Journal of the Korean Society of Mathematical Education Series D:
Research in Mathematical Education
Vol. 16, No. 1, March 2012, 51–66

Impact of Entry-Level Mathematics Subject-matter Knowledge on Student Teachers' Mathematics Pedagogical Content Knowledge Development and their Mathematics Teaching Practice Performance[1]

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(Received February 6, 2012; Revised March 26, 2011; Accepted March 26, 2012)

This study investigated the impact of entry level of mathematics subject knowledge on student teachers' mathematics pedagogical content knowledge development and performance in mathematics teaching practice. The sample consisted of 24 mathematics student teachers, 12 of whom passed A-Level mathematics and 12 of whom only passed O-level mathematics. They were all studying in a 4-year bachelor of education (Honours/Primary) programme; they were either majoring or minoring in mathematics. Results showed that student teachers' entry-level mathematics subject knowledge is not related to their mathematics pedagogical content knowledge development or their mathematics teaching performance. These findings may lead society to consider whether student teachers who have passed O-level mathematics are already eligible to be trained as professional primary mathematics teachers. As a consequence, this study raises the issues of how to develop student teachers' mathematics pedagogical content knowledge and whether we need to restructure our bachelor of education (Primary) programmes' curriculum in teacher professionalism.

Keywords: entry level of mathematics subject knowledge, mathematics pedagogical content knowledge, mathematics teaching performance
MESC Classification: B50
MSC2010 Classification: 97B50

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[1] This paper will be presented at 2012 Spring Conference on Mathematics Education at Seoul National University, Gwanak-gu, Seoul 151-742, Korea; April 6–7, 2012.

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0. INTRODUCTION

When we talk of teacher quality, most people—even some primary school principals—take it for granted that teachers' mathematics subject-matter knowledge should correlate with teaching competency. For example, many primary school principals would like to use mathematics subject-matter knowledge as an important factor for selecting applicants to be their regular primary mathematics teachers. They would ask whether candidates have distinction grades or credit grades in standardized public mathematics examinations. Have they completed a pure-subject mathematics bachelor's programme? What honour did they get in their subject degree?

Schofield (1981), Shulman (1987), and Ball (1991) all measured achievement by measuring mathematics subject-matter knowledge. Thus, subject-matter knowledge has been considered a measurable performance indicator of teachers' mathematics achievement. In Hong Kong, most educators take the same view of primary school mathematics teacher's quality, but whether these quantitative measures can represent the entire knowledge that teachers use in their teachings. Of course, good subject-matter knowledge may reflect their professional knowledge growth, but we do not know whether subject-matter knowledge is a unique factor that helps mathematics teachers develop their mathematics teaching knowledge or whether it is absolutely correlated with mathematics teaching knowledge.

These are questions that we need to further investigate because we know that, although all primary mathematics student teachers have passed public mathematics examinations, most of them did not get top grades in mathematics. Many top students in mathematics may prefer to study other disciplines, such as medicine, business, finance, or engineering, rather than taking a teacher-education degree, especially in primary mathematics. Thus there have been whispers in our society recently questioning whether our mathematics student teacher graduates can teach primary mathematics effectively. With entry-level mathematics subject-matter knowledge (ELMSK) not at the top level, can they teach effectively?

That is why this study investigates whether ELMSK is a crucial factor for training student teachers to be effective primary mathematics teachers. Li (2010, 323–324) said,

> "Mathematics Pedagogical Content Knowledge (MPCK) is an important manifestation of a professional mathematics teacher. It is an important characteristic for distinguishing mathematics teachers from mathematicians and other subject teachers".

Yang (2010) also emphasized that MPCK is a crucial factor in determining whether primary mathematics teachers can help students learn mathematics effectively. It is because MPCK can reflect whether teachers can effectively use teaching aids in their **teach-**

ings, such as creating technology-based environments to help students develop their number sense and learning attitudes. Therefore, since MPCK reflects mathematics teachers' professionalism, it is necessary and essential for us to investigate whether ELMSK affects student teachers' MPCK development. Therefore, whether student teachers with better ELMSK have better mathematics teaching performance is also worth investigating.

