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AN INVESTIGATION OF THE KNOWLEDGE COMPETENCY OF PROSPECTIVE MATHEMATICS TEACHERS IN THE PERSPECTIVE OF RELATIONSHIP BETWEEN THEIR SUBJECT MATTER KNOWLEDGE AND NON-COGNITIVE FACTORS

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Abstract

This study investigates the relationship between subject matter knowledge (SMK) for mathematics teaching and self-reported non-cognitive factors among 201 prospective mathematics teachers (PMTs) in Hong Kong. Participants completed a survey adopted from Fennema and Sherman [19] were assessed their confidence in learning mathematics (CLM), attitude towards success in mathematics (ASM), mathematics anxiety (MA), effectance motivation in learning mathematics (EMM), while 73 of them were assessed in a written test on their knowledge. The regression analysis suggests that CLM is the main predictor of the performance in SMK compared to MA and EMM. Findings also show that there were statistically significant effects of both gender and program of studies on their performance on

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MA, EMM and CLM. The results suggest a further investigation of the relationship between beliefs and SMK among PMTs in other contexts. Implications for the current teacher education system in Hong Kong are also discussed.

Introduction

A number of researchers have investigated the relationship between cognitive variables and non-cognitive variables regarding learning mathematics among students (e.g., Morony et al. [29]). Those non-cognitive variables including motivation, personality and self-beliefs constructs were also found to be the best predictors of achievement. According to Morony et al. [29], self-beliefs constructs include self-efficacy, self-concept, anxiety and confidence. A common and essential purpose of those previous studies has some insights into the causal relationship between attitudes in learning mathematics and mathematics performance. Those studies can provide suggestions on the inventions in education to satisfy prospective teachers' both cognitive and affective needs in mathematics learning and teaching. Similarly, some researchers have extended such an investigation on prospective teachers (e.g., Bursal and Paznokas [14] and Tosun [35]). Those studies suggested that confidence in learning mathematics, mathematics anxiety, and attitudes towards learning mathematics play a significant role in their mathematics achievement. In addition, motivation orientation is identified as an important factor that is closely relevant to academic achievement (Hannula [22], McLeod [27] and Zan et al. [40]). The majority of those above studies were conducted among students, and few were about mathematics teachers especially pre-service mathematics teachers.

On the other hand, after the New Senior Secondary curriculum reform was launched in 2009 in Hong Kong, while there was a clear paradigm shift from "content" to "process" (ability) in mathematics learning, mathematics teachers have become a concern of whether their professional knowledge is competitive enough to cope with such a shift. In the studies on the mathematics teachers' professional competency and development, some affective variables such as beliefs including the beliefs towards the nature of mathematics and mathematics teaching and learning were treated as the important factor influencing teacher's teaching behaviour and effectiveness (e.g., Schoenfeld [33]). However, compared to those studies investigating students' affective and cognitive dimensions towards mathematics learning, the studies in the field of teacher education seldom explored the effects of other non-cognitive factors expect beliefs and goals on cognitive performance. In addition, gender as the factor has been reported as an important moderator between non-cognitive variables and academic performance (e.g., Ercikan et al. [17], Fleming [20] and Forgasz et al. [21]). However, the effect of gender on students' academic achievement is unstable and highly depending on the different programs and countries (e.g., TIMSS studies [3-5]), and also influenced by grades range and content areas (e.g., Hyde et al. [23]). By analyzing the item-level data from the Teacher Education and Development Study in Mathematics (TEDS-M) across three countries, namely, the US, Singapore and Germany, Albano and Rodriguez [9] found that gender and opportunities to learning interact towards future secondary mathematics teachers' item-based mathematics performance. Besides, culture is another factor influence teacher candidates' self-reporting those affective variables (e.g., Morony et al. [29]). Based on what have found in previous studies, this current study aims to investigate the relationship between those above mentioned non-cognitive and subject matter knowledge among a group of pre-service mathematics teachers in the context of Hong Kong. We want to confirm which non-cognitive variable is the strongest indicator of their performance in mathematics. In particular, the impacts of gender and program difference are taken into consideration in this study because of the special cases in Hong Kong.

Literature Review

In this section, the concepts of relevant variables investigated in this current study are reviewed first.

