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Exploring Factors Affecting Mathematics Teaching Effectiveness among Pre-Service Primary Mathematics Student-Teachers

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Abstract

This study investigated factors affecting mathematics teaching effectiveness among pre-service primary mathematics student-teachers. The sample consisted of twenty-four primary mathematics student-teachers, twelve take mathematics as their major subject and other twelve take mathematics as their minor subject in their Bachelor of Education programmes. Data sources were the Mathematics Teaching Supervision Form and post lesson interviews. This study found that Pedagogical Content Knowledge (PCK) is the crucial factor leads to effective mathematics teaching. However, it is surprising that Subject Content Knowledge (SCK) has no statistically relationship with Pedagogical Content Knowledge (PCK) and Teaching Effectiveness (TE). Besides, and surprisingly, mathematics minor student-teachers had better PCK than mathematics major student-teachers. The result indicated that female student-teachers taught better than male student-teachers. The supervisions also indicated that female student-teachers' instructional strategies were more creative and well designed than male student-teachers.

Keywords: Pre-service teacher education, Teaching effectiveness, Mathematics

1. Background of the Study

1.1 What factors would affect mathematics teachers' teaching effectiveness?

When we talk about a mathematics teacher's quality in teaching mathematics, most people would take teachers' mathematics achievement as a correlated variable, which would relate to teachers' teaching competency.

1.2 What does mathematics teacher's mathematics achievement define?

In Schofield (1981), Shulman (1987) and Ball(1991)'s papers, they took subject-matter knowledge as mathematics teacher's mathematics achievement. Thus, subject-matter knowledge is considered as a measurable performance indicator for assessing teachers' mathematics achievement. In the past decade, teacher's subject-matter knowledge was measured by the scores achieved on standardized tests, by number of academic modules, by number of courses taken in university (Ball, 1991; Shulman, 1987). In Hong Kong, most educators have the same view on taking mathematics subject-matter knowledge as mathematics teacher's mathematics achievement. But these quantitative measures do not represent the teacher's entire knowledge of subject matter, especially in the teaching profession, since subject matter knowledge also includes pedagogical content knowledge.

1.3 What does mathematics teacher's pedagogical content knowledge define?

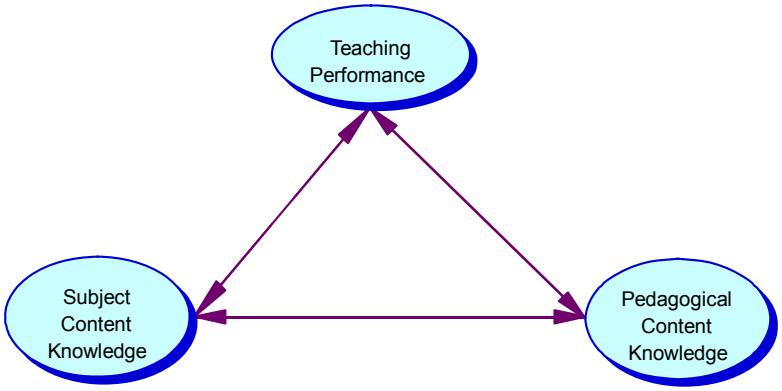
In recent years, pedagogical content knowledge has been considered as another category of teacher's subject-matter-knowledge. Ball (1991) and Shulman (1986) feel that this kind of knowledge can be described as knowing the ways of representing and formulating the subject matter and making it comprehensible to students. As teachers' instructional devices influence the process of learning, it is therefore important to understand how teachers explain mathematics knowledge to students, what they emphasize and what they do not; and what methods they choose to help students understand. Although many researchers assumed that teachers' pedagogical content knowledge is influenced by their subject–matter knowledge (Ball, 1991; Shulman, 1986), the interrelationship between the two is not clear enough. Up to the present, there still has been very little research, especially in Hong Kong, studying this correlation among mathematics teachers. Therefore, there are strong rationales to support the researcher to investigate their relation in the Hong Kong context. As most teachers consider pedagogical content knowledge as another category of teacher's subject-matter knowledge, in order to make the difference between pedagogical content knowledge (PCK) and subject-matter knowledge (academic) more unambiguous, in this study, the subject-matter knowledge (academic) is replaced by the new term, Subject Content Knowledge (SCK).

2. Objectives of the study and statements of the problem

The purpose of this research was to explore the relationships among pre-service mathematics teachers' mathematics Subject Content Knowledge (SCK), Pedagogical Content Knowledge (PCK) and Teaching Effectiveness (TE) in teaching primary mathematics.

The framework is mainly based on a quantitative analysis of student teachers' TP performance, SCK and PCK. Figure 1 explains the main things to be studied and the assumed relationships among the factors of SCK and PCK with student teachers' teaching performance.

FIGURE 1 THE FRAMEWORK FOR THE STUDY



More specifically, this study addresses the question, what essential mathematics knowledge should a competent primary mathematics teacher have? Within this context, the researcher is also interested to find out whether differences exist across teachers' gender.

2.1 Research Questions

Thus the primary research question is: What are the effects of Subject Content Knowledge (SCK) and Pedagogical Content Knowledge on student teachers' teaching performance in primary mathematics teaching.

