



**RESEARCH PAPER**

**Maximizing Content-Based Knowledge of the Novice Teachers in Mathematics: An Experimental Study**

<sup>1</sup> Dr. Muhammad Akram\*, <sup>2</sup> Dr. Muhammad Irfan Malik and <sup>3</sup> Zainab Kamran

1. Associate Professor, Institute of Education and Research, University of the Punjab, Lahore, Punjab, Pakistan
2. Lecturer, Department of Education, The Islamia University of Bahawalpur, Bahawalnagar Campus, Punjab, Pakistan
3. PhD Scholar, Department of Advance Studies in Education, Institute of Education and Research, University of the Punjab, Lahore, Punjab, Pakistan

**\*Corresponding Author:** akram.ier@pu.edu.pk

**ABSTRACT**

This study used an experimental approach to find out the effect of content-based professional development training in mathematics on novice primary school teachers' achievement in mathematics. Professional development training to in-service teachers provides need-based support to maximize their knowledge in the areas they need support. The study has its theoretical bases on Knowles (1984) theory of adult learning that assumed that adults should be involved in the planning and evaluation of their learning as this experience provides them basis to teach the subject which is relevant to their lives. 140 primary school teachers from rural areas of Sheikhpura district were clustered into 5 places for intervention. The intervention included hands on activities related to mathematics lasted 40 hours to mathematics teachers during the span of one week. The study employed one group pre-test post-test experimental design. The teachers were pretested and post-tested on a researcher-made test related to Mathematics content knowledge taken from grade 5 textbook of mathematics. Descriptive and inferential statistics were used to analyze the data. The study revealed that achievement scores in post-test of the teachers were better as compared to pre-test for the mathematics subject. The researcher recommended that continuous professional development programs should be in practice to provide in-service teachers especially the novice teachers to support them.

**KEYWORDS** Professional Development Training of Teachers, Content-Based Knowledge In Mathematics, Quality Education

**Introduction**

Teacher professional development (PD) is essential to increasing teacher expertise, it has received increased attention in recent decades. Teachers have to improve their knowledge of the present educational system and their skill set as part of the teacher professional development program. An effective teacher is essential to the nation's efforts to prepare the next generation. The character development and academic success of students are also impacted by a competent instructor (Bruckmaier et al., 2016). The process of teacher development can be aided and elevated by professional development for teachers. Therefore, in order to better their instruction, teachers must possess the most recent information and abilities. By putting in place an efficient professional development (PD) program, educators can improve their knowledge and abilities to better support students' learning in the classroom (Rosli & Aliwee, 2021 & Muzaffar, 2016). With the aim of raising student accomplishment, professional development opportunities give teachers better learning chances, in-depth topic knowledge, and improved teaching techniques (Hardré et al., 2019)

In school, mathematics is a compulsory subject. The study of mathematics deals with quantities, measurements, numbers, and shapes. It is impossible to teach mathematics

effectively without a thorough understanding of the pedagogy, knowledge, and skills that will be applied throughout instruction (Oslund, 2016). Instructors have long viewed mathematics as a discipline of facts that students must learn by heart, and they incorporate this mindset into their lessons. As a result, pupils may find it challenging to master mathematics if they are not proficient in the subject (Rosli & Aliwee, 2021). A math teacher's job is to guide pupils through the challenges. However, a teacher needs to have a firm understanding of teaching and learning in the classroom in order to assist pupils in becoming proficient mathematicians. In order to lead a successful learning process, teachers must continue their education in order to gain the most up-to-date information and abilities in the curriculum, technology, and teaching methods (Auletto & Stein, 2019).

