

# Pedagogical Content Knowledge and Classroom Teaching of Mathematics Teachers at the Secondary Level

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## Abstract

*The present study was conducted to compare the pedagogical content knowledge and classroom teaching of mathematics teachers in relation to sex, qualification and experience and to find out the relationship between the pedagogical content knowledge and classroom teaching. The investigator adopted descriptive method. The tools consist of self-developed test on pedagogical content knowledge of mathematics and observation schedule for assessing classroom teaching of mathematics teachers. The study found that (i) There is no significant difference in pedagogical content knowledge and classroom teaching of male and female mathematics teachers. (ii) There is a significant difference in pedagogical content knowledge and classroom teaching of mathematics teachers in relation to qualification and experience. The teachers having higher qualification and teaching experience found having better pedagogical content knowledge and classroom teaching. (iii) The pedagogical content knowledge and classroom teaching of mathematics teachers is positively related both with respect to total sample and sub groups. Implication of the study is that teacher education institutes may think of enriching the Teacher Education curriculum incorporating adequate specific content that will help trainees to develop pedagogical content knowledge and educational authority may consider pedagogical content knowledge as criteria for the recruitment of teachers.*

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## Introduction

Mathematics is an important subject of learning at the secondary stage. Developing children's abilities for Mathematisation is the main goal of

mathematics education (NCF-2005). It helps learners in acquiring decision-making ability through its applications to real life both in familiar and unfamiliar situations. It predominately

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contributes to the development of precision, rational and analytical thinking, reasoning and scientific temper. Mathematics teaching at the secondary stage aims at developing the student's resources to think and reason mathematically to pursue assumptions to their logical conclusion and to handle abstractions. It helps students to acquire skill of representing data in the form of tables, graphs and to draw conclusions from the same. At this stage, the students begin to perceive the structure of Mathematics as a discipline. Highlighting the vision, the NFG on teaching of mathematics (NCERT, 2006) states that 'school mathematics takes place in a situation where:

- Children learn to enjoy mathematics
- Children learn important mathematics. (Equating mathematics with formulas and mechanical procedures does great harm).

Children see mathematics as something to talk about, to communicate, discuss among themselves, to work together on. Making mathematics a part of children's life experience is its best mathematics education possible.

- Children pose and solve meaningful problems.
- Teachers expect to engage every child in class: settling for anything less can only act towards systematic exclusion, in the long run. (NFG on Teaching of Mathematics, NCERT 2006, pp-2-3).

Teacher plays an important role in developing students' abilities for Mathematisation. They must create a stimulating atmosphere; the teacher must possess desire, passion and

patience to facilitate the learning of others. An effective teacher of Mathematics needs to help in removing the fear and anxiety that Mathematics represents to so many students. For an effective teacher, one must have content knowledge, pedagogical knowledge, contextual knowledge, technological knowledge and pedagogical content knowledge. The pedagogical content knowledge has a significant role to play in better classroom teaching. Therefore, all teachers should have pedagogical content knowledge in their subject.

The term pedagogical content knowledge was introduced by Shulman in 1986. According to him, it is a knowledge formed by the synthesis of three knowledge bases: subject matter knowledge, pedagogical knowledge and knowledge of context. Pedagogical content knowledge was unique to teachers and separated, for example, a science teacher from a scientist. It is as a set of special attributes that helped someone transfer the knowledge of contents to others (Geddis, 1993). It include the most useful form of representation of these ideas, most powerful analogies, illustrations, examples and demonstrations, in a word the way of representing and formulating the subject that make it comprehensible (Shulman, 1987, p. 9). Furthermore, in a practical way, pedagogical content knowledge included those special attributes a teacher possessed that helped him/her guide student to understand content in a manner that was personally meaningful. It is an understanding of how particular topics, problems or

