The Influence of Teachers' Mathematics Pedagogy Content Knowledge Training on Pupils' Mathematics Achievement

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Abstract The study aimed to determine the subject matter knowledge (SMK) of Grade-V Mathematics teachers and the influence of teachers’ Mathematics Pedagogy Content Knowledge (MPCK) training on their pupils’ achievement. It used a quantitative and qualitative method of research to address the low performance of pupils in national and local assessments. The study was done in Camiguin among 40 teachers and 825 pupils who were randomly chosen. A teacher made test to assess the teachers’ SMK and pupils’ achievement with reliability of .95 and open-ended test to assess teachers’ MPCK with reliability coefficient of .80. This test was given as pretest before teachers’ training and posttest after training. Interview was done for triangulation. After analysis of the data the result revealed that the experimental group of teachers has significantly higher MPCK than those without training and pupils’ achievement score is significantly higher than pupils under the teacher without training. The researchers recommend that teachers MPCK training be done to improve pupils achievement and teacher-training institutions should include MPCK in the curriculum.

Keywords: subject matter knowledge, mathematics pedagogy content knowledge, achievement


1. Introduction

Mathematics is part of life and is used by every one every day. It is also recognized as one of the important tools of science and technology. The Second International Mathematics Study (SIMS) in 1989 have pointed out that knowledge of mathematical concepts and techniques is indispensable in commerce, engineering and the sciences. However, in spite of the cognizance of the usefulness of mathematics, many people have not learned to love the subject because they find it difficult. This feeling of difficulty may not be related to pupils’ mathematical intelligence. They may possess the potential to learn more than what they are achieving, but their deficiency in computational and mathematical reasoning skills may be attributed to their mathematical anxieties, attitudes and behavioral patterns related to their past learning experiences.

Results of the Trends of International Mathematics and Science Study [9], national, regional, division and school examinations support the perception that a good number of pupils are confronted with varying degrees of difficulty in mathematics. In this regard, the National Council of Teachers in Mathematics [5] has challenged the teachers to be more effective, to understand deeply the mathematics they are teaching, and to be able to share that knowledge with flexibility in their teaching tasks. Mathematics teachers are expected to have mastered the competency of the content and skills to be taught including the appropriate process or strategies to be employed. Teacher’s mathematical knowledge is indeed a very important factor that helps how mathematics is taught. However, the concept of Pedagogical Content Knowledge (PCK) as defined by Shulman [7]; Hill et al, [2] and Hill, [4], they said PCK is also equally important.

Shulman [7] further said that mathematical content knowledge and pedagogical content knowledge are integral parts of effective mathematics instruction. In order to construct mathematical concepts in pupils’ mind, PCK as well as mathematical content knowledge is necessary. Teachers need Mathematics pedagogy content knowledge (MPCK) appropriate to specific content to facilitate learning; how to motivate; how to organize a classroom and how to plan a lesson. Niess [6] also said that to be prepared to teach mathematics, teachers need an in-depth understanding of mathematics (the content), teaching and learning process (the pedagogy) and technology. Clearly, teachers play a critical role in the pupils’ learning process; hence, it is in this context that the researchers were prompted to investigate the extent of influence of teachers’ Subject Matter Knowledge (SMK) and Mathematics Pedagogy Content Knowledge (MPCK) training on pupils’ performance. The result would be the
strong basis for intervention and further professional development in Camiguin.

2. The Method

This study used quantitative and qualitative methods of research. The qualitative part assessed the teacher’s ability to evaluate the pupils’ misconceptions, possible reasons for the misconception, create a solution to remove misconception and ask appropriate question to reveal misconceptions. The subjects of the study were the 40 grade V mathematics teachers with their respective 825 pupils in public elementary schools during the school year 2009-2010. They were randomly chosen from all the 54 teacher participants of the seminar workshop on mathematics in the province of Camiguin. Two instruments were used in this study namely; a 36-item teacher-made test to determine teachers’ Subject Matter Knowledge (SMK) and pupils’ performance and six open-ended problems on Mathematics Pedagogy Content Knowledge (MPCK). The topics included in the seminar workshop in the training of teachers how to apply appropriate pedagogy were fractions, decimal numbers, ratio, proportion and percentage. The features of the training includes how to teach a particular topic with an appropriate strategy, how to establish knowledge of pupils typical errors and misconceptions, knowledge of best and appropriate method of representing particular subject matter, knowledge how to assist pupils how to correct their misconceptions and knowledge how to arrive at correct answers.