Confidence in learning mathematics (CLM)

Confidence was regarded as a predictor of academic achievement (Burton [15]). In their study, Stankov et al. [34] investigated the major predictor among confidence, self-efficacy, self-concept and anxiety of academic achievement of 15-year old students from Singapore, it was found that confidence is the better predictor of academic achievement than others. The results from Ercikan et al.'s [17] second analysis in the 1995 TIMSS study also showed that confidence in mathematics was the strongest predictor of achievement for students from Canada and Norway, yet not for the students from the USA.

Effectance motivation in learning mathematics (EMM)

The term "effectance motivation" was firstly used by (Fennema and Sherman [19]). According to White, the definition of effectance motivation is "inferred specifically from behaviour that shows a lasting focalization and that has the characteristics of exploration and experimentation, …, it is selective, directed and persistent, … instrumental acts will be learned for the sole reward of engaging in it". When Fennema and Sherman [19] measured the "effectance motivation" in learning mathematics, they revised it as the extent of enjoyment involving in mathematics. Some researchers found that it is a positive relationship between effectance motivation in mathematics and mathematics achievement (e.g., Bretscher et al. [1]). But when using the same scale of EMM among a group of matriculation students, Zakaria and Nordin [39] found that effectance motivation had a significantly low positive correction between motivation and achievement in mathematics. According to Pearlman [30], effectance motivation in the cognitive domain is probably related to individual intelligence as well.

Mathematics anxiety (MA)

It is also important to learn mathematics anxiety of pre-service mathematics teachers, since Martinez has asserted that "math-anxious teachers can result in math-anxious students" ([26], p. 117). It is also reported that mathematics anxiety is one of the key affective variables which can impede both learning and achievement in mathematics (Ma [25]). Recently, some researchers have identified the relationship between mathematics anxiety and mathematics performance among prospective teachers' learning advanced mathematics courses in universities (Bekdemir [12], Brady and Bowd [13] and Bursal and Paznokas [14]), and usually mathematics anxiety and confidence in learning mathematics were considered to be associated. For example, the findings of Bursal and Paznokas' [14] study suggest that low mathematics anxious pre-service teachers are more confident in teaching elementary mathematics and science than are their peers who have higher levels of math anxiety. In addition, they also found that negative correlations between pre-service teachers' mathematics anxiety and their confidence scores to teach elementary mathematics.

Attitudes towards success in mathematics (ASM)

According to studies in the learning of mathematics, the attitudes of the learners regarding their competency and achievement levels were found to be directly correlated (see Forgasz et al. [21]). Some studies found that the attitude might be a strong indicator for mathematics achievement for students in some countries, but not others. For example, Ercikan et al. [17] did a comparative study across three countries (i.e., USA, Canada and Norway) based on a second analysis on the 1995 TIMSS study. Among a group of variables, they found that the attitude towards mathematics was the strongest predictor among female American students' participation in advanced mathematics courses, but was not the strongest one for other groups. Ma and Xu [37] tried to identify the causal predominance over attitude across grades in secondary school. By contrasting elite and non-elite groups, they found that some imbalanced reciprocal relationship between attitudes and achievement across the entire secondary school for non-elite students.

Gender difference

The effect of gender difference on mathematics achievement was observed differently in different countries and in different content areas

(Casey et al. [16], Fennema et al. [18], Forgasz et al. [21] and Leder [24]). For example, by studying TIMSS data of the 8th grade students' mathematics performance, Casey et al. [16] found that male students' strength in spatial-mechanical skills provided them a certain advantage in solving certain types of mathematics problems than their female counterparts. They also explained that probably the type of tasks requesting problem solving favored by male students rather than female students. Indeed some studies have reported that different strategies were employed by male and female students in problem solving. Girls tend to use concrete solution strategies while boys prefer abstract solution; and boys use more invented algorithm for extension problem than girls (Fennema et al. [18]). In addition, the effect of gender difference on mathematics achievement should be related to international and cultural dimensions (e.g., Mullis et al. [3] and Mullis et al. [4]).