The related research questions are:

1. Does primary mathematics teachers' subject content knowledge interrelate with their pedagogical content knowledge?
2. Does teaching performance correlate with subject-matter knowledge and pedagogical content knowledge?
3. Do these relationships vary across gender?

The above-mentioned questions form the basis of the study. Results are then used as a basis for a discussion of directions which student teacher training may consider with the aim of improving student teachers' mathematics teaching effectiveness.

3. Method

This study is mainly a quantitative research. A quantitatively based survey was conducted first in order to collect data about samples' subject content knowledge achievement (SCK) by using questionnaire and then followed by teaching practice (TP) supervision for collecting data about samples' TP performance and pedagogical content knowledge (PCK) levels. Thus, there are two stages: survey and teaching practice supervision.

3.1 Subjects

The participants in the survey were 24 student teachers, all studying in the Hong Kong Institute of Education (HKIEd). Among them, 12 take mathematics as their major subject and other 12 take mathematics as their minor subject in their 4-year Bachelor of Education Programme.

The mathematics major student teachers are training to be specialist mathematics teachers in the primary school stream and around half of them have the Advance-Level or AS- Level mathematics pass. In contrast, the mathematics minor student teachers are training to teach mathematics but not considered at the specialist mathematics teachers as they haven't got enough module-credits to be registered as specialist mathematics teachers. Unfortunately, most mathematics minor students didn't get any A-level or AS-level mathematics pass; most of them left school with only a ordinary level mathematics pass. Since the purpose of this study is mainly to investigate student teachers' relationships among SCK, PCK, and TP effectiveness (TE) and also because of time and TP supervision constrains, the subjects of the case studies are only 24 student teachers. They are evenly scattered between two programmes. Details of group distribution appear in Table 1.

Table 1 Group Distributions in Stage 1

Courses / Year	4-Yr Full-time BEd (Mathematics Major)		4-Yr Full-time BEd (Mathematics Minor)	
	Male	Female	Male	Female
Year 3	3	3	3	3
Year 4	3	3	3	3

3.2 The Instruments Used in the Study

The design of this study is mainly quantitative. It includes:

- Survey: using questionnaire to collect samples' background information and their SCK achievement.

Case study: including direct TP observation and post TP discussion for the purpose of collecting samples' PCK level and also assessing their TE.

3.2.1Survey

The survey for collecting samples' background information and achievement of SCK was conducted by using questionnaire.

The questionnaire includes some information about age, sex, Mathematics Major or Minor in the enrolled programmes and also the highest level of mathematics in public examinations that the respondents achieved before entering the Hong Kong Institute of Education. This information provides an overview of the respondents' background.

The questionnaire is enclosed as appendix 1.

3.2.2 Teaching Practice (TP) Supervision and Post TP Conferencing

As described earlier, this study has two phases. The first phase aims at getting a general picture of the student teachers' subject content knowledge (SCK) in mathematics. The second phase aims at clarifying student teachers' pedagogical content knowledge (PCK) and also getting assessment result on student teachers' teaching practice effectiveness (TE). These data are collected via teaching practice observation and post TP discussion.

The teaching practice appraisal form is enclosed as appendix 2.

In the study, 24 student teachers were invited to be supervised by the researcher across two academic years, 2002-2004. The researcher had observed their teaching twice during teaching practicum (TP) and met them twice in the post TP discussion. Among 24 student teachers, some were classified as high achievers in mathematics and the others were classified as low achievers by their SCK in mathematics in public examination or equivalent.

Post-TP Discussion

After the lesson supervision, the supervisor should share the collected data with the student. He / she should analyze the data, diagnose mistakes and make plans for the next observation. The student should be encouraged to share the opinions and feelings aroused by the supervisor's comment. The supervisor may give the student opportunity to practice specific behavior and suggested teaching strategies, including teaching devices and aids in teaching particular mathematics topics or concepts in the next observation. Thus the aim of the post TP discussion is to improve the student teacher's PCK in primary mathematics teaching, to overcome his or her mistakes, to improve his / her competency in primary mathematics teaching.

The term observation in this study refers to any objective procedure for recording the lesson planning and teaching performance of the subjects. Relevant data were collected by two instruments:

1. **teaching practice appraisal forms** for direct observation and
2. **lesson plans**.

During supervision, the researcher observed and assessed the student teacher's teaching performance and also his / her PCK. In addition, the researcher also used the teaching practice appraisal form to ascertain the student teachers' teaching effectiveness.

3.3 Methods of Analyzing Data

To analyze the quantitative data, the statistical software SPSS was used on a personal computer. The Pearson Product-moment Correlation, t-tests, Cross-tabulation Correlation of Ordinal Variables and ANOVA were carried out using SPSS.