Primary education is most important for the education system in which essential skills of child are developed therefore governments of Pakistan have been making serious effort for providing the quality education to students and assisting them to make successful member of the society (Muzaffar, et. al., 2020). There are multiple of measurements such as increasing enrollment number, enough teachers, enough teachers, and different other requirements to enhance the level of quality education in primary schools. Through Public School Support Program (PSSP), Punjab Education Foundation (PEF) were being allowed by the government of Pakistan to improve the quality of primary schools. 44 primary schools located in rural area of district Sheikhpura were being adopted by public university in the Punjab province, Pakistan under that program to set up a monitoring mechanism for their continuous and effective supervision.

Various of teachers were less qualified and inexperienced and most importantly teachers are lacking in content-based competency in science and mathematics subject in that set up, therefore students' success rates are not improving in the examination of these subject (Kouser et al., 2011; Muhammad & Iqbal, 2015) and much required professional development training of teachers on regular basis to maintain the quality and enhance their content-based competency in mathematics subject. Multiple of studies emphasized on the importance of professional development training for develop and update content-based knowledge especially in mathematics subject because teacher must understand about all the mathematical concepts and how to teach these concepts effectively (Appova & Taylor, 2019; Black, 2009; Gomez-Zwiep & Benken, 2013; Lee et al., 2018; Phelps et al., 2016; White et al., 2004). Therefore, the study examined the effect of professional development training on teachers' content-based knowledge in mathematics subject by using an experimental approach which is highly required to evaluate the effectiveness of professional development training programs in Pakistan.

### **Conceptual Framework**

Theory of adult learning given by Knowles (1984) was used to theorize the study at hand which supposed that logic of different concepts and motivation towards learning must be comprehend by the adult to improve their professional approach (Borg, 1998). The study involved an experimental approach which assist the stakeholder to improve their approach towards their profession. The study used the following interrelated conceptual framework to understand the prevailing mechanism.

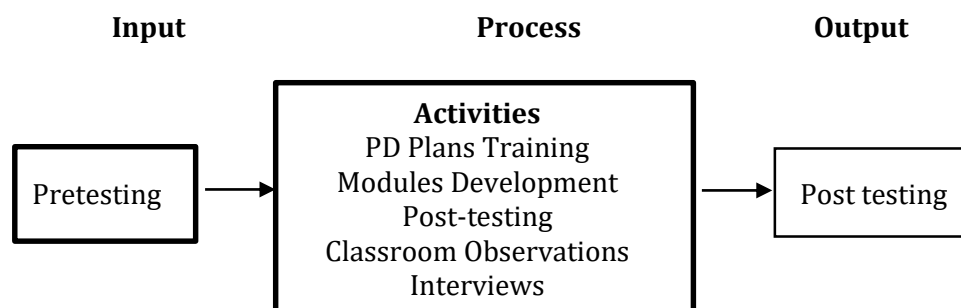


Figure 1: Conceptual framework of the study

## **Literature Review**

### **Professional development Training of Teachers and Content-Based Knowledge in Mathematics Subject**

According to Parrish et al. (2020), professional development need to concentrate on improving teachers' content knowledge while allowing them flexibility in using newly acquired knowledge in the classroom. Since there is evidence that some preservice teachers have just a limited conceptual understanding of specific mathematics concepts at the end of their teacher preparation programs, the efficacy of content-focused professional development is especially important (Avcu, 2019). Less qualified teachers, use of poor teaching methods, and assessment techniques, and lack of professional development training are the major issues involves at primary school level (Kouser et al., 2011; Ministry of Education, 2009; Muhammad & Iqbal, 2015), but most important teachers are lacking in their content knowledge especially in mathematics subject which required high competencies to teach at primary school level (Ahmad et al., 2013; Appova & Taylor, 2019; Phelps et al., 2016). Further, Memon (2007) was also concerned about the low teaching quality and poor content knowledge of declining student performance. Akram and Butt (2021) also identified the multiple of reasons of failure for primary education system in Pakistan which includes memory-based assessment, poor content knowledge, and low teacher quality. Furthermore, insufficient teaching staff, ineffective teachers' content knowledge and lack of financial resources are also the important problems of low quality teaching in Pakistan at primary school level (Ahmad et al., 2013; Kouser et al., 2011).