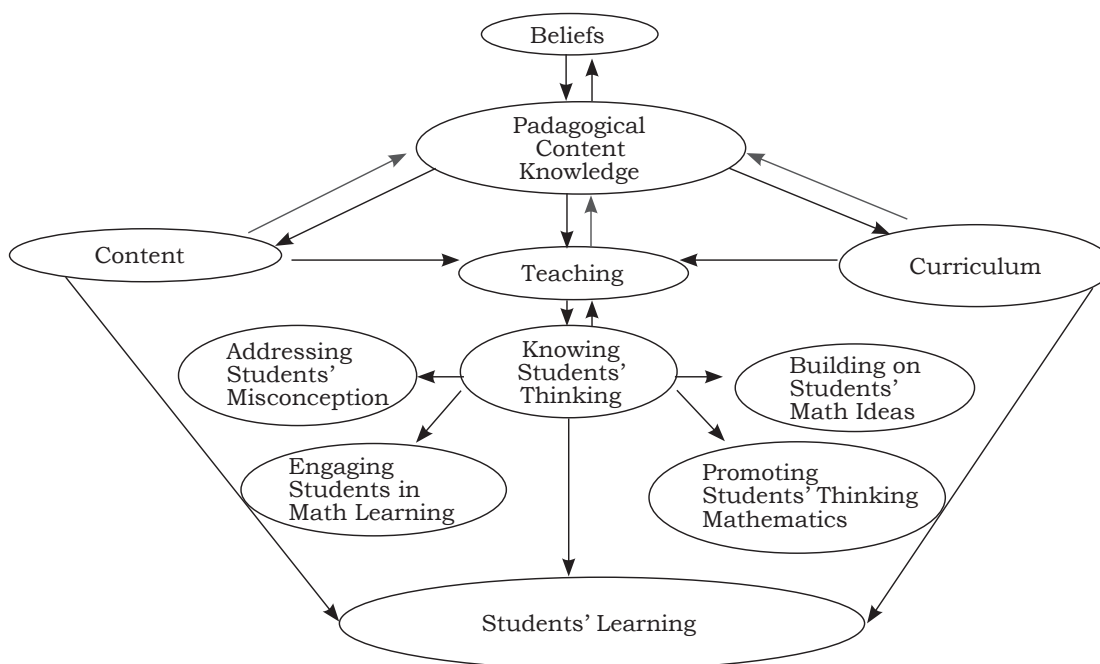


Fig. 1: Network of pedagogical content knowledge (adapted from Kulum and Wu, 2004)

issues are organised, presented and adapted to the diverse interest and abilities of learners and presented for instruction (Shulman, 1987, p. 8). Kulum and Wu (2004) reported that pedagogical content knowledge has three components: Knowledge of content, Knowledge of curriculum and Knowledge of teaching. It is integration and interconnection of these three types of knowledge as presented in figure 1.

The main responsibility of teacher is to teach, thereby make students understand concepts of mathematics. Classroom teaching behaviour is another very important factor for successful teaching and learning. It refers to behaviour and activities of teacher inside the classroom. It includes different skills of the teaching

such as organising activities, assigning project and assignments, questioning, explaining, blackboard writing and using teaching aids etc. It is the process that brings the curriculum into contact with students and through which educational goals are to be achieved. The quality of classroom teaching is a key to improve students' learning. The pedagogical content knowledge and classroom teaching are related to each other as sound pedagogical content knowledge helps in better classroom teaching.

### Need of the Study

Pedagogical content knowledge of teachers is very essential for effective teaching and learning. Majority of classroom teachers lack substantial subject knowledge, the knowledge

of what to teach, and how to teach the subject matter. Because of lack of pedagogical content knowledge of teachers, students are underachieving or not performing well in mathematics. This is also reflected in students' poor results in examinations. The poor performance could be due to a number of reasons but one of the important reasons is lack of mathematics pedagogical content knowledge of school teachers. The pedagogical content knowledge of teachers reflects how far h/she is capable of bringing improvement in the quality in terms of students' higher achievement. Pedagogical content knowledge illustrates how the content matter of mathematics is transformed for communication with learners. To teach Mathematics at secondary stage the teacher need to understand the mathematical concepts and also the methods to execute, so that it can help the students to map their own ideas, relate one idea to other and redirect their linking to create powerful learning.

