 1986). Knowledge and skills related to classroom management (Doyle, 1986). Teaching of Mathematics is a multifaceted human endeavor, involving a complex, moment-by-moment interplay of different categories of knowledge. Teachers' mathematical knowledge, pedagogical competence and reasoning are key to improving students' mathematical achievement.

However, the success or failure in the process of teaching a particular concept in Mathematics lies in the pedagogical approach adopted by the teacher, without which the teaching would appear to the students as what

Odili and Popoola (2011) described as having some major setbacks due to lack of teachers pedagogical knowledge. Research has established that teacher beliefs about how to teach Mathematics are linked to their pedagogical knowledge and consequently students learning in the classroom (Phillip, 2007; Wilson & Cooney, 2002). Traditionally, the teaching of Mathematics is about telling or providing clear, step-by-step explanations of procedures while students learn by listening and practicing these procedures. Hiebert (2003) had noted the deficiencies of this traditional approach which is a contrast to the pedagogical knowledge.

2. Teacher pedagogy

It is of paramount importance to begin this part of the paper by posing a question to all and sundry which may be open to contribution. The question is; *how pedagogical is a classroom teacher?* To begin with, the term "Pedagogy" is derived from two Greek words: *paid* meaning "child" and *Agogus* meaning "leader of". Literally, pedagogy means the art and science of teaching children. To this end, pedagogical assumptions made about learning and learners were based on the observation by monks in teaching simple skills to children which later spread to elementary schools throughout Europe and North America in the 18th and 19th centuries (Knowles, 1980). The pedagogical model of teaching was further reinforced when at the turn of the 20th century educational psychologists limited their research on learning to the reaction of children and animals. Based on the pedagogical model of teaching, the teaching strategy prescribed for teachers is the transmittal of knowledge and skills through the techniques of lecture, drills, quizzes, note memorization or rote learning, assigned readings and examination. In pedagogy, teacher is considered alpha and omega in the teaching and learning process. By being pedagogical, a classroom teacher is expected to make learning a compulsory task for the learner. The method to be adopted according to pedagogical teaching model should be centered on course content where all learning experiences and knowledge to be acquired by the learner are in accordance with pedagogical philosophy. The teacher operating in the realm of pedagogy is guided by the demand of his discipline. For this reason, he (teacher) unilaterally transmits knowledge and skills to a learner deemed to be empty and a "tabula rasa"

Because of its overwhelming importance and relevance, a lot of studies were conducted to ascertain the extent of teacher pedagogy as to the failure or success in learning Mathematics. For instance Enesi (as cited in Korau, 2011) observed that lack of inexhaustible strategies are said to be responsible for Colleges of Agriculture Mathematics failures. These strategies are concerned with all the ramifications of the art of teaching; the teaching personnel, techniques of teaching, approaches, textbooks, materials, audiovisual aids, libraries, curriculum implementation, learners' participation and teacher feedbacks are all part of the problems. For teachers to be pedagogical therefore, the aforementioned strategies should adequately and strictly be followed and adhered to.

3. Pedagogical knowledge

In a classroom, it is not only the knowledge acquired by the classroom teacher that matters. The process of imparting the knowledge to the learners by employing techniques and strategies that will make the least in the class in terms of understanding to get a clear picture of the lesson. The failure of the teachers to devise this means of enriching the class is one of the reasons why the lesson of Mathematics is ever becoming a subject of discussion among students and consequently leads them to poor result whenever they sit for an exam that has to do with Mathematics. This problem emanates due to quite a number of reasons; one of which is pedagogical know-how

Pedagogy has variously been defined by scholars to mean different things depending upon the context of its usage. Pedagogical knowledge is a strategy and style which allow the teacher to present his lesson in a stimulating way (Korau, 2011). If a teacher is able to present his lesson in such a way that learners appreciate and appeal strongly, it means the pedagogical knowledge of the teacher is sound. By being pedagogically knowledgeable, Timothy (1991) observed that teachers who provide student relationship and apply good classroom conditions will improve the academic achievement of students thereby motivating them to score high marks. Pedagogical knowledge can be used to consider how teacher can teach in the class. This is in line with the opinion of some Mathematics educators, who stated that teachers characteristics behavior such as attitude, interest, mode of teaching are a combination of factors that enable teachers to teach well in classroom (Agbarevo, 2006; Chapman, 1990 and Popoola, 1997)