1. LITERATURE REVIEW

How can we define MPCK? Is teachers' MPCK influenced by their mathematics subject-matter knowledge? In recent years, MPCK has been considered another category of teachers' mathematics subject knowledge in addition to mathematics subject-matter knowledge. Ball (1991) and Shulman (1986) argue that this kind of mathematics knowledge can be described as knowing how to represent and formulate mathematics subject matter and make it comprehensible to students. Since teachers' instructional devices influence the learning process, it is important to understand how teachers explain mathematics knowledge to students, what they emphasize, what they do not, and what methods they choose to help students understand. Although many researchers have assumed that subject-matter knowledge influences teachers' pedagogical content knowledge (PCK; Ball, 1991; Shulman, 1986), the relationship between the two is not clear enough. Up to now, there has been very little research, especially in Hong Kong, on the correlation among mathematics teachers. Do student teachers who have better ELMSK develop better MPCK and then have better mathematics teaching performance? All of these questions are worth studying.

2. OBJECTIVES AND FRAMEWORK OF THE STUDY

The purpose of this study was to explore the relationships among primary mathematics student teachers' ELMSK, MPCK, and mathematics teaching practice performance (MTPP).

The framework is mainly based on a quantitative analysis of received primary mathematics student teachers' ELMSK, MPCK, and MTPP. Figure 1 explains the hypothesis that most people have: ELMSK affects MPCK, and MPCK affects MTPP.

ELMSK → **MPCK** → **MTPP**

Figure 1. The framework for the study

More specifically, the major research question is: What are the effects of ELMSK on student teachers' MPCK development and MTPP? In order to answer this statistically, we elaborate the question into two research questions. In addition, this study also explores whether or not there are differences based on teacher gender.

1. Does primary mathematics teachers' ELMSK relate to their MPCK?
2. Does MTPP correlate with ELMSK and MPCK?
3. Do these relationships vary across gender?

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

3. RESEARCH DESIGN

This study is mainly quantitative. Student teachers first filled out a simple quantitative questionnaire about their ELMSK. Then they completed a teaching practice supervision block that was used to collect data about the sample's MPCK and MTPP scores.

3.1. Subject

The subject in the survey was 24 student teachers, all studying in the Hong Kong Institute of Education (HKIEd). Among them, 12 were majoring in mathematics, and the other 12 were taking mathematics as their minor subject in their 4-year bachelor of education programme.

The 12 mathematics majors were training to be specialist mathematics teachers in the primary school stream and will be mainly teaching primary mathematics. They have all passed either Advance Level (A-level) or Advanced Supplementary Level (AS-Level) mathematics examination in Hong Kong. In contrast, the 12 mathematics minors are also training to teach mathematics, but they are not considered to be mainly teaching mathematics because they have another major teaching subject, such as music, physical education, and general studies. In addition, most of these mathematics minors have not passed A-level or AS-level mathematics. Most of them left high school having passed only ordinary-level (O-level) mathematics. Table 1 shows the details of group distribution.

Table 1. Group Distributions in Stage 1

Course 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. Instruments

As described earlier, a questionnaire was used to collect 24 student teachers' background information and their ELMSK achievements. The questionnaire included age, sex, mathematics major or minor, and year in the enrolled programmes (either year 3 or 4). The questionnaire also included the highest level they passed on the public mathematics examinations (What was the highest level of mathematics **you passed** in the public examination? (A-level/AS-level/O-level). This was used to reflect student teachers' ELMSK.

After collecting ELMSK, their MPCK and MTPP were collected via teaching practicum (TP) observation and post-TP conferencing. In the study, the researcher invited 24 student teachers to be supervised across two academic years. The researcher observed their teaching twice during TP and met with them twice in the post-TP discussion. Of the 24 student teachers, those student teachers with A-level / AS-level mathematics pass were classified as high-ELMSK achievers, and the others only with O-level pass were classified as average-LMSK achievers.

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

- **Teaching practice appraisal forms** for direct observation and post-TP conferencing
- **Lesson plans**

During supervision, the supervisor/researcher assessed the student teachers' teaching practice performance and their MPCK. In addition, the researcher also used the comments written on the teaching practice appraisal form to ascertain the student teachers' MTPP score by translating those comments into quantified scores.

3.3. Methods of Analysing Data

Pearson product-moment correlations, t-tests, cross-tabulation correlations of ordinal variables, and ANOVAs were calculated.