Pedagogical content knowledge and classroom teaching is an important variable of research in education.

Adedoyin, O. O. (2011) found that pupils perceived that mathematics teachers' in-depth pedagogical content knowledge has an impact on their academic performance. It is recommended that teacher training colleges should incorporate in their curriculum in-depth mathematics pedagogical content knowledge for Mathematics teachers in order to be effective in the classroom and thereby improving pupils learning outcomes and academic performance in Mathematics.

Yusminah and Effandi (2010) reported that the PCK of these three teachers were mediocre level. Due to their lack of conceptual knowledge, these teachers failed to deliver the related concepts of functions accurately and clearly in class. Sara (2010) found that there is a relationship between teacher pedagogical content knowledge and students' standards of learning scores in geometry and measurement. Joyce, S. (2009) suggests that teachers with insufficient SCK will probably have limited PCK, although the two are not entirely dependent on each other. In cases where teachers' displayed low levels of SCK and PCK, their learners were more likely to perform poorly and their results often indicated similar misconceptions as displayed by their teachers. Lianhua (2009) reported that there was a gap between the teachers' pedagogical content knowledge and their teaching practice. M. K. Jussi and Pekka Heikkinen et al., (2009) revealed that good content knowledge has positive influence on student-teachers' PCK and thus on effective teaching. Content experts became conscious of students' conceptual difficulties better than content novices. It is very difficult for a content novice to recognise students' misconceptions because of his/her own misconceptions. Krauss, S. et al., (2008) show that mathematics teachers with an in-depth mathematical training (i.e., teachers qualified to teach at the academic-track Gymnasium) outscore teachers from other school types on both knowledge categories and exhibit a higher degree of cognitive connectedness between the two knowledge categories. Turnuklu,

Elf. B. and Yesildere, S. (2007) found that having a deep understanding of Mathematics knowledge was necessary but not sufficient to teach mathematics. This finding pointed out the connection between knowledge of mathematics and knowledge of mathematics teaching. It is suggested that primary mathematics teachers should be educated both from “Mathematics knowledge” and “pedagogical content knowledge” aspects. Heather et al., (2005) found that teachers’ mathematical knowledge was significantly related to student achievement gains in both first and third grades, controlling for key student and teacher-level covariates. Shuhua et al., (2004) indicated that Mathematics teachers’ pedagogical content knowledge in the two countries differs markedly, which has a deep impact on teaching practice. Jan, H.D.V. et al., (1998) identifies teaching experience as the major source of PCK, whereas adequate subject-matter knowledge appears to be a prerequisite. The effects on teachers’ PCK of participation in an in-service workshop and conducting an experimental course in classroom practice are reported.

### **Objectives**

- To compare pedagogical content knowledge of mathematics teacher in relation to sex, educational qualification and experience.
- To compare the classroom teaching of mathematics teacher in relation to sex, educational qualification and experience.
- To find out the relation between pedagogical content knowledge and

classroom teaching of Mathematics teacher.

### **Hypotheses**

There is no significant difference in pedagogical content knowledge of mathematics teacher with regard to sex, educational qualification and teaching experience.

There is no significant difference in classroom teaching of mathematics teacher with regard to sex, educational qualification and teaching experience

There is no significant relation between pedagogical content knowledge and classroom teaching of mathematics teacher.

### **Operational definition of key terms used**

**Pedagogical Content Knowledge** included those special attributes a teacher possessed that helped him/her guide student to understand content in a manner that was personally meaningful. It is an understanding of how particular topics, problems or issues are organised, presented and adapted to the diverse interest and abilities of learners and presented for instruction.