The mathematics supervisor conducted a one week seminar workshop and at the start of the workshop, the participants were given pretest with the MPCK and SMK two groups the experimental and control using stratified instruments. The teacher participants were divided into two groups the experimental and control using stratified random sampling based on their MPCK results. The corresponding pupils of the randomly chosen teachers were also given pretest. The experimental groups of teachers with their respective school heads were included in the training-workshop on curriculum, content, pedagogy and technology to improve their MPCK. During the MPCK intervention training workshop, the supervisor presented a wrong solution of a problem in fraction done by a pupil in a test. The teachers were asked to identify what concept was wrongly interpreted and what process was used by the pupil to arrive the answer. After identifying, the supervisor discussed the processes that were not appropriately done and illustrated how to correct the wrong concept and process of the pupil. She showed a model to go about the appropriate approach to promote conceptual understanding. For example in adding dissimilar fractions, she showed a cut colored paper representing the given fractions. She required the teachers to explain and interpret the meaning of the fractions given and to determine the relationships. With the used of the cut colored papers, the groups were required to discuss among themselves what to do to make the denominators the same before they added the fractions to emphasize the concept and processes. Later they were asked to use actual objects like cutting cakes of similar size but cut into different parts to make an actual application. When the units of the given problem are different, appropriate pedagogy was again illustrated in the training until all topics included were covered.

To follow-up whether the teachers implemented the strategies and lessons learned from the training-workshop, the researchers conducted monitoring and supervision through classroom observations and interviews. At the end of the experimental period, both groups of teachers were given posttest of MPCK. The pupils were also given posttest on the teacher-made test after the third grading period. The data gathered were analyzed quantitatively using analysis of covariance (ANCOVA).

3. Results and Discussions

The results of the analysis are shown in the following tables.

Table 1 shows the mean and standard deviation of the pretest and posttest scores of pupils’ achievement test.

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest Mean</td>
<td>8.69</td>
<td>8.81</td>
</tr>
<tr>
<td>Posttest Mean</td>
<td>15.22</td>
<td>10.39</td>
</tr>
<tr>
<td>Sd</td>
<td>3.22</td>
<td>4.71</td>
</tr>
<tr>
<td>Adjusted Mean Squares</td>
<td>246</td>
<td>14.94</td>
</tr>
<tr>
<td>F Computed</td>
<td>14.94</td>
<td>0.002*</td>
</tr>
<tr>
<td>Prob.</td>
<td>0.002*</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 shows the results of the analysis of covariance of the pupils’ pretest and posttest achievement. The result revealed that there is a significant difference in the pupils’ achievement scores as shown in the computed F-ratio of 14.94 with probability value of 0.002 which is less than .05. This means that in the experimental group, the
pupils who were taught by teachers with MPCK training has better achievement than those who were taught by teachers with no training. It also means that the posttest score of pupils under the teacher with training which is 15.22 is significantly higher than the pupils’ score of 10.39 who were taught by teachers without training. This implies that training-workshop on MPCK done with close supervision and follow-up is an effective way to improve teachers’ effectiveness in teaching.

Table 3. Mean and Standard Deviation of pretest and posttest scores of Teachers’ MPCK

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Adjusted Mean Squares</th>
<th>F Computed</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Between</td>
<td>547.76</td>
<td>1</td>
<td>547.76</td>
<td>36.15</td>
<td>.01*</td>
</tr>
<tr>
<td>Error Within</td>
<td>560.70</td>
<td>37</td>
<td>15.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1108.46</td>
<td>38</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at .05 level.

Table 4 shows the result of the analysis of covariance of the teachers’ pretest and posttest MPCK scores. The analysis yields a computed F-ratio of 36.15 with a probability value of .01 which is less than the critical value at 0.05 level. This means that the MPCK scores of teachers who underwent training was significantly better compared to the teachers who did not undergo training. This result is consistent with the finding of Cohen [1] who claimed that an intervention program for professional development (in-service training course) contributed to a shift in the teachers’ beliefs, knowledge and behavior. It also constituted a turning point in their professional development and caused a perpetual change in their goals, teaching methods and evaluation of the topic discussed. Teachers reported a change in beliefs and knowledge in each of the elements of MPCK through the re-orientation towards the topic and pupils. This result implies that when massive training in MPCK will be done, it is possible that the teaching style would be changed from the traditional way of teaching to help the implementation of giving emphasis on conceptual understanding.