There were two background information variables collected in part 1 of the questionnaire. The first variable is the student teachers' achievement in mathematics. What is the level of their highest mathematics study while at secondary school?
Another background variable is they are enrolled as either mathematics major or minor. The level of their highest mathematics study is used to define their achievements in mathematics, their levels of subject content knowledge (SCK). Those student teachers who had studied mathematics at tertiary level or had passed either A-level or AS-level mathematics were classified as students with high achievement in mathematics, with sound subject content knowledge (SCK). While those student teachers who only had school certificate mathematics passed were classified as students with fair achievement in math, fair in SCK. For overseas students, if they had any recognized equivalent mathematics qualification, this was considered to be valid and classified by the same standard.

Data collected from the teaching practice appraisal form was used to assess students' PCK levels and their overall teaching performance during teaching practice. For each assessing item, such as Lesson Planning, Selection and Use of Resources etc (in total there are 18 items.), three assessment grades would be offered. They were: distinction, pass and fail. Those grades would be converted into scores 3, 2 and 1 respectively. Normally, in the HKIEd, only one overall rating of teaching practice performance

would be offered to student teachers, graded as distinction, pass or fail. Those grades would be converted into scores, 3, 2 and 1 respectively. However, for this research, TP achievements were categorized into 5 bands instead of the original 3 grades. This is because in the past few years of TP supervisions, more than 85% student teachers obtained the pass grade, only very few students were assessed to be failing or getting a distinction in their TP. Thus, if we use the 3-point scale to assess their overall TP performance, it would limit the ability to discriminate or rank their mathematics teaching achievements.

Generally speaking, student teachers' SCK, PCK, IAT and TE were compared between different sub-groups by use of the t-test. In addition, Pearson's correlation coefficients were calculated by using SPSS to investigate the relationships among these factors.

4. Results

4.1 Results Regarding Achievements in Math

From the analysis of their background subject knowledge, we can discover that the percentage distribution of mathematics high achievers (MHA) in Mathematics minor group is severely small as compared with mathematics major group. There are only around 33% students in mathematics minor group are categorized as MHA. However, for mathematics major group, all students (100%) passed either A-level or AS-level math, and all are categorized as MHA. This is because at least an AS-level pass in mathematics is required for admission to be a mathematics major student in the BEd programme. The subjects of the case studies are 24 student teachers only. They are evenly scattered between programmes years, major and minor enrollments and gender. The details of these distributions are displayed in Table 2.

Courses / Year	4-Yr Full-time BEd (Mathematics Major)		4-Yr Full-time BEd (Mathematics Minor)	
	Male	Female	Male	Female
Achievement in Mathematics(SCK)	MHA (MLA)	MHA (MLA)	MHA (MLA)	MHA (MLA)
Year 3	3 (0)	3 (0)	2 (1)	2 (1)
Year 4	3 (0)	3 (0)	2 (1)	2 (1)

Table 2 Achievement (SCK) in Mathematics Distributions

The other type of achievement in mathematics is defined as Pedagogical Content Knowledge (PCK), which is described as **" knowing the ways of representing and formulating the subject matter that make it comprehensible to students as well as understanding what makes the learning of specific topics easy or difficult" (Even, 1993, P. 94).** This measure

focuses on a student teacher's lesson planning and presentation of his or her teaching. In this study, this type of achievement (PCK) was mainly measured by summing a subject's scores achieved in the specified items in their teaching practice appraisal form. Details of items related to PCK in the teaching practice appraisal form are listed in Table 3.

Planning and Evaluation	**Management and Instruction**	**Communication**
Lesson Planning	Selection and Use of Resources	Verbal Communication
Teaching and Learning Strategies	Sequencing of learning Activities	Non-verbal Communication
	Design of Learning Environment	Use of Media

Table 3 Items for measuring sample's PCK

Each item's result was graded as distinction, pass or fail. These grades were then translated into 3, 2 and 1 respectively and the total scores were classified into five bands by using the following grade descriptors (neutral score is 16, min. score is 8 and max. score is 24):

A(5): greater than 20 **B(4)**: 18-20 **C(3)**: 15-17 **D(2)**: 12-14

E(1): less than 12

These numeric results were then used for the statistical analysis with student teacher's SCK and TP performance in Teaching Math.

4.2 The mean scores for the Pedagogical Content Knowledge (PCK)

The mean scores for the Pedagogical Content Knowledge (PCK) categorized by year of study and Major or Minor enrolled are shown in Table 4.

Major or Minor	**Year of Study**	**Pedagogical Content Knowledge (PCK) Mean**
Major	Year 3	2.75
	Year 4	3.25
Minor	Year 3	2.88
	Year 4	3.75

Table 4 Pedagogical Content Knowledge (PCK) Mean Distribution

At a first glance, the researcher found that student teachers achieved better and better

in PCK as they are promoted year by year. As can be seen in the table, the mean scores for the Pedagogical Content Knowledge (PCK) increased from the third year to fourth year for both Mathematics Major and Mathematics Minor students respectively. Students in the higher year seemed to have much better results in PCK than those in lower years (mean scores of 3.25 versus 2.75 for mathematics major Year 4 and Year 3 students; mean scores of 3.75 versus 2.88 for Year 4 and Year 3 for mathematics minor students). It indicates that student teachers' PCK is improved year by year.