There were two background variables collected in the first part of the questionnaire: ELMSK and whether or not they were enrolled as mathematics majors or minors. Those student teachers who had studied mathematics at the tertiary level or had passed either A-level or AS-level mathematics were classified as students with high ELMSK, with good subject-content knowledge (SCK) background before entering HKIEd. Those student teachers who had only passed school certificate or O-level mathematics were classified as students with average ELMSK, with a satisfactory SCK background.

Data collected from the teaching practice appraisal form was used to assess students' MPCK levels, and their MTPP was used to assess their overall mathematics TP performance. For each assessing item—such as lesson planning, selection, and use of resources (in total there are 18 items)—there were three assessment grades. They were: distinction, pass, and fail. Those grades were converted into the scores 3, 2, and 1 respectively. Normally in HKIEd, only one overall rating of teaching practice performance would be offered to student teachers (distinction, pass/satisfactory, or fail/unsatisfactory). Those grades would be also converted into scores of 3, 2, and 1. However, for this research, the overall MTPP 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 passing grades; only very few students were assessed as failing or getting a distinction in their TP. Thus, if we were to use the 3-point scale to assess their overall MTPP achievements, it would limit the ability to discriminate or rank their MTPP and make it difficult to assess whether this variable is correlated with MPCK and ELMSK.

Generally speaking, student teachers' ELMSK, MPCK, and MTPP were compared between different sub-groups using t-tests. In addition, Pearson's correlation coefficients were calculated to investigate the relationships among these factors.

4. RESULTS

4.1. ELMSK Achievements

From the analysis of their background subject knowledge, we can discover that the percentage distribution of high ELMSK in the minors group is a lot smaller than in the majors group. Only 33% of mathematics minors were categorized as high ELMSK. However, all of the mathematics majors had passed either A-level or AS-level math, and all were categorized as high ELMSK. This is because at least an AS-level pass in mathematics is required to be mathematics major in the BEd programme. Table 2 displays the details of the ELMSK distributions.

Table 2. ELMSKs Distributions

Courses / Year	4-Yr Full-time BEd (Mathematics Major)		4-Yr Full-time BEd (Mathematics Minor)	
	Male	Female	Male	Female
Entry-Level Mathematics Subject-Matter Knowledge (ELMSK)	High (Average)	High (Average)	High (Average)	High (Average)
Year 3	3 (0)	3 (0)	1 (2)	1 (2)
Year 4	3 (0)	3 (0)	1 (2)	1 (2)

4.2. MPCK

The other type of achievement in mathematics is defined as MPCK, 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 student teachers' lesson planning and presentation of their teaching. In this study, MPCK was mainly measured by summing a subject's scores in the specified items of their teaching practice appraisal form. Table 3 lists details of MPCK items (shaded) in the teaching practice appraisal form.

Table 3. Items measuring MPCK

The Teacher	**Content of Teaching**	**Planning and Evaluation**	**Management and Instruction**	**Communication**	**Individual Needs of Pupils**
Attitude in Teaching	Aims and Objectives	Lesson Planning	Selection and Use of Resources	Verbal Communication	Learning Difficulties
Relationship with Pupils	Subject Matter Selected for Teaching (Level, Appropriateness, Scope, etc.)	Teaching and Learning Strategies	Sequencing of learning Activities	Non-verbal Communication	Learning Styles
Reflective Ability	Organization		Design of Learning Environment/Aids	Use of Media	

As stated before, each item was graded as distinction, pass, or fail. These grades were then coded as 3, 2, and 1 (respectively), and the total scores were classified into five bands by using the following grade descriptors (8 = minimum score; 16 = neutral; 24 = maximum):

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 MSCK and MTPP achievements in teaching primary mathematics.

MPCK Mean Scores

MPCK mean scores were categorized by year of study and major vs. minor and are shown in Table 4.

Table 4. Pedagogical Content Knowledge (PCK) Mean Distribution

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

The results showed that student teachers achieved better MPCK scores as they moved from their 3rd year to their 4th year for both majors and minors. Students in the 4th year had much better MPCK scores than those in their 3rd year.

4.3. Relationship between ELMSK and MPCK

To explain the relationship between MPCK and ELMSK, Pearson correlations were calculated. Table 5 shows the correlations for each sample of student teachers between MPCK and ELMSK.

Table 5. Correlations between ELMSK and MPCK.