Mathematics subject matter knowledge for teaching

Subject matter knowledge is the cornerstone for mathematics teachers in conducting effective mathematics teaching. In an elaborate sense, the professional knowledge mathematics teachers possessing are called the *mathematical knowledge* for teaching, which is a kind of knowledge that teachers own in supporting the instruction to their students (Ball et al. [10]). Usually mathematics academic achievement of mathematics (pre-service) teachers in the past studies is indicated by prior course grades or general measures of ability (e.g., Monk [28] and Morony et al. [29]). Some large-scale international studies have developed content knowledge test covering varied content areas for mathematics teachers and pre-service mathematics teachers, such as Mathematics Teaching in the 21st Century (MT21) - a pilot study for TEDS-M study (Schmidt et al. [6]), learning mathematics for teaching (LMT) project (e.g., Charalambous [2]) and TEDS-M project (Tatto et al. [7]). It is also common for researchers and teacher educators to design curriculum topic-related mathematics tests as the instruments for collecting subjects' academic achievement. In the field of mathematics teacher education, achievements in university courses and field experience were regarded as the major predictors for pre-service teachers' subject matter knowledge for teaching (e.g., Youngs and Qian [38]), relatively speaking, the effect of affections and other non-cognitive factors on their mathematics knowledge for teaching is still under explored.

Based on the above literature reviews, some questions are remained to be unclear and worth further investigating in different contexts, including the effects of those most reported non-cognitive variables on pre-service mathematics teachers' mathematics performance. This study aimed to address two major research questions:

(1) What is the relationship between four non-cognitive variables confidence in learning mathematics, effectance motivation, mathematics anxiety and attitude towards learning mathematics and subject matter knowledge among Hong Kong prospective mathematics teachers? Among those four variables, which is the major predictor for those prospective teachers' SMK?

(2) How do gender and program difference affect those Hong Kong prospective teachers' performance in the four non-cognitive variables and SMK?

Methods

The sample of pre-service mathematics teachers

In Hong Kong, university graduates entering their career as a teacher must possess a recognized teacher training qualification before becoming certified teachers. They can obtain this qualification from either one of the two ways. The one is to obtain a degree of Bachelor of Education (BEd, 4 year program) with a subject major or study a training program, and the other is through Postgraduate Diploma of Education, PGDE (1 year full-time, FT, program or 2 year part-time, PT, program) after they graduate from a first degree (not necessary mathematics). In all local education programs, the subject (disciplinary) major and level for teaching (e.g., kindergarten, primary or secondary) are specified, such as BEd(P) program is for nurturing future primary teachers and PGDE(S) for training secondary school teachers.

In Hong Kong, a teacher trained to teach primary students can be possibly recruited to teach lower secondary classes, or vice versa, depending on the school organization body and the principal as well as the needs of the school. In addition to PDGE and BEd programs, there are two special programs for training future mathematics teachers, that is, Bachelor of Mathematics Education (BMED) of The Chinese University of Hong Kong and Bachelor of Science in Mathematics (Mathematics and IT Education, the abbreviation is MAIE program). BMED program is quite similar to BEd program majoring in mathematics. MAIE program is an integrative and collaborative program between the University of Sciences and Technology (UST) and The Hong Kong Institute of Education (HKIED). The students involving MAIE program are those mathematics major UST students. They studied at HKIED for pedagogical courses and practical trainings in their Year-3 and Year-4 to fulfill the requirement of a teacher qualification.

A total 201 Hong Kong pre-service mathematics teachers from ten educational programs in Hong Kong participated in this study. Table 1 describes the characteristics of those participated Hong Kong PSTs.

Table 1. Summary of characteristics of Hong Kong prospective mathematics teachers (*N* = 201)

Char.	Categories	Program	Part 1- survey number (%)	Part 2- survey number (%)
Gender	Male		124(61.7)	60(84.9)
	Female		73(36.3)	13(16.5)
	Unspecified		4(2)	0(0)
Program	CUHK	BMED	13(6.5)	0(0)
		PT-PDGE(S)_Year 1	28(13.9)	14(19.2)
	HKBU	PT-PDGE(P)	26(12.9)	0(0)
	HKIED	PDGE(P)_Year 1	33(16.4)	3(4.1)

	PDGE(S)_Year 1	8(40)	8(11.0)
	PDGE(S)_Year 2	7(3.5)	5(6.8)
	MAIE_Year 4(2013)	13(6.5)	7(9.6)
	MAIE_Year 4(2014)	13(6.5)	6(8.2)
HKU	PT-PGDE(S)_Year 1	23(11.4)	12(16.4)
	PT-PGDE(S)_Year 2	32(15.9)	13(17.8)
Unspecified		5(3.1)	5(6.8)

"CUHK": The Chinese University of Hong Kong; "HKBU": Hong Kong Baptist University; "HKIED": The Hong Kong Institute of Education; "HKU": The University of Hong Kong; "BMED": Bachelor of Mathematics Education; "PT-PDGE(S)": Part-time Postgraduate Diploma of Education (secondary); "PT-PDGE(P)": Part-time Postgraduate Diploma of Education (primary); "MAIE": The integrative program between The University of Sciences and Technology (UST) and The Hong Kong Institute of Education (HKIED).