4.3 Relationship between SCK and PCK

To explain the relationship between subject content knowledge (SCK) and pedagogical content knowledge (PCK), the Pearson Correlation Coefficient was used to find out whether significant correlations existed between SCK and PCK. Table 5 contains the Pearson Correlation Coefficients for each sample of student teachers between subject content knowledge (SCK) and pedagogical content knowledge (PCK) related to their course taken.

	Subject groups (Major or minor and major + minor)	**Pedagogical Content Knowledge (PCK)**	**Significance (2-tailed)**
Subject Content Knowledge (SCK)	Mathematics major students	0.083	0.759
	Mathematics minor students	-0.054	0.843
	Mathematics major students and Mathematics minor students	0.023	0.495

Table 5 Correlations between Subject Content Knowledge (SCK) and Pedagogical Content Knowledge (PCK)

As shown in the table, no positive associations existed in the Mathematics major students group ($r = 0.083$), and also no relationship is found in the Mathematics minor students group ($r = -0.054$). Even when the correlation between Subject Content Knowledge (SCK) and Pedagogical Content Knowledge (PCK) was calculated without the effect of the elective enrollments (major or minor), the relationship was still less strong, and could be considered as nearly independent ($r = 0.023$). If we plot *SCK* and *PCK* on the graph, the points are randomly scattered. Thus the relationship between achievement SCK and achievement PCK in mathematics was considerably

less strong, virtually non-existent.

4.4 The mean scores for Teaching Practice (TP) performance

Since the Teaching Practice (TP) performance was assessed via teaching practice observation. As a pilot research, the sample size could only be 24. In order to make it be valid in this analysis, their means were categorized by mathematics major and minor groups only.

Both students groups (Mathematics major and Mathematics minor) had the same mean in teaching practice supervisions (mean score was 3.00 with S.D. equals 0.97 and mean score was 3.00 with S.D. equals 1.10 for Mathematics Minor group and Mathematics Major group respectively). Therefore no differences TP in results are found between Mathematics Minor and Major groups.

4.5 Gender and Achievement Results

The student teachers' scores in SCK and PCK in mathematics were further examined to determine whether gender differences exist in Mathematics Minor and Major groups. The results of t-tests are shown in Tables 6 and Table 7.

Groups	Pedagogical Content Knowledge (PCK) Mean	Mean Male (Female)	t-test Value	Significance (2-tailed)
Mathematics Major	**Males with Females**	1.57 (4.11)	-5.791	0.000*
Mathematics Minor	**Males with Females**	3.13 (3.50)	-0.614	0.549

Table 6 t-test results examining the gender difference on PCK achievement

As can be seen in Table 6, there was only a small difference between the mean scores of mathematics minor males and females (mean scores were 3.13 and 3.50 for males and females respectively, and t = -0.614). On the other hand, it is surprising that the females in mathematics major group performed much better than males on PCK achievement, the mean scores for males and females being 1.57 and 4.11 respectively, and t-value equals -5.791. There is no doubt that a strong significant difference existed between males and females in the mathematics major group in their PCK achievement. This phenomenon could be explained by a general tendency on the part of female student teachers, who paid more efforts to preparing their lessons and creating more appropriate teaching aids. Besides, female teachers are perhaps more

willing than male teachers to change their presentation and speaking style to be closer to children's ways of speaking and build up closer relationship with their pupils.

Groups	Subject Content Knowledge (SCK) Mean	t-test Value	Significance (2-tailed)
Mathematics Major	**Males with Females**	0.475	0.642
Mathematics Minor	**Males with Females**	0.966	0.350

Table 7 t-test results examining the gender difference on SCK achievement

Table 7 presents the details of the results, comparing males and females on their subject mathematics content knowledge (SCK) none of which was statistically significant at the 0.05 level. In other words, there was no gender difference found in student teachers' mathematics academic achievement.

5. Findings

Numerous positive and negative findings emerged in the study. For the purposes of drawing conclusions from these findings and of providing answers to the research questions, these findings are summarized as follows.

5.1 Pedagogical Content Knowledge (PCK)

Surprisingly, by the results of measuring student teachers' lesson planning and presentation of his or her teaching in TP, mathematics minor students were found to have better PCK than mathematics major students. On the whole, student teachers in the higher years of study have much better results in PCK than those in lower years. This suggests that student teachers' PCK is improved year by year.

5.2 Relationship between SCK and PCK

No significant relationships were found between subject content knowledge and pedagogical content knowledge among mathematics major and mathematics minor student teachers. Even when the correlation between SCK and PCK was calculated irrespective of the major or minor in math, the relationship was still less weak, and nearly could be considered as independent.

5.3 Gender Difference in PCK

Among mathematics minor student teachers, although the difference is not statistically significant, females did better than males in achieving PCK scores in their

TP teaching. However, for mathematics major student teachers, a strong significant difference existed between males and females in their PCK achievements. The females performed much better than males on PCK achievement. On the whole, females did better than males on presenting mathematics content in their mathematics teachings.

5.4 Gender Difference in SCK Achievement

There was no gender difference in student teachers' mathematics subject content knowledge in all sample groups (all student teachers, major and minor student teachers).