**Classroom Teaching** refers to behaviour and activities of teacher inside the classroom. It includes different skills of the teaching such as organising activities, assigning assignments and projects, questioning, explaining, using blackboard and teaching aids.

**Qualification** is the teacher’s educational achievements in terms of academic and professional degree. For the present study, it is divided

into two types such as teachers having qualification of (i) B.Sc. with B.Ed., (ii) M.Sc with B.Ed.

**Teaching experience** is the professional teaching practice of a teacher in terms of years. For the present study the experience is considered at two levels such as (i) Less than 10 years of teaching experience. (ii) More than 10 years of teaching experience.

### Procedure

The present study is a descriptive survey. The sample consists of 60 mathematics teachers randomly selected from CBSE-affiliated secondary schools of Eastern Odisha (undivided district of Baleswar, Cuttack and Puri). Equal weightage was given to sex, qualification and experience in selecting sample.

The tools consist of self-developed test on pedagogical content knowledge of mathematics having 50 marks and observation schedule having 120 points for assessing classroom teaching of mathematics teachers.

The test on pedagogical content knowledge consists of 50 multiple choice items based on secondary school mathematics curriculum. The content validity of the test is ensured by taking expert opinion and trying out on 10 secondary school mathematics teachers. The test re-test reliability of the test is .68 with seven days gap. The observation schedule consists of 40 items based on different skills of teaching with five point scales, 1 indicates lowest and 5 indicate highest. The validity of the observation schedule is ensured by taking expert comments and tried out with secondary school teachers and test-retest reliability is .73. The collected data are analysed by using mean, SD, t test and correlation.

### Analysis and Interpretation

The first objective of the study is to compare pedagogical content knowledge (PCK) of mathematics teacher in relation to sex, qualification and experience. For this, investigator calculated t value of obtained score which is presented in table 1.

Table 1  
**t value of math teachers in pedagogical content knowledge**

Group	Category	N	Mean	SD	df	t	Result
1	Male	30	35	4.5	58	.784	Not Significant
	Female	30	33	7.6			
2	B.Sc. B.Ed	30	28	5.67	58	17.77	Significant
	M.Sc. B.Ed	30	40	3.24			
3	Below 10 Yrs	30	30	6.59	58	3.297	Significant
	Above 10 Yrs	30	38	5.42			

Table value: 2.00 at 0.05 level and 2.66 at 0.01 levels.

Table 1 indicates that calculated  $t$  value (.784) for pedagogical content knowledge of male and female teacher is smaller than table value (2.00). So there is no significant difference in pedagogical content knowledge of male and female mathematics teachers. The table also indicates that calculated  $t$  value for pedagogical content knowledge of teachers having B.Sc. B.Ed. and M.Sc. B.Ed. qualification and having experience of below 10 years and above 10 years is significant.

Table 2 reveals that the calculated  $t$  value (1.735) for classroom teaching of male and female mathematics teachers is not significant at 0.05 levels. The same table also indicates that  $t$  value for classroom teaching of mathematics teachers having different qualification and experience is significant at 0.01 levels. Hence the null hypothesis 'there is no significant difference in classroom teaching of mathematics teachers in relation to qualification and

Table 2  
**t value of math teacher in classroom teaching**

Group	Category	N	Mean	SD	df	t	Result
1	Male	30	88	4.76	58	1.735	Not Significant
	Female	30	84	6.82	58		
2	B.Sc, B.Ed	30	75	6.57	58	10.180	Significant
	M.Sc, B.Ed	30	97	4.66	58		
3	Below 10 Yrs	30	80	3.38	58	5.591	Significant
	Above 10 Yrs	30	92	7.28	58		

Table value: 2.00 at 0.05 level and 2.66 at 0.01 levels.

So the null hypothesis is rejected at 0.01 levels. Hence it can be inferred that there is a significant difference in pedagogical content knowledge of mathematics teachers in relation to qualification and experience.