Table 5. Correlation of Pupils’ Performance with Teachers’ SMK and MPCK

Table 5 shows the simple regression analysis done to determine if teacher respondents’ SMK and MPCK had influenced pupils’ performance. The results shown in Table 5 reveals that MPCK has contributed to the achievement of the pupils as evidenced by the correlation coefficient of .53 with a t-value of 2.65 and a probability value of .02 which is significant at .05 level. This means that MPCK has significant influence on pupils’ achievement. It implies that teachers’ MPCK is a good predictor of pupils’ achievement in mathematics. It can be seen on the same Table 5 that teachers’ subject matter knowledge has little relation to pupils’ achievement gains as evidenced by the correlation coefficient of 0.3 with a t-value of 1.33 and a probability value of .06 which is not significant. This means that although subject matter knowledge is necessary but is not sufficient to influence pupils’ performance. It implies that teachers’ subject matter knowledge in mathematics has contributed in their teaching to help pupils learn but not as effective when appropriate pedagogy is applied. This finding is consistent with the research of Wong and Lai [11] on “Exploring factors affecting mathematics effectiveness among pre-service primary mathematics student-teachers” which revealed that Mathematics Pedagogy Content Knowledge (MPCK) is the crucial factor that leads to effective mathematics teaching. Some teachers could solve problem and demonstrate the procedure but could not explain why the procedure is mathematically correct or why it is not applicable in some situation and not in other problems. This implies that the teacher might have learned the mathematical concepts but do not know how to use it in their teaching to help pupils understand. They might have limited knowledge on the different strategies or methods in teaching that help develop the conceptual understanding of pupils. Maybe they lack perspective, empathy and self-knowledge that is why their MPCK is not enhanced.

Table 6 shows the correlation of teachers’ subject matter knowledge and Mathematics Pedagogy Content Knowledge. The results reveal that teachers’ SMK has relationship with MPCK as shown in the correlation coefficient of 0.427 with a t-value of 2.9. This is evident in the probability value of 0.01. This means that teachers’ subject matter knowledge is a good predictor of their Mathematics pedagogy content knowledge. This implies
that if the teachers are competent in the subject matter, they can be competent in pedagogy if they have undergone appropriate training; hence, it is necessary that for effective instruction, teachers must be good both in subject matter knowledge and Mathematics pedagogy content knowledge. In addition, the information from classroom observations and teachers’ interviews revealed that teachers heavily depend on mathematics textbooks in classroom teaching. Majority of the teachers are more likely to incorporate mathematical difficulties. Most teachers have their pupils engage in drills and repetitive practice as an alternative method for mathematical instructions without focus on the conceptual understanding of the pupils. Furthermore the experimental group of teacher said that in most in-service training they undertook, it deals only the idea how to teach, but in the MPCK training they learn how to identify typical errors and misconceptions of pupils, the best method of representing the particular subject matter, how to assist pupils to correct their misconceptions and additional knowledge how to arrive at correct answer in given mathematical task on their level.

4. Conclusions and Recommendation

Based on the analysis it can be inferred that teachers’ MPCK training has a great influence on pupils’ performance. The researchers therefore recommend that mathematics teachers and their respective school heads should undergo more trainings and seminars on curriculum, content, pedagogy and technology to improve their MPCK. Education supervisors and school heads should continue to conduct in-service trainings to improve the MPCK for all mathematics teachers. They should provide technical assistance to their teachers and do close monitoring and supervision to ensure that strategies and lessons learned from seminar -workshops be properly implemented. Moreover, teachers and administrators should be oriented with new standards of mathematics teaching set by the National Council for Teachers in Mathematics [5] as well as the Philippine Mathematics Standards to enhance instruction for better pupil performance. In addition, teachers in training institutions should incorporate Mathematics pedagogy content knowledge (MPCK) in their curriculum for mathematics major and the use of Understanding by Design (UbD) curriculum framework to enhance pupils’ conceptual understanding in mathematics.

References