5.5 Inter-correlations among TP Performance, PCK and SCK

No statistically significant differences in teaching practice results were found between mathematics minor and major students. However, there were statistically significant correlations found between teaching practice performance and students' pedagogical content knowledge. They are highly, positively, correlated. Lastly, it is more important to note that no significant relationship was found between teaching practice performance and subject content knowledge.

6. Discussions and Conclusion

The primary research question is: What are the effects of Subject Content Knowledge (SCK) and Pedagogical Content Knowledge (PCK) on student teachers' teaching performance in mathematics? As stated by Noddings (1990) and Confrey (1990) the mathematics teacher's main function is to establish mathematical learning environments that encourage students to explore and raise questions in their studying. They claim that when doing so, teachers' pedagogical content knowledge, which includes questions they ask, activities they design, teaching aids they use and student's suggestions they follow, are based on their subject content knowledge. Thus they feel that an important initial step in improving mathematics teaching should be better subject content knowledge preparation for mathematics teachers. Thus many researchers assumed that subject content knowledge and pedagogical content knowledge should be positively correlated with mathematics teaching performance and pedagogical content knowledge is influenced by subject content knowledge (Ball, 1991; Confrey, 1990; Noddings, 1990 and Shulman, 1986). Although this study found that pedagogical content knowledge (PCK) has strong positive relationship with student's performance in mathematics teaching, no significant effect was found from subject content knowledge (SCK) on teaching practice performance. In addition, it is surprising that PCK is not correlated with SCK. In the study, Mathematics Major students were found to have much better SCK than Mathematics Minor students but

Mathematics Minor students were found to have better PCK than Mathematics Major students and no statistically significant differences in teaching practice performance were found between Mathematics Minor students and Mathematics Major students. Thus it is unrealistic to expect all good in mathematics subject-matter teachers to be good in primary mathematics teaching and also have much better primary mathematics PCK.

Figure 2 explains the interrelation among these variables: subject content knowledge (SCK), pedagogical content knowledge (PCK) and the teaching performance with respect to mathematics.

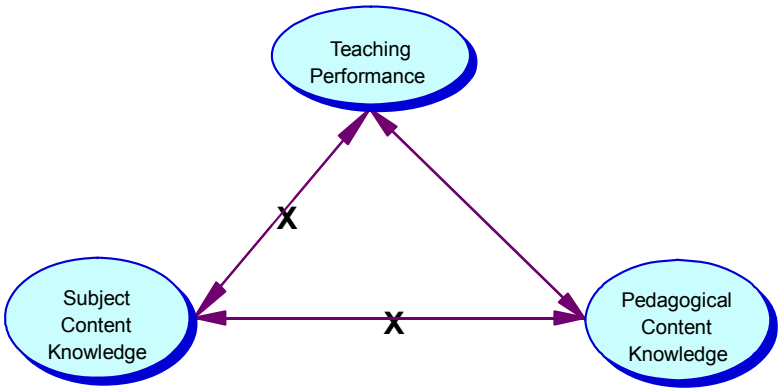


FIGURE 2 INTER- RELATION AMONG SCK, PCK AND THE TEACHING PERFORMANCE

Findings only relate to the primary mathematics stream

However, it should be noted that these findings only relate to the primary mathematics stream, and even those student teachers who are categorized as mathematics low achievers, they still have passed ordinary level mathematics. This implies that the minimum requirement of holding an ordinary level mathematics pass for enrolling as mathematics minor students is still acceptable in Hong Kong. It doesn't imply that student teachers with mathematics subject content knowledge below ordinary level are still capable to be enrolled as mathematics student teachers. Therefore for secondary mathematics teaching, as the mathematics knowledge being presented to students is more subject-specific, abstract and harder when compared with the knowledge being taught in primary mathematics lessons, further research is needed to re-test the hypotheses developed here again if the sample is changed from primary

student teachers to secondary student teachers. Once again, in Hong Kong primary mathematics teaching, the planning and preparation of lessons is commonly textbook oriented; all mathematics concepts presentation approaches and class practice exercises have already been planned and scheduled by the textbook authors. Primary teachers are encouraged to follow the teaching instructions suggested in the "Teacher Guide" to teach their pupils, self-designed supplementary worksheets or exercises are provided for pupils if necessary. It is extremely different from those countries where they advocate teaching by using self-tailored materials. For example, in Australian primary schools, there is no textbook; teachers prepare all teaching content and practical worksheets themselves. Therefore the requirement of SCK, PCK are absolutely different from Hong Kong. For this reason, even within the same stream, primary mathematics, further research is needed to examine teachers' SCK, PCK and their teaching competency once the research context is changed to be outside Hong Kong.