Instruments

For answering these research questions, the two corresponding questionnaires-type surveys (1 and 2) were designed to capture the factors related to Hong Kong PSTs' professional performance and their mathematics achievement, respectively. Corresponding to our research questions, one section of the survey 1 was in the focus of this study, which measured the PSTs' performance in four non-cognitive variables, i.e., confidence in learning mathematics scale (CLM), attitude toward success in mathematics scale (ASM), mathematics anxiety scale (MA) and effectance motivation in mathematics scale (EMM). All these scales were adopted from Fennema and Sherman [19], which was regarded as the most widely used for measuring mathematics attitude scales (Forgasz et al. [21]). According to them, CLM scale is intended to measure confidence in one's ability to learn and to perform well on mathematical tasks. MA scale is intended to measure feelings of anxiety, dread, nervousness and associated bodily symptoms related to doing mathematics. EMM scale in mathematics is intended to measure effectance as applied to mathematics. The dimension ranges from lack of involvement in mathematics to active enjoyment and seeking of challenge. ASM scale is designed to measure the degree to which students anticipate positive or negative consequences as a result of success in mathematics. 48 five-point Likert scale items in total were used and the applied categories reflecting the extent to which they agree, from “very disagree: 1” to “very agree: 5”. The scores for some negatively-keyed items were reversed to ensure a high score indicating a relatively high level of CLM, EMM and ASM yet low level of MA. The mean score of items was attained to determine the score of each scale. Table 2 describes the sample item and the *Cronbach*’*s alpha* value (α) under each scale. The *Cronbach*’*s alpha* value for each scale was above 0.8 that is considered to be high in most social science studies. The whole set of 48 items are attached in Appendix A.

Table 2. Description, sample item and Cronbach’s alpha for four non-cognitive scales

Abb.	Variable	Items and sources	Sample item	Cronbach’s α
CLM	Confidence in learning mathematics	Items: 2, 3, 6, 10, 14, 18, 22, 25, 29, 33, 37, 45	Item 3: Generally I have felt secure about attempting mathematics	.906
ASM	Attitude toward success in mathematics	Items: 21, 32, 1, 24, 5, 13, 40, 36, 28, 17, 44, 9	Item 21: It would make me happy to be recognized as an excellent student in mathematics	.843
MA	Mathematics anxiety	Items: 11, 42, 46, 34, 41, 38, 7, 15, 19, 30, 23, 26	Item 42: It would not bother me at all to take more math courses	.893

EMM	Effectance motivation in mathematics	Items: 35, 48, 31, 8, 27, 12, 39, 20, 43, 47, 16, 4	Item 35: Mathematics is enjoyable and stimulating to me	.915

Survey 2 - the SMK questionnaires consist of ten multiple choices questions and eight short open questions. The range of content topic of the questions in the SMK survey covers the most part of secondary mathematics curriculum. Table 3 shows the distribution of the topics and types of questions.

Table 3. The distribution of the number and type of questions in different content topics

Topics	Number of multiple choices	Number of short questions
Algebraic functions/inequalities/ quadratic equations	1	3
Vectors	1	
Plane geometry/solid/coordinate geometry	2	2
Probability and statistics	3	1
Calculus	2	
Trigonometry	1	
Matrices		1
Series and sequences		1

Those questions were either selected from sample items of MT21 report or developed by our research group. Those questions were designed to assess those PSTs' core mathematics knowledge in a certain content topic that teachers should have. PSTs were required to possess a clear and complete understanding of the concept and theory of the related topics to answer those questions correctly. In scoring, two points for a correct answer of one multiple choice question and zero point for a wrong answer. The score on each open question ranges from 0 to 6 depending on the correctness PSTs gained for each step. The total score of all SMK questions was used as a variable of their performance in SMK in this study. The details regarding the sample items and their corresponding scoring rubrics can be seen in Appendix B.