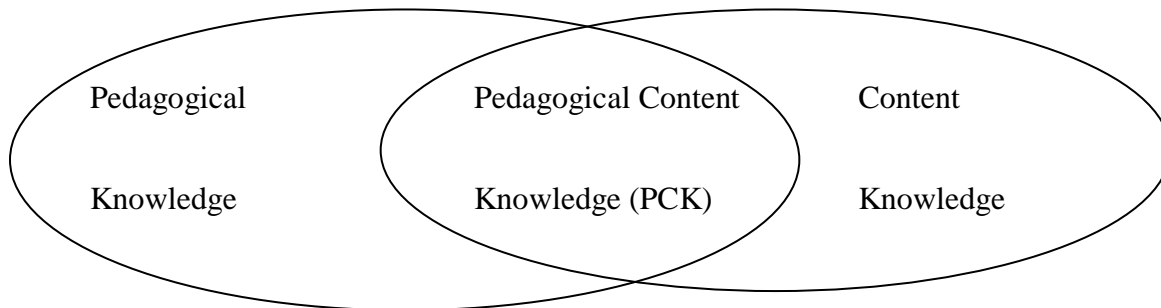
4. Teacher pedagogical knowledge in mathematics and its effect on learning

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. Teachers' knowledge of subject matter as such continues to draw an increasing attention from policy makers in recent years all over the world, since more emphasis is given to highly qualified teachers (Crespo & Nicole, 2006)

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.

5. Pedagogical content knowledge (PCK) and how it affects learning

It has been revealed that having a flexible, thoughtful and conceptual understanding of subject matter is critical to effective teaching (Borko & Putnam, 1996; Darling-Harmond, 1998). The substantial amount of knowledge required by teachers is known as pedagogical content knowledge (PCK), which is the intersection between pedagogy and content (Shulman, 1986) as could be seen below:



Pedagogical content knowledge refers to how teachers blend content and pedagogy to determine the most effective means to teach a particular topics or problems consistent with students' interest and ability (Shulman, 1986). Teachers must be aware that the practice of teaching is complex. They have to understand that teaching occurs in certain circumstances and requires constant decision making. It encompasses deep, flexible knowledge and ability to apply that knowledge to students, content, the curriculum, instruction, assessment and the school and local communities (Fullan & Hargreaves, 1992). Prospective teachers and those already in the field who might not have had the opportunity to acquire must be subjected to some capacity building workshops so as to make them become familiar with this concept of pedagogical content knowledge. This is because being an effective teacher is ultimately judged in terms of imparting knowledge and values that students can comprehend and relate to. Effective teaching according to Arends (1994), Stephens and Crawley (1994) includes the following

- Making the subject exciting and linking it, whenever possible, to issues students can relate to in their world;

- Unashamedly loving the subject and getting the students to know that they love it;
- Making complex issues understandable;
- Listening to the students and thereby avoiding too much chalk and talk;
- Setting work that students can realistically handle

The history of pedagogical content knowledge (PCK) will not be complete without making reference to Lee Shulman, who was the first person to have coined the term with such an acronym. According Shulman (1986) the concept of pedagogical content knowledge is the teachers' interpretation and transformation of subject matter knowledge in the context of facilitating students' learning. He further proposed several key elements of pedagogical content knowledge as:

- Knowledge of representation of subject matter (content knowledge)
- Understanding of students' conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter
- General pedagogical knowledge for teaching strategies
- Curriculum knowledge
- Knowledge of educational contexts
- Knowledge of the purpose of education

However, proponents of pedagogical content knowledge concept are of the opinion that the value in their work has served to re-focus educators' attention on the important role of subject matter in educational practice and away from the more general approach to teacher education that dominated the field since the 1970s (Gess-Newsome & Lederman, 2011)

Therefore, for teacher to be effective in the art of his/her instruction, he must be familiar with the pedagogy of his subject-matter otherwise the teaching would be marked by inconsistencies and thereby leading students to virtually learn nothing from the lesson