	Subject groups (Major or minor and major + minor)	Mathematics Pedagogical Content Knowledge (MPCK)	Significance (2-tailed)
Entry-Level Mathematics Subject-matter Knowledge (ELMSK)	Mathematics majors	0.083	0.759
	Mathematics minors	–0.054	0.843
	Mathematics majors and minors	0.023	0.495

As shown in the table, there were no positive associations in the majors group (r = 0.083) or the minors group (r = –0.054). Even when the correlation between ELMSK and MPCK were calculated without the effect of elective enrolments (major or minor), the relationship was still less strong (r = 0.023). Thus the relationship between achievement ELMSK and achievement MPCK in mathematics was considerably less strong—virtually non-existent.

4.4. Mean MTPP Scores

Because this study was a pilot study and also because the teaching practice performance was assessed via teaching practice observation and there were only 24 student teachers assigned to the researcher to take up his supervision role, thus the sample size was limited. With limited sample sizes and variability in the measures, the researcher only can used between-groups analyses to compare mathematics major and minor groups, each group has 12 samples.

Both majors (M = 3.00, SD = 0.97) and minors (M = 3.00, SD = 1.10) had the same mean in TP supervisions. Therefore, there were no differences in MTPP scores between minors and majors.

4.5, Gender and Achievement Results

The student teachers' scores in ELMSK and MPCK were further examined to determine whether there are gender differences among minors and majors. The results of the t-tests are shown in Tables 6 and 7.

Table 6. t-test results examining gender differences in MPCK achievement

Subject Groups	MPCK Mean Male (Female)	t Value	Significance (2-tailed)
Mathematics Majors	1.57 (4.11)	-5.791	< 0.000
Mathematics Minors	3.13 (3.50)	-0.614	0.549

As seen in Table 6, there was only a small difference between the mean scores of male and female minors. On the other hand, it is surprising that the female majors performed much better than males. There was a strong, significant difference between male and female majors in MPCK achievement. According to the researcher's 15 years of TP supervision findings, this phenomenon could be explained by a general tendency on the part of female student teachers to expend more effort 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 closer relationships with their pupils.

5. FINDINGS

This study revealed two significant relationships and a host of null findings. The findings are summarized as follows.

5.1. MPCK

Even though mathematics majors have studied more mathematics subject-matter modules than minors in the BEd Programme, it was the minors who scored higher on lesson planning and teaching presentation in TP. In other words, student teachers with higher math subject-matter knowledge do not mean that they can achieve better teaching performance. But on the whole, students in their 4th year scored much better on MPCK than students in their 3rd year. This suggests that student teachers' MPCK improves year by year.

5.2. Relationship between ELMSK and MPCK

No significant relationships were found between ELMSK and MPCK. Even when the correlation between ELMSK and MPCK was calculated irrespective of the major or minor in math, the relationship was still weak to imply that it was significant.

5.3. Gender Differences in MPCK

Among mathematics minors, females did better than males in MPCK scores in their TP teachings, although the difference was not statistically significant. But for mathematics majors, there was a strong, significant difference between males and females. Females performed much better than males on MPCK. On the whole, females did better than males on presenting mathematics content in their teaching.

5.4. Correlations among MTPP, MPCK, and ELMSK

There were no statistically significant differences in MTPP between minors and majors. However, MTPP and MPCK did correlate positively and strongly. Lastly, it is most important to note that there was no significant relationship between MTTP and ELMSK.

6. DISCUSSION AND CONCLUSION

6.1. Interrelation between MSCK, ELMSK, and MTTP

The primary research question was: What are the relationships between ELMSK and MPCK development and MTPP results? This study found that MPCK has a strong, positive relationship with student teachers' MTPP in their mathematics teaching TP. At the same time, there was no significant relationship between ELMSK and MTTP results. In addition, it is surprising that MPCK did not correlate with student teachers' ELMSK. In the study, mathematics majors were found to have much better ELMSK than mathematics minors but minors were found to have better MPCK than majors. This study also found no statistically significant differences in TP performance between mathematics minors and majors. Thus it is unrealistic to expect student teachers with better ELMSK will have better MPCK and also better teaching performance in teaching primary mathematics. Figure 2 explains the interrelation among MSCK, ELMSK, and MTTP.