Data collection and analyses

Two surveys including non-cognitive variables survey and SMK questionnaires were carried out separately. The recruitment of all PSTs from the ten education programs started from April 2013 to February 2014. A total of 201 PSTs took the first survey regarding the performance in non-cognitive variables; and 73 out of 201 PSTs participated in second survey measuring their mathematics knowledge. Table 1 describes the characteristics of the 73 participants involving both surveys.

For analysis, the data from the two questionnaires were analysed using the statistics software SPSS and AMOS. The data for the first questionnaire were initially analysed for internal consistency reliability using SCALE from SPSS. The relationships between four dependent variables (i.e., CLM, ASM, MA and EMM) and one independent variable (i.e., subject matter knowledge achievement) were attained through regression analysis by AMOS and multivariate regression analysis by SPSS. Multivariate regression analysis provides information about the relationship between an interval dependent variable and a set of independent variables. This information includes the degree to which variation in the dependent variable is explained by the independent variables as a set. The path analysis in AMOS also provides to visualize the relationship in a model. Besides, considering the sample size, gender as the factor is not included in the regression model on testing the relationship between SMK and beliefs. We only make qualitative analysis related to gender difference. Multivariate Analysis of Variance (MANOVA) was conducted to examine the major effects of gender and program difference on the beliefs and attitude scales.

Findings

The relationship between belief scales and SMK performance

The Pearson correlation test was conducted to test the hypothesis if there is a relationship between EMM and SMK, between CLM and SMK, between ASM and SMK, and between MA and SMK. We use 0.05 as the significant level in the subsequent tests of inference. The results reveal that there is a statistically significant positive relationship between HK pre-service mathematics teachers' effective motivation in learning mathematics (EMM) and SMK performance ($r = .516$, $p < .05$); there is a statistically significant positive relationship between those PSTs' confidence in learning mathematics (CLM) and SMK performance ($r = 606$, $p < .05$); there is a statistically significant relationship between those PSTs' mathematics anxiety scores (MA) and SMK ($r = .453$, $p < .05$); and the relationship between PSTs' attitude toward success in mathematics score (ASM) and SMK is statistically significant at the level of .05 ($r = .255$, $p < .05$). Comparably speaking, the correction between ASM and SMK is very weak since the correction coefficient is lower than 0.3.

To confirm the hypothesis that CLM, EMM and MA could predicate the PSTs' mathematics achievement, multiple regression tests were carried out to test the hypothesis. The result shows that the cumulative effects of the three variables, CLM, EMM and MA, on SMK performance are significant $F(3, 72) = 7.671$, $p < .05$. From the coefficient table (see Table 4), the unique factor of each IV on SMK can be observed. After controlling two IVs MA and EMM, the effect of CLM on SMK is statistically significant ($t = 2.753$, $p < .05$).

Table 4. SPSS output of regression analysis on coefficients

Coefficients[a] (*, p < .05)						
Model	Unstand. coeff.	Stand. coeff.	*t*	Sig.	Model	Unstand. coeff.
1	(Constant)	4.675	8.693		.538	.592
	MA	–2.542	3.833	–.129	–.663	.510
	EMM	1.677	2.655	.092	.632	.530
	CLM	10.688	3.883	.539	2.753	*.008

a. Dependent variable: SMK

Abbreviation: unstand. coeff. stands for "unstandardized coefficient"; stand. coeff. stands for "standardized coefficient"; and sig. stands for "significant"

Figure 1 describes the correlation between any two variables of CLM, EMM and MA and standardized regression coefficients linking each predictor (independent variable, IV) to dependent variable (DV) SMK.

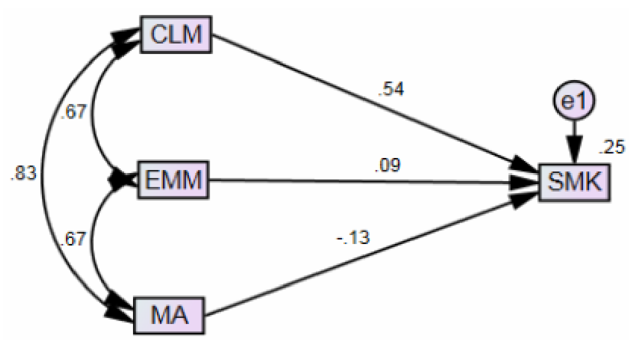

Figure 1. Path diagram for a single equation causal model for the effects of CLM, EMM and MA on SMK by AMOS.