6. 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 variously posited 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 to 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)

7. Born or made teachers in teaching mathematics

Ever since the evolution of Western Education in Nigeria, one of the pressing issues is getting the required adequate number of well trained teachers to cater for the needs of the learners at all levels. Where the number is sufficient, it would be found that the expertise and technical know-how to man the profession effectively may be missing. This is when most of the teachers are found to be operating almost on the same level with some students. This is why perhaps a lot of programs were initiated to see to the provision of well trained teachers, who can handle the teaching process with efficacy and can employ all strategies and resources around them to enrich the process and ensure adequate and proper dissemination of the subject matter to the learners (Pedagogy). Some of these programs that were initiated to cater for these needs include Pivotal Teachers Training Program (PTTP), NCE by DLS and Postgraduate Diploma Programs. In addition to Universities that run these Postgraduate Diplomas, National Teachers Institute was also created to serve as a response to this national need and Universal Basic Education was also put in place; the aim of which is to provide adequate basic knowledge to the Nigerian child and could not be actualized without qualified teachers who pedagogically master their area of specialization.

Why the attainment of teacher pedagogical knowledge could be untenable is because of what had over the years generated discussion in the field of education as to whether teachers are born or made. Born teachers has an intrinsic tendency to teach; as a result of which they go extra-mile to become acquainted with the necessary pedagogy to enable them deliver successfully, even though they might not have attended teacher professional programs while teachers who are believed to have been made, who professionally acquire the pedagogical skills through various teacher education programs they might have attended, many of them on the contrary lack such an intrinsic tendency to teach. To this category of teachers, whatever is given to them as a motivation may not make them to act professionally pedagogical and as a result cannot adequately deliver in the classroom. What is required to boost the morale of teachers for them to unveil their pedagogical abilities is professional reorientation. The negative image as often viewed by the society should be revisited and whatever is it they (teachers) are entitle to should be given to them so as to enable them compete favorably with other professionals. In olden days, no profession was comparable to teaching but now some took it up as a last resort if they could not get jobs elsewhere. Doing something without interest would not make an individual to fully harness the potentials, if any, he was naturally born with. Therefore, it is the duty of leaders in the positions of authorities to make teaching profession a priority so as to make teachers develop interest in the art of teaching thereby culminating in the acquisition of adequate pedagogical knowledge in their areas of endeavor.

8. Conclusion

For teaching of Mathematics to be effective within the context of pedagogy, teachers should be mindful of quite a number of things; one of which has been pointed out by Abdullahi (2005) as anything a teacher uses in teaching situations to make learning easy from small stones, piece of paper, chalkboard, maps, radio, television and computer. Such resources provide students with opportunity to use their senses so that at the end of instruction, students can perform the teacher stated objectives. This is one of the ways through which teachers can be said to be pedagogically sound and mathematically-centered because every stage of Mathematics teaching requires concretization

9. 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 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.