There were three main problems of poor results of students in overall that needed to be resolved such as poor subject matter knowledge of teachers especially in mathematics subject, poor use of the teaching strategies, and poor use of student assessment techniques. In certain situation, when the primary schools were not performing well and the Punjab government was paying billions of rupees to the caretakers of these failing schools, it was right time to provide trainings of these teachers where possible, and suggest remedial actions so that the system could work effectively. The study was initiated to address these challenges properly and find out proper solutions to improve content knowledge and educational improvement of schools.

Gomez-Zwiep and Benken (2013) examined the relationship between professional development and content based knowledge in mathematics subject and found that knowledge of contents and pedagogical skills are highly interlinked with the professional development which further leads their learners towards the quality education. In another study, White et al. (2004) were focused on improving the teachers' mathematical knowledge through using professional development model which further emphasized on the improvement of mathematical content and research based pedagogy. Similarly, Black (2009) investigated how much professional development contributes in content knowledge about all mathematical concepts, pedagogical skills and instructional practices. The study revealed that content knowledge and pedagogical skills about mathematics makes the instructional practices effective which might be improved through conducting professional development trainings.

Lee et al. (2018) revealed in their study that content matter knowledge and pedagogical skills both are essential for the quality learning of students which can be maximized through providing the opportunities of professional development of teachers. In another study, Appova and Taylor (2019) also examined the importance of professional development to enhance the understanding about mathematical content and skills of teachers and explored that through professional development, all the weakness of teachers can be minimized in teaching of all mathematical concepts. Phelps et al. (2016) also found

the similar results in their study that professional development of teachers highly mainly contributes in the content knowledge of teachers and pedagogical competency in mathematics subject at elementary school level.

The efficacy of an online program for early childhood teachers to receive professional development in early mathematics was assessed by Sheridan and Wen (2021). Early childhood educators were introduced to mathematical topics such as math literacy, number sense, patterns, geometry, measurement, data collecting, and math processes through the eight online courses, the Math at Home: Early Math Matters website, and other resources. The findings demonstrated that program participants had a good time, and the professional development program had a significant effect on the knowledge, self-assurance, attitudes, and beliefs of early childhood educators toward teaching early math. Parrish et al. (2020) investigated teachers' perceptions of content-focused professional development in a study. The findings demonstrated that middle school math instructors believe content-focused professional development is beneficial for enhancing their own knowledge and, as a result, their own teaching.

Hill and Ball (2004) reported that elementary mathematics teachers' content knowledge improved when provided with significant opportunities to examine the mathematics taught in the classroom followed by ways in which to connect the learned content with teaching practice. In a related study, middle school teachers took part in a summer academy where they finished courses in mathematics designed to improve their knowledge of both subject matter and pedagogical content. According to the study, middle school teachers appreciated having more topic knowledge in the mathematics they teach as well as having higher levels of self-efficacy (Swackhamer et al., 2009).

In overall, it has been concluded through reviewed of previous studies that there are various issues involved in declining the primary education in which most important are the lacking in content matter knowledge in different subject especially in mathematics and science subjects, therefore, professional development trainings in these subjects are required on continuous basis. In global perspectives, it was also emphasized on the need of professional development trainings to enhance the capability of teachers in mathematics subject and pedagogical skills to uphold the quality of teachers and primary education system in Pakistan.

### **Material and Methods**

140 primary school teachers were selected from 5 clusters as a participants of the study. Training to prepare the professional development plan was provided to them after sharing the achievement score of pre-test to improve their weak areas. Teacher training module was prepared to develop the content-based knowledge in Mathematics subject and training was given teachers by high qualified teacher education faculty of a public university. After taking the post-test, effect of training was measured through the difference between their scores in the pretests and posttests.