The second objective of the study is to compare classroom teaching of mathematics teachers in relation to sex, qualification and experience. The investigator calculated  $t$  value of obtained score, which is presented in Table 2.

experience' is rejected at 0.01 levels. So it can be said that teacher having different qualification and experience display different classroom teaching practice.

The last objectives of the study are to find out correlation between pedagogical content knowledge and classroom teaching of mathematics teachers. The investigator calculated correlation both for total sample and group-wise, which is given in Table 3.

Table 3  
**Correlation between pedagogical content knowledge and classroom teaching**

<i>Group</i>	<i>Category</i>	<i>N</i>	<i>r</i>	<i>Result</i>
1	Total Sample–Pedagogical Content Knowledge	60	.76	High correlation
	Total Sample–Classroom Teaching	60		
2	Male–Pedagogical Content Knowledge	30	.67	Marked correlation
	Male–Classroom Teaching	30		
3	Female–Pedagogical Content Knowledge	30	.72	High correlation
	Female–Classroom Teaching	30		
4	B.Sc. B.Ed.–Pedagogical Content Knowledge	30	.57	Marked correlation
	B.Sc. B.Ed.–Classroom Teaching	30		
5	M.Sc. B.Ed.–Pedagogical Content Knowledge	30	.64	Marked correlation
	M.Sc. B.Ed.- Classroom Teaching	30		
6	Below 10 yrs–Pedagogical Content Knowledge	30	.58	Marked correlation
	Below 10 yrs–Classroom Teaching	30		
7	Above 10 yrs–Pedagogical Content Knowledge	30	.73	High correlation
	Above 10 Yrs–Classroom Teaching	30		

Table 3 indicates that pedagogical content knowledge and classroom teaching of mathematics teachers is positively related both with respect to total sample and sub groups. So it can be said that pedagogical content knowledge contributes towards better classroom teaching. This result is supported by Adedoyin, O. O. (2011), Talley, Sara (2010), M. K. Jussi and Pekka Heikkinen et al., (2009), Heather et al., (2005) and Shuhua, A. et al., (2004).

### **Major Findings**

There is no significant difference in pedagogical content knowledge of male

and female mathematics teachers at 0.05 levels.

There is a significant difference in pedagogical content knowledge of mathematics teachers in relation to qualification and experience at 0.01 levels. The teachers having higher qualification and teaching experience have better pedagogical content knowledge.

There is no significant difference in classroom teaching of male and female mathematics teachers at 0.05 levels.

There is a significant difference in classroom teaching of mathematics teachers in relation to qualification and experience at 0.01 levels. So it can



be said that teachers having higher qualification and experience display better classroom teaching practice.

The pedagogical content knowledge and classroom teaching of mathematics teachers is positively related both with respect to total sample and sub groups.

### **Educational Implications**

The study has several implications for educational practice. All teachers should possess adequate pedagogical content knowledge in respective subject as it will help them for better teaching, thereby improving students' academic performance. Teachers should take personal interest to develop pedagogical content knowledge in their subject. Similarly the educational administrator and planners may take initiatives for organising in-service training programmes in the form of workshops, lectures and discussions relating to pedagogical content knowledge. The teacher education institutes may think for adding contents in teacher education curriculum that will help trainees to develop pedagogical content knowledge. The educational

authority can consider pedagogical content knowledge as criteria for recruitment of teachers. The study may create awareness among educational researchers about the pedagogical content knowledge as variable of research. Large scale research can be undertaken at national level and for other subjects.

### **Conclusion**

The pedagogical content knowledge is one of the significant aspects of effective teaching and learning. To be effective teacher, one should possess content knowledge, pedagogical content knowledge and technological knowledge. The study found that pedagogical content knowledge has positive relationship with classroom teaching. In other words, teachers having good pedagogical content knowledge can teach better than teachers having poor pedagogical content knowledge. Therefore steps should be taken at individual level, teacher education level and educational administrators' level for improving pedagogical content knowledge of teachers.

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