References

- Adedoyin, O.O., 2011. The impact of Teachers' in-depth pedagogical mathematical content knowledge on academic performance: As perceived by Botswana Junior Secondary School Pupils. *European Journal of Educational Studies* 3(2), P277
- Agbarevo, M.N., 2006. The effects of teachers' behavioral characteristics on students' interest in science. *Journal of Research in Education* 3(1), 47-50
- Arends, R.I., 1994. Learning to Teach. New York: McGraw Hill
- Arthur, B.P., Evelyn, H., 2006. Researching Teachers' knowledge for teaching Mathematics. *Rational and Whole numbers* 2, 377-383
- Ball, D.L., 2003. Mathematical proficiency for all students towards a strategic research and development program in Mathematics Education. RAND Mathematics study panel. Santa Monica, CA
- Ball, D.L., Hill, H.C., Bass, H., 2005. Knowing Mathematics for teaching: Who knows Mathematics well enough to Third Grade, and how can we decide? *American Educator*, 29(3), 14-17
- Borko, H., Putnam, A., 1995. Learning to teach in D.C. Berliner & R.C. Calfee (eds), Handbook of Education Psychology (Pp 673-708). New York: Macmillan
- Carpenter, T.P., Fennema, E., Franke, M.L., 1996. Cognitively Guided Instruction: A Knowledge Base for Reform in Primary Mathematics Instruction. *The Elementary School Journal* 97(1), 3-20
- Chapman, O., 1996. Reconstructing Teachers' Thinking in Teaching Problem Solving in L. Puig & A. Gutierrez eds. Proceedings of the 20th Annual Conference of the International Group for the Psychology of Mathematics Education 2, 193-201, Valcucia.
- Cohen, D., 1986. Assessing the Quality of Teacher Education. East Lansing, MI: National Centre for Research on Teacher Education
- Crespo, S., Nicole, C., 2006. Challenging Pre-service Teachers' Mathematical understanding: The case of division by zero. *School Science and Mathematics*, 106(2), 84-97, USA
- Darling-Harmond, L., 1998. Teacher learning that supports student learning. *Educational Leadership*, 55(5), 6-11
- Doyle, W., 1986. Classroom Organization and Management, in M.C Withrock (Ed.), Handbook of Research on Teaching (3rd ed. Pp. 392-431). New York: Macmillan
- Enesi, A.O., 2007. Effects of pedagogical variables on senior school certificate English Language Examination. *Zaria Journal of Studies in Education*, 3(2), 52-58
- Fullan, M., Hargreaves, A., 1992. What is worth fighting for in your school? Toronto: Ontario Public School Teacher Federation.
- Gess-Newsome, J., Lederman, N.G., 2001. Examining Pedagogical Content Knowledge: The Construct and its Implications for Science Education. *Contemporary Trends and Issues in Science Education*
- Grossman, P.L., 1990. The making of a Teacher: Teacher knowledge and Teacher Education. New York: Teachers College Press
- Hiebert, J., 2003. What research says about the NCTM standards? In J. Kilpatrick, G.W. Martin & D. Schifter (Eds). A research companion to principles and standards for school Mathematics (Pp. 5-23). Reston V.A: National Council of Teachers of Mathematics.
- Ibeh, A.E., 2007. Pedagogy Versus Andragogy Dichotomy: An unresolved debate in the teaching methodology of adult. *International Journal of Research in Education*, 4(1&2). Pp.47-55
- Knowles, M.S., 1980. The Modern Practice of Education: Pedagogy versus Andragogy. 2nd Ed. Association Press: New York
- Korau, Y.K., 2010. Pedagogical Strategies for Improving the Teaching and learning of Mathematics at the Colleges of Agriculture in Nigeria. *Journal of Studies in Science and Mathematics Education*, 1(1) Ahmadu Bello University Zaria.
- Odili, G.A., 2006. Mathematics in Nigeria Secondary School: A Teaching Perspective: Anachua Educational Books, Lagos.
- Phillip, R.A., 2007. Maths Teachers' belief and Effect, in F.K. Lester (Ed), Second Handbook of Research on Mathematics Teaching and Learning (Pp. 257-315). United States.
- Popoola, A.A., Odili, G.A., 2011. Secondary School Mathematics Teachers' utilization of Pedagogical Knowledge and their Teaching effectiveness. *African Journal of Education and Technology*, 1(3) Pp. 53-61

- Popoola, A.A., 1997. Level of Competence of Teachers for the Teaching of Mathematics in Primary Schools. *Journal of Educational Issues*. 1(1) Pp. 152-157
- Shulman, L.S., 1986. Those who understand: knowledge growth in teaching. *Educational Research*, 15(2)
- Stephen, P., Crawley, T., 1994. *Becoming an Effective Teacher*: Chaltenham: Starley Thornes
- Timothy, J., 1991. Effectiveness of Inquiry versus Lecture Methods of Teaching in Secondary School in Niger State. Unpublished M.Ed Thesis, Ahmadu Bello University, Zaria.
- Wilson, M., Cooney, T.J., 2002. Mathematics Teacher change and Development, in G.C. Leder, Pehkonen & G. Tornen (Eds), *Beliefs; A hidden variable in Mathematics Education*. (Pp. 127-147), Dordrecht, the Netherlands: Kluwer Academic Press.