### **Threats and Control**

Numerous biases pose a threat to educational research studies that use the single group "pre- and post-test" design. This design usually involves the following steps: participant selection, pre-testing, exposure to an educational intervention, and post-testing (Marsden & Torgerson, 2012). The possible threats that typically occur during one group pre-test post-test design experiment are history, maturation, instrumentation and testing (Creswell, 2012).

The researcher made sure to control these threats so that the outcome of the experiment can be stated confidently. The threat of history is related to events may occur

between the pre-test and post-test that influence the outcome of experiment. Maturation is related to participants becoming older, wiser, stronger, and more experienced during an experiment. This may result in changes in their scores between the pre-test and post-test. In this experiment, the training period was one week which minimize the chance of maturation and happening any event which can affect the results of training. Testing is another potential threat to internal validity which means participants may become familiar with the outcome measures and remember responses for later testing. The researcher carefully conducted the test and did not tell participants that same test will be used for post-test. To control the threat of instrumentation the researcher used standardize procedures throughout the experiment.

**Table 1**  
**Cluster-Wise Sample Distribution**

S. No.	Name of Cluster	Participants (f)
1	Cluster 1	30
2	Cluster 2	27
3	Cluster 3	30
4	Cluster 4	30
5	Cluster 5	23
	Total	140

### Testing

The major segment of the study was testing teachers' current knowledge in Mathematics subject. To serve this purpose, the researcher developed the test of Mathematics subject from the content and the questions were taken from the textbook of grade 5 approved by the Punjab Textbooks Board (PTB) Lahore. The test of *Mathematics* comprised 80 marks and included questions related to general mathematical concepts, definitions, concepts of interest, fractions, ratios, basics of geometry and geometrical shapes, and calculating areas of rectangle and triangles. The test comprised both objective and subjective type questions. The objective type part included fill in the blanks and short questions, while extended-response essay type questions were also included. Multiple Choice questions were not included in the test to minimize the guessing chance. The content validity of the test was ensured by the experts and practitioners. Five content experts (2 from public universities) with the background in teaching Mathematics were requested to validate the content of the test. The changings were made in the test according to the given feedback from the experts.

### Pre-Testing

In the given study, sampled teachers were pretested after making proper seating arrangements through ensuring strict invigilation and marking according to rubrics by the researcher.

### Developing Professional Development Plan and Module Development

Professional development plan was developed with the help of training to achieve all targets of training. Tucker (2013) Professional Development Taxonomy (PDT) framework was used which is suitable for effective training. After that, the teachers were given an assessment sheet regarding designing individual plan for their professional development. Responding to the assessment sheet, the trainees were able to describe objectives of their professional development and find out the gaps in their learning, and were much interested in developing their knowledge in all the content of Mathematics subject they were pretested in. They set similar objectives and were ambitious to achieve them after receiving the training. The module for Math subject was developed based on the content from the textbooks of class 4 and 5.

The training related to *Mathematics* teaching was conducted by the trainer. The content-based training in *Mathematics* comprised detailed introduction of the basic concepts of Mathematics. The trainees were taught about place value, rounding, understanding and comparing whole numbers, conversion of units, Least Common Multiple (LCM), calculating area, fractions and mixed numbers, multiplication of fractions, percentage and its application, questions related to rates and ratios, temperature conversion, and understanding different pictures to perform mathematical functions properly. The trainer designed models and charts to perform mathematical descriptions along with frequent use of white board. After clarifying similar concepts, the trainees were distributed into small groups (of 4 to 5) and assigned different tasks to apply their knowledge through cooperative learning. During such activities, the trainer performed role of a mentor and a facilitator to provide effective feedback to the questions of the trainees. Peer teaching was being highly encouraged during the whole session.

### Post-Testing

Within the gap of one week, examinees were post-tested through using the same procedure of the pre-test. The scores of each examinee were entered into SPSS for conducting relevant analyses and further data were made clean before making the analysis.