The correlation between any two variables of CLM, EMM and MA is high (all are above 0.6), especially CLM and MA is highly correlated (0.83). Consistent with SPSS regression analysis output, the standardized regression coefficients linking each predictor to the DV SMK appears above the one direction arrow. The R2 value for the DV is 0.25.

To sum up, this current model suggests that the cumulative effects of CLM, EMM and MA on Hong Kong PSTs' SMK achievement are statistically significant, and the lowest R2 value is .25. In particular, after controlling the effect of the EMM and MA, the effect of CLM on SMK is positively statistically significant at the level of .01.

The effects of gender and program difference on attitudes and SMK

The effects of gender and program difference on four non-cognitive variables. The descriptive statistics related to various programs of male and female PSTs with respect to performance in seven belief scales are summarized in Table 5. Means, standard deviations and sample size (*N*) are displayed for each dependent variable.

Table 5. Descriptive statistics for HK pre-service teachers' performance in belief scales with respect to gender and program difference (*N* = 201)

	Program		Mean			Std. dev.		
		N	Male	Female	Total	Male	Female	Total
CLM	1	13	3.56	3.69	3.60	0.51	0.44	0.48
	2	26	3.29	3.23	3.24	0.66	0.57	0.59
	3	33	3.56	2.91	3.30	0.78	0.63	0.78
	4	8	3.85	3.08	3.66	0.48	1.06	0.67
	5	7	4.06	3.43	3.79	0.41	0.23	0.46
	6	13	3.61	3.54	3.59	0.47	0.37	0.43
	7	23	4.18	4.17	4.18	0.49	0.39	0.46
	8	32	3.92	3.99	3.98	0.54	0.45	0.51
	9	28	4.10	4.33	4.14	0.58	0.24	0.54
	10	13	3.67	3.00	3.46	0.22	0.41	0.42

ASM	1	13	3.65	3.96	3.74	0.38	0.52	0.43
	2	26	3.46	3.67	3.63	0.29	0.45	0.42
	3	33	3.54	3.80	3.64	0.57	0.57	0.57
	4	8	3.75	3.05	3.63	0.68	1.06	0.74
	5	7	3.69	3.61	3.65	0.44	0.67	0.50
	6	13	3.69	3.79	3.72	0.37	0.16	0.32
	7	23	4.09	4.01	4.07	0.50	0.49	0.49
	8	32	3.66	3.94	3.79	0.35	0.48	0.42
	9	28	3.98	4.30	4.04	0.52	0.28	0.49
	10	13	3.69	3.35	3.58	0.51	0.37	0.61
MA	1	13	3.27	3.27	3.27	0.46	0.39	0.42
	2	26	3.32	3.09	3.16	0.56	0.56	0.54
	3	33	3.47	2.94	3.26	0.76	0.66	0.76
	4	8	3.69	3.25	3.58	0.42	0.00	0.41
	5	7	3.85	3.25	3.60	0.46	0.33	0.50
	6	13	3.44	3.52	3.46	0.75	0.47	0.66
	7	23	4.03	3.87	3.98	0.49	0.50	0.49
	8	32	3.75	3.79	3.78	0.57	0.45	0.50
	9	28	3.87	4.08	3.91	0.60	0.20	0.55
	10	13	3.37	2.5	3.10	0.29	0.48	0.54
EMM	1	13	3.80	3.73	3.78	0.65	0.65	0.62
	2	26	3.69	3.54	3.55	0.23	0.52	0.49
	3	33	3.58	3.17	3.42	0.66	0.57	0.65
	4	8	4.08	3.13	3.84	0.66	1.00	0.81

	5	7	4.02	3.86	3.95	0.20	0.29	0.24
	6	13	3.79	3.71	3.76	0.71	0.31	0.60
	7	23	3.97	3.98	3.97	0.59	0.48	0.55
	8	32	4.04	3.99	4.03	0.48	0.48	0.48
	9	28	4.13	4.23	4.15	0.50	0.30	0.47
	10	13	3.23	2.75	3.08	0.84	0.95	0.86

Legend: "1" = CU-BMED; "2" = HKBU-PT-PGDE(P); "3" = HKIED-PGDE(P)_Year 1; "4" = HKIED-PGDE(S)_Year 1; "5" = HKIED-PGDE(S)_Year 2; "6" = HKIED-MAIE(graduated); "7" = HKU-PT-PDGE(S)_Year 1; "8" = HKU-PT-PGDE(S)_Year 2; "9" = CUHK-PT-PDGE(S)_Year 1; "10" = HKIED-MAIE(year 4).