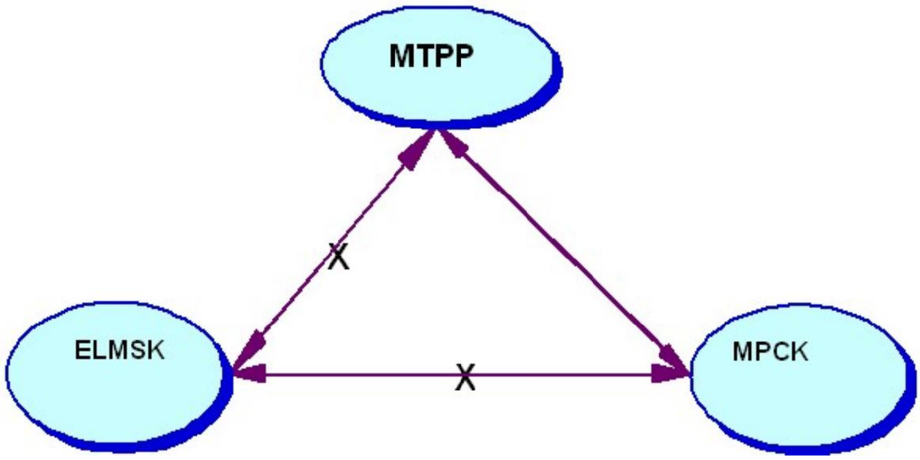

Figure 2. Relationships between ELMSK, MPCK and MTTP

6.2. 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 mathematics minors have at least passed ordinary-level mathematics. This implies that mathematics student teachers with the minimum requirement of having passed ordinary-level mathematics can also be trained to be good primary mathematics teachers. This finding does not imply that we can pull down our entry requirement to below ordinary-level mathematics pass. This research cannot inform policy for secondary mathematics teaching, since the mathematics knowledge being taught in secondary school especially in senior forms is more subject-specific, abstract, and harder compared to the knowledge being taught in primary mathematics lessons. Further research is needed to re-test the hypotheses developed here with secondary student teachers.

6.3. Gender and Programme Differences in MPCK development

This study also tested whether there are gender and group differences in MPCK development. The study found that, among minors, females did slightly better than males in MPCK. Among majors, this difference was greater, with females performing much better than males. Generally speaking, females did better than males in presenting mathematics content in their TP teaching, but there were no statistical gender differences in ELMSK or TP teaching performance.

By assessing their written lesson plans and self-made teaching aids, it is easy to see that female student teachers made more effort in their preparations. In addition, during teaching practice, the researcher also found that females were more patient in explaining mathematics concepts to their pupils than males, and they were also more willing than male student teachers to change their presentation and speaking style to suit young children. From this study, there seem to be gender differences in MPCK and this gender difference in MPCK might affect student teachers' teaching performance and eventually lead to gender differences in teaching competency. Are females born to be more suitable than males to teach in primary schools? Really, this question cannot be answered here, and it is also not an objective in this study. In addition, the gender difference issue is very controversial and the sample size used in this study is not too large, the researcher recommends that this issue does need serious consideration and is worth further investigation.

6.4. Do student teachers with better ELMSK teach primary mathematics better?

This study compared mathematics minors and majors and found that majors had better previous ELMSK than minors. But it is surprising that minors had better MPCK measured in their TP. Because MPCK was found to correlate with teaching performance, the general public would logically hope that majors would perform better than minors. That would be logical because majors have achieved better mathematics subject-matter knowledge before matriculation and also have been studying more academic mathematics modules than minors in their BEd programme. However, the results of this study did not confirm that notion.

There are many factors that could have caused this result, such as student teachers' perceptions of mathematics and their attitude toward mathematics and mathematics teaching. It is not an objective of this study to figure out these causes, but it is worth serious consideration and further investigation.

At the same time, MPCK was found to be positively correlated with mathematics teaching performance. This has important implications for how teacher-training institutes and related lecturers design appropriate modules for their student teachers. Teacher-training institutes should review their program structure, the balance between subject-knowledge modules (academic study modules), and pedagogical content modules (curriculum and teaching modules). In addition, curriculum and teaching modules should consider some additional aims:

- To stimulate student teachers' interest in acquiring MPCK;
- To develop student teachers' ability to use teaching aids, language, and activity in teaching mathematics concepts and skills;
- To promote student teachers' powers of observation, diagnosis, analysis, and judgment for the purpose of giving them a deeper understanding of their pupils' needs.