Gender and Programme Differences in PCK and SCK in Mathematics

In this study, the researcher also was concerned to establish whether gender and groups differences exist in PCK and SCK in mathematics. The study found that, regarding PCK, SCK achievements and mathematics teaching performance, among mathematics minor student teachers, females did slightly better than males in PCK. Among mathematics major student teachers, this difference was greater, the females performing much better than males in PCK score. Generally speaking, females did better than males on presenting mathematics content in their TP teaching but there was no statistical gender difference in SCK and TP teaching performance. By assessing their written lesson plans and self-made teaching aids, it is easy to discover that female student teachers had paid more efforts on these preparations. In addition, during teaching practice, the researcher also found that females are more patient to explain mathematics concepts to their pupils than males and they are also more willing than male student teachers to change their presentation and speaking style for the purposes of achieving better teaching effectiveness. From this study, one could see that the gender differences in achieving PCK truly existed. This gender difference in PCK might exert an effect on student teachers' teaching performance and eventually lead to gender difference in teaching competency. Are females born to be more suitable than males to teach in primary schools? This question cannot be answered here and it is not an objective in this study but it does need serious consideration and is worth further investigation.

In the present study, when comparisons were made between Mathematics Minor and

Mathematics Major students, one could see that mathematics major students had better previous subject content knowledge (SCK) than Mathematics Minor students, but it is surprising that Mathematics Minor students had better PCK than BEd student teachers in their TP. As PCK is found to be statistically correlated with teaching performance, general public hopes that Mathematics Major students would perform better than Mathematics Minor students is a logical expectation because Mathematics Major students have achieved better SCK in matriculation and also have been studying more academic mathematics modules than Mathematics Minor students in the HKIEd. However, this is not confirmed by the results of this research. As there are so many factors may cause to have this result, and it is not an objective in this study to find out the causes. Thus it does need serious consideration and is worth further investigation. However, PCK is found to be positively correlated with mathematics teaching performance, there are important implications for how the teacher-training institute and related lecturers design and provide appropriate modules and lectures for their student teachers. The program structure, the balance between subject knowledge modules (academic study modules) and pedagogical content modules (curriculum and teaching modules), should be reviewed. In addition, Thus some additional aims should be involved in some specific curriculum and teaching modules. They are

- To stimulate the student teacher's interest in acquiring pedagogical content knowledge (PCK);
- To develop the student teacher's ability in the use of teaching aids, language and activity in teaching mathematics concepts and skills.
- To promote the student teacher's powers of observation, diagnosis, analysis and judgment for the purpose to make him / her to have a deep understanding of their pupils' needs.

In this study, there are many other factors which would affect mathematics teaching performance which are not discussed in this study. For instance, the researcher also has interests concerning whether:

- the ratio of pupils to teacher is appropriate to a teacher's teaching approach;
- resources devoted to teachers are enough, cost-effective and efficiently used;
- schools and parents can cooperate with teacher's teaching; and
- schools and teachers can match with Government's educational reform.

In summary, on the basis of this study, the researcher agrees that pedagogical content

knowledge (PCK) in mathematics could affect teachers to teach mathematics effectively. This finding is coherent with previous studies. For examples, Ball (1991) and Even (1993) found that mathematics teachers' teaching performance is highly correlated with their achievement in mathematics. Besides, the researcher also found that teaching practice performance is also highly correlated with students' PCK. However, insignificant correlations were found between SCK and teaching performance. The analysis reveals that student teachers' teaching performance is not significantly affected by their SCK. In addition,, there are also no significant relationships found between student teacher' SCK and PCK. These distinctive findings are different from Ball (1991) and Shulman (1986)'s assumption that teacher's pedagogical content knowledge (PCK) is strongly influenced by their subject content knowledge (SCK). All these findings are worth further investigation for the purpose of developing a series of recommendations for reforming the teacher training policy.

On the whole, the study has revealed PCK as an important factor that affect the teaching performance most. Once reviewing the collected data, there are two immediate issues that emerged from this finding. The first issue is that although student teachers' PCK is better than pass, they are just slightly above the minimum requirement; they are not as good as the researcher expected. The second issue is that due to insignificant correlation found between student teachers' SCK and PCK, it is risky to continue using student teachers' previous public examination results as the main factor for selecting student teachers in BEd programmes. As a consequence, revising the entrance requirement of teacher training courses, how to improve student teachers' PCK, restructuring teacher-training curriculum become major issues in mathematics teacher professionalism. In order to nurture our primary mathematics teachers with adequate PCK, the curriculum of present mathematics teacher training programmes should be revised. As stated before, some additional aims should be involved in some modules. For instance, because of the rapid growth of information technology (IT), IT is also being explored as a tool for improving education quality. Applying IT effectively in teaching should be considered as another Pedagogical Content Knowledge (PCK). Therefore, the objectives in the current primary mathematics teacher training programme can no longer meet the demands of the recent societal development, mathematics educators and institutions should provide updated knowledge and information on the recent development of mathematics education as well as affective factors and teaching strategies of mathematics so as to boost our teachers' professionalism.