Multivariate analysis of variance (MANOVA) was conducted to determine the effect of gender and programs on those PSTs' performance in four non-cognitive scales, i.e., CLM, EMM, MA and ASM. The result revealed that there was a statistically significant effect for different programs on their scores in beliefs and attitudes (Wilks' $\lambda = .543$, $F(40, 704) = 2.878$, $p < .05$, partial eta squared = .140. Power to detect the effect was 1.000). However, the effect of both gender and the interaction between gender and program has not a significant effect on those four variables. A one-way MANOVA was conducted as a follow-up test to reveal the effect of programs on each scale. The result indicates significant main effects for program were obtained for all four scales: CLM (confidence in learning mathematics), $F = 7.738$, $p < .05$, partial eta square = .305, power = 1.000; ASM (attitude towards success in mathematics), $F = 2.551$, $p < .05$, partial eta square = .127, power = 0.949; MA (mathematics anxiety), $F = 5.985$, p < .05, partial eta square = .254, power = 1.000; and EMM (effectance motivation in mathematics), $F = 5.438$, $p < .05$, partial eta square = .236, power = 1.000.

Since the overall *F* test was significant on three belief scales, CLM, EMM and MA, follow-up tests were conducted to evaluate mean difference among varied teacher training programs. Bonferroni post hoc analysis was carried out to reveal the significant mean difference between programs on pre-service teachers' performance on CLM, EMM and MA.

Table 6. Mean difference of CLM scales with respect to various programs

DV	Program (I)	Program (J)	Mean difference (I-J)
CLM	HKU-PT-PGDE(S)_year 2	BU-PT-PDGE(P)	*.7364
		HKIED-PGDE(P)_year 1	*.6753
	HKU-PT-PGDE(S)_year 1	BU-PT-PDGE(P)	*.9360
		HKIED-PGDE(P)_year 1	*.8749
		HKIED-MAIE_year 4 (2014)	*.7160
	CUHK-PT-PGDE(S)_year 1	BU-PT-PDGE(P)	*.9013
		HKIED-PGDE(P)_year 1	*.8402
		HKIED-MAIE_year 4 (2014)	*.6813
MA	HKU-PT-PGDE(S)_year 2	BU-PT-PDGE(P)	*.6188
		HKIED-PGDE(P)_year 1	*.5174
		HKIED-MAIE_year 4 (2014)	*.6732
	HKU-PT-PGDE(S)_year 1	CU-BEMD	*.7094
		HKIED-PGDE(P)_year 1	*.7202
		BU-PT-PDGE(P)	*.8215
		HKIED-MAIE_year 4 (2014)	*.8762
	CUHK-PT-PGDE(S)_year 1	CU-BEMD	*.6385
		HKIED-PGDE(P)_year 1	*.6493
		HKIED-MAIE_year 4 (2014)	*.8052

EMM	HKU-PT-PGDE(S)_year 2	HKIED-PGDE(P)_year 1	*.6121
		HKIED-MAIE_year 4 (2014)	*.9505
	HKU-PT-PGDE(S)_year 1	HKIED-PGDE(P)_year 1	*.5493
		HKIED-MAIE_year 4 (2014)	*.8877
	CUHK-PT-PGDE(S)_year 1	BU-PT-PDGE(P)	*.6005
		HKIED-PGDE(P)_year 1	*.7301
		HKIED-MAIE_year 4 (2014)	*1.0685

Legend: "*" indicates the mean difference is significant at the .05 level, the score for MA is reversed, which means that the higher score in MA, the lower anxiety PSTs have in learning mathematics.