### Results and Discussion

In the given study, descriptive statistics (Mean & SD) and paired sample t-test were used to analyze the data.

**Table 2**  
**Descriptive Statistics--Pre-Test and Post-Test Achievement Scores in Math Subject**

Subject		N	Mean	SD
Mathematics	Pre-test	140	27.71	16.355
	Post-test	140	58.87	15.518

Table 2 revealed that teachers achievement scores in post-test for Mathematics subject (M=58.87, SD=15.518) was found better as compared to teachers achievement scores in pre-test for Mathematics subject (M=27.71, SD=16.355).

**Table 5**  
**Paired Samples t-test for Content-based Comparisons in Mathematics Achievement**

Subject		M	SD	t	df	Sig	Effect size
Mathematics	Pretest	27.71	16.355	24.038	139	.000	1.954
	Posttest	58.87	15.518				

Table 5 shows there was significant mean difference in mean score of trainees in pre-test (M=27.71, SD=16.355) and post-test (M=58.87, SD=15.518),  $t(139)=24.038$ ,  $p=.000$ . The effect size ( $d=1.954$ ) is larger than Cohen's limit for large effect size ( $d=.80$ ).

### Discussion

The study involved an experimental approach to find the effect of professional development training on the teachers' content-based knowledge in science subject at primary school level which found that there was significant difference in the achievement scores in pre-test and post-test for the mathematics subject which strengthen the idea that professional development training significantly affected the teachers' content-based knowledge in mathematics subject. The results of study are in line with multiple of previous research, theories and models that teachers' content-based knowledge in mathematics subject might be improved through professional development trainings at school level (Appova & Taylor, 2019; Black, 2009; Gomez-Zwiep & Benken, 2013; Lee et al., 2018; Phelps et al., 2016; White et al., 2004).

Gomez-Zwiep and Benken (2013) found that knowledge of contents and pedagogical skills are highly interlinked with the professional development which further leads their learners towards the quality education. In another study, White et al. (2004) were focused on improving the teachers' mathematical knowledge through using professional development model which further emphasized on the improvement of mathematical content and research based pedagogy. Similarly, Black (2009) also revealed the similar results that content knowledge and pedagogical skills about mathematics makes the instructional practices effective which might be improved through conducting professional development trainings. All the provided studies are in line with the given study and confirmed the importance of professional development trainings to comprehend the content based knowledge in math.

Lee et al. (2018) revealed in their study that content matter knowledge and pedagogical skills both are essential for the quality learning of students which can be maximized through providing the opportunities of professional development of teachers. In another study, Appova and Taylor (2019) also explored that through professional development, all the weakness of teachers can be minimized in teaching of all mathematical concepts. Phelps et al. (2016) also found the similar results in their study that professional development of teachers highly mainly contributes in the content knowledge of teachers and pedagogical competency in mathematics subject at elementary school level. In overall, all the previous studies are in line with the given study and endorsed the idea that all the content matter knowledge and pedagogical skills can be improved and maximized through arranging the professional development trainings.

## **Conclusion**

The study investigated the effect of professional development training on the teachers' content-based knowledge in mathematics subject through using an experimental approach. The study revealed that achievement scores in post-test were better than pre-test for the teachers' content-based knowledge in mathematics subject and significant difference in achievement scores of pre-test and post-test for teachers' content-based knowledge in mathematics subject was also found which confirmed that professional development training affected the teachers' content-based knowledge in mathematics subject at primary school level.

## **Recommendations**

The study revealed the difference in achievement scores of pre-test and post-test in the teachers' content-based knowledge in mathematics subject, therefore the study recommended to conduct professional development trainings for primary school teachers on regular basis to enhance and update teachers' content-based knowledge in mathematics subject that are most required to achieve the targets about the provision of quality education. Further, the study also asked to policy makers and district authorities to make arrangements for these trainings of teachers to develop the content-based knowledge in mathematics subject at primary level.

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