Clearly the study of competency in mathematics teaching is a difficult and indefinable task. Although, in this study, the researcher has got a clear conclusion that PCK is positively correlated with mathematics teaching performance, there are still so many factors that might affect the performance of teaching. Moreover, although there no significant effect was found from SCK on teaching performance and Mathematics Minor student teachers got slightly better results in teaching practice than Mathematics Major student teachers, it doesn't imply that teachers without sufficient SCK can achieve sound PCK and can do the primary mathematics teaching well. By these findings, it only illuminates that the minimum subject requirement for BEd (primary) mathematics students should be revised to O-level pass. In this study even for those student teachers categorized as fair achievers in math, this doesn't mean that they are unknowledgeable in math, especially the relevant aspects of primary mathematics. There is no doubt that they are able to solve all relevant mathematics problems. Even students classified as fair achievers in math, all have passed O-level mathematics and even some of them had got credit or distinction in HKCEE mathematics. Besides, after entering the HKIEd, they still have the opportunity to study more mathematics. Therefore whether they can achieve more knowledge in both SCK and PCK in mathematics mainly depends on their learning attitude. Thus developing their learning attitudes and attitudes toward teaching become the major factors that affect the quality of our future primary mathematics teachers. On the whole, a competent mathematics teacher must be knowledgeable and with sound PCK about the subject they are teaching.

7. Recommendations

The implications derived from this study, although far from being conclusive, suggest certain directions for further investigation. It is recommended that the government should encourage teachers, schools, teacher training institutes, curriculum planners and even the textbook publishers to collaborate for the purposes of improving the effectiveness of teaching and improving teachers' teaching competency. For instance, all need to understand the importance of pedagogical content knowledge (PCK) in mathematics teaching. They need to design and provide appropriate programmes, modules for pre-service and in-service mathematics teachers to improve their PCK in mathematics teaching. Besides, schools and government should provide appropriate material support to teachers for improving the effectiveness of teaching. For example, teachers need resources in the form of teaching aids, reference books, professional journals and also the opportunities for further studies and attending relevant conferences and seminars for assisting them in the development of their PCK and these materials can also help them create ideal learning environments for their pupils.

In addition, seven specific recommendations arise from the previous discussion in relation to the training of mathematics student teachers, as follows:

1 Besides covering mathematical subject knowledge, curriculum and methodology, programmes for student teachers should include modules written for designing of / discussion on pedagogical content knowledge on specific mathematics concepts and skills. Thus, such modules may focus on the teaching and learning process on the selected topics of the five major primary mathematics streams: Number, Algebra, Shape & Space, Measures and Data Handling.

2 Within teacher training institutions, besides teaching practice, there should be another assessment mode for assessing student teachers' PCK for the purpose of motivating student teachers to increase their awareness of the importance of PCK and also to help them to achieve PCK. For instance, during some specific curriculum and methodology lessons, providing student teachers practical tests in which they are asked to explain the methodologies for teaching particular concepts either in writing or via verbal description. Besides, the current non-assessed pre-teaching practice micro-teaching is recommended to be assessed so that this hands-on activity, trial teaching and evaluation, will be enhanced considerably.

3 This investigation should be replicated with more year groups for BEd student teachers. It should involve all year groups of student teachers, so that we can reveal and investigate the development of PCK among student teachers more precisely.

4 It is recommended that similar research be replicated for kindergarten and secondary student teachers, full time kindergarten, primary and secondary teachers, and, in the Hong Kong context, with questionnaires written in Chinese if necessary.

In summary, the "Basic Competencies" of a primary mathematics teacher have been defined but these conclusions have been drawn within the limitations of this study and the instruments used. Because of the nature of the study and the emphasis on quantitative outcomes, the data is only analyzed by statistical testing. More precisely, a qualitative based, longitudinal study for measuring student teachers' PCK should be set up for further investigations. Case studies can be used as a follow-up investigation for deeper study of teachers' pedagogical content knowledge in mathematics.

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Appendix 1: Background information

Sex (Female or Male): _____

Age: _____

What mathematics elective are you enrolled in? (Major / minor):_____

Studying Year (Yr 3 / Yr 4)

Have you studied mathematics at tertiary level prior to enrolling in Hong Kong Institute of Education?