Bonferroni post hoc test results, as indicated in Table 6, suggest the PSTs from HKU part-time secondary PGDE programs and CUHK part-time PDGE program have a significant mean difference than HKIED-PGDE(P)_year 1, HKIED-MAIE_year 4 and BU-PT-PDGE(P) in CLM, EMM and MA scales. For example, in the CLM (confidence in learning mathematics) scale, the PSTs from HKU-PT-PGDE(S)_year 1 scored highest among other programs, and statistically outperform than HKIED-PGDE(P)_year 1 ($p < .05$), HKIED -MAIE_year 4 ($p < .05$) and BU-PT-PDGE(P) ($p < .05$). In the EMM (effectance motivation in learning mathematics) scale, the PSTs from CUHK part-time PDGE program have the highest effectance motivation in learning mathematics, and statistically higher than HKIED-PGDE(P)_year 1 ($p < .05$), HKIED-MAIE_year 4 ($p < .05$) and BU-PT-PDGE(P) ($p < .05$). In the MA (mathematics anxiety) scale, PSTs from HKU-PT-PGDE(S)_year 1 have the highest score among their peers from other programs. The PSTs from three programs: HKU-PT-PGDE(S)_year 1, HKU-PT-PGDE(S)_year 2 and CUHK-PT-PGDE(S)_year 1 have statistically significant lower mathematics anxiety than HKIED-PGDE(P)_year 1 and HKIED-MAIE_year 4 ($p < .05$). The PSTs from CU-BEMD program have a statistically significant higher mathematics anxiety than HKU-PT-PGDE(S)_ year 1 and CUHK-PT -PGDE(S)_year 1; and the mathematics anxiety of PSTs from BU-PT-PDGE(P) also are significantly higher than two HKU programs.

The effects of gender and program difference affects SMK

The descriptive statistics related to program and gender with respect to their SMK scores are summarized in Table 7.

Table 7. Descriptive statistics for male and female students with respect to performance on SMK

	Program		Mean			Std. dev.		
		N	Male	Female	Total	Male	Female	Total
SMK	1	3	41.67		41.67	12.342		12.342
	2	8	50.67	18.50	42.63	6.282	9.192	16.186
	3	5	45.67	43.00	44.60	12.741	7.071	9.788
	4	7	40.40	44.50	41.57	11.567	4.950	9.863
	5	12	49.55	40.00	48.75	11.255	0.000	11.079
	6	13	37.71	39.33	38.46	12.958	11.396	11.780
	7	14	44.71		44.71	7.800		7.8000
	8	6	42.17		42.17	11.409		11.409
	9	5	47.80			5.675		
	Total	73			43.60			10.880

Legend: “1” = HKIED-PGDE(P)_Year 1; “2” = HKIED-PGDE(S)_Year 1; “3” = HKIED-PGDE(S)_Year 2; “4” = HKIED-MAIE_Year 4 (2013); “5” = HKU-PT-PDGE(S)_Year 1; “6” = HKU-PT-PGDE(S)_Year 2; “7” = CUHK -PT-PDGE(S)_Year 1; “8” = HKIED-MAIE_Year 4 (2014); “9” = unspecified.

A two-factor ANOVA was conducted to examine the effect of gender and program and their interaction on SMK scores. The results revealed that there was a statistically significant mean difference in SMK scores with respect to the interaction between gender and program, $F = 3.397$, $p < 0.05$, partial eta (η) squared = 0.187, power = 0.822.

Discussion and Conclusion

Echoing previous studies (e.g., Stankov et al. [34]), this current study suggested that confidence in learning mathematics is a better predictor than other emotional factors such as mathematics anxiety, attitude towards success in learning mathematics and effectance motivation. To confirm the model suggested by previous studies on the effects of non-cognitive factors on mathematics achievement, our study also found that confidence in learning mathematics (CLM), effectance motivation in learning mathematics (EMM) and mathematics anxiety (MA) have a high correlation with mathematics achievement among Hong Kong pre-service mathematics teachers. The results suggest that the cumulative effect of the three predictors on SMK performance is statistically significant ($p < .05$). 25% of SMK performance can be accounted by these pre-service teachers' CLM, EMM and MA performance. Yet only the effect of CLM on SMK performance is statistically significant ($t = 2.753$, $p < .05$) after the two other variables (i.e., EMM and MA) are controlled. Ma and Xu's study [37] also investigated the ordering predominance between attitudes and achievement and found that achievement demonstrated causal predominance over attitude across the entire secondary school. They found that changes in prior attitude did not result in any significant changes in later achievement, but changes in prior