There are many other factors that would affect mathematics teaching performance that this study did not discuss. For instance, whether:

- The ratio of pupils to teacher is relevant to a teacher's teaching approach;
- Resources devoted to teachers are enough, cost-effective, and efficiently used;
- Schools and parents can cooperate with a teacher's teaching; and
- Schools and teachers can meet the goals of the government's educational reform.

In sum, on the basis of this study, the researcher agrees that MPCK could affect how effectively teachers teach mathematics. This finding is consistent with previous studies. For example, Ball (1991) and Even (1993) found that mathematics teachers' teaching performance is highly correlated with their achievement in mathematics which including PCK. However, there were no significant correlations between ELMSK and teaching performance. The analysis showed that student teachers' teaching performance is not significantly related to their ELMSK.

In addition, there were also no significant relationships between student teachers' subject-matter knowledge (majors having studied more math subject modules than minors) and MPCK. These distinctive findings are different from Ball (1991) and Shulman's (1986) assumption that teacher's PCK is strongly influenced by their SCK. All of these findings are worth further investigation for the purpose of developing a series of recommendations for reforming teacher-training policy.

6.5. Two Immediate Issues Emerging from the Findings

On the whole, the study revealed that MPCK is the most important factor relating to primary mathematics teaching performance. After reviewing the data, two immediate issues emerged. The first issue is that, although student teachers' MPCK 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 because of the non-significant correlation between student teachers' ELMSK and MPCK, 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, the major issues of mathematics teachers' professionalism become how we should revise the entrance requirements for teacher-training courses, improve student teachers' MPCK, and restructure teacher-training curriculum. In order to instil adequate MPCK in our primary mathematics teachers, the curriculum of 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 another form of PCK. Therefore, the objectives in the current primary mathematics teacher-training programme can no longer meet the demands of recent societal developments. Mathematics educators and institutions should provide updated knowledge of the recent developments of mathematics education, as well as effective factors and teaching strategies for mathematics so as to boost our teachers' professionalism.

Clearly the study of competency in mathematics teaching is very difficult. Although this study clearly found that MPCK is positively correlated with mathematics teaching performance, there are still many factors that might affect teaching performance. Moreover, although there was no significant effect of subject-matter knowledge on teaching performance and minors got slightly better results in TP than majors, this does not imply that teachers without sufficient mathematics subject-matter knowledge can achieve sound MPCK and teach primary mathematics well. These findings only demonstrate that the minimum subject requirement for BEd (primary) mathematics students should be revised to passing the O-level.

In addition, after entering the HKIEd, they still have the opportunity to study more mathematics. Therefore whether they can achieve more knowledge in both MSCK and subject-matter knowledge 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. However, there have been whispers in our society recently questioning whether our mathematics student teachers graduates can teach primary mathematics even though their ELMSK are not as good as those undergraduates who are studying pure mathematics or engineering degrees. This study has shown that ELMSK is not a crucial factor for developing student teachers'

MPCK. It means that once we can have student teachers with satisfactory ELMSK, we can train them to be effective primary mathematics teachers as long as the teaching programme is well structured. Can our current programmes train professional primary mathematics teachers? We need further investigation.

For instance, are the present modules enough to develop student teachers' MPCK and subject-matter knowledge? Within the programme is there an assessment mode that can be used to assess student teachers' MPCK other than teaching practice? This kind of assessment can also motivate and increase student teachers' awareness of the importance of MPCK. For instance, specific curriculum and methodology modules can ask student teachers to explain the methodologies for teaching particular mathematical concepts either in writing or via verbal description. In addition, we recommend that the currently non-assessed pre-teaching practice of micro-teaching be assessed so that this hands-on activity, trial teaching, and evaluation will be enhanced considerably.

In summary, the data shows that MPCK is positively related to teaching performance and (surprisingly) that ELMSK is not related to MPCK development or teaching performance. However, 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 analysed with statistical tests. More precisely, a qualitative longitudinal study for measuring student teachers' MPCK should be set up for further studies. Case studies can be used as a follow-up investigation that will give us a deeper understanding of teachers' pedagogical content knowledge of mathematics.

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