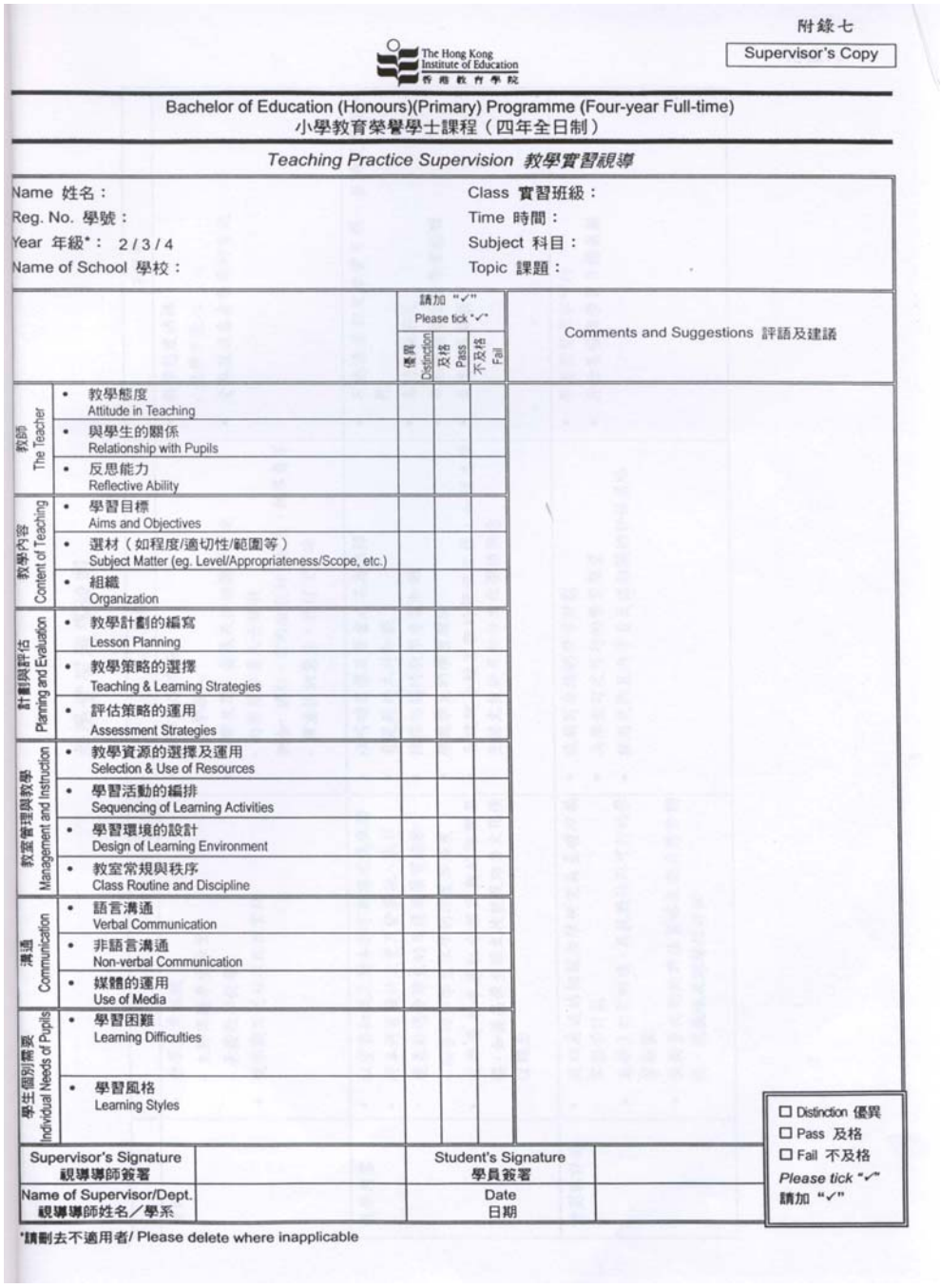
(Yes / No):_____ If so, please state._____

What was the highest level of mathematics **you passed** in public examination? (AL / ASL / SCL):_____

Current Mathematics Teaching Practicum Result (Distinction / Pass / Fail): _____

Your responses to this questionnaire are confidential, but it is necessary to have a unique identification code for a follow up survey. Please print your identity code (up to 6 digits). Don't forget this code, it will be used in the follow-up survey. I.D. Code: ( )

Appendix 2: TP Supervision Form Teaching



附錄七

Supervisor's Copy

The Hong Kong Institute of Education 香港教育學院

Bachelor of Education (Honours)(Primary) Programme (Four-year Full-time)
小學教育榮譽學士課程（四年全日制）

Teaching Practice Supervision 教學實習視導

Name 姓名：
Reg. No. 學號：
Year 年級*： 2 / 3 / 4
Name of School 學校：

Class 實習班級：
Time 時間：
Subject 科目：
Topic 課題：

		請加 "✓" Please tick "✓" 優異 Distinction	及格 Pass	不及格 Fail	Comments and Suggestions 評語及建議
教師 The Teacher	• 教學態度 Attitude in Teaching				
	• 與學生的關係 Relationship with Pupils				
	• 反思能力 Reflective Ability				
教學內容 Content of Teaching	• 學習目標 Aims and Objectives				
	• 選材（如程度/適切性/範圍等） Subject Matter (eg. Level/Appropriateness/Scope, etc.)				
	• 組織 Organization				
計劃與評估 Planning and Evaluation	• 教學計劃的編寫 Lesson Planning				
	• 教學策略的選擇 Teaching & Learning Strategies				
	• 評估策略的運用 Assessment Strategies				
教室管理與教學 Management and Instruction	• 教學資源的選擇及運用 Selection & Use of Resources				
	• 學習活動的編排 Sequencing of Learning Activities				
	• 學習環境的設計 Design of Learning Environment				
	• 教室常規與秩序 Class Routine and Discipline				
溝通 Communication	• 語言溝通 Verbal Communication				
	• 非語言溝通 Non-verbal Communication				
	• 媒體的運用 Use of Media				
學生個別需要 Individual Needs of Pupils	• 學習困難 Learning Difficulties				
	• 學習風格 Learning Styles				

☐ Distinction 優異
☐ Pass 及格
☐ Fail 不及格
Please tick "✓"
請加 "✓"

Supervisor's Signature 視導導師簽署		Student's Signature 學員簽署	
Name of Supervisor/Dept. 視導導師姓名／學系		Date 日期	

*請刪去不適用者/ Please delete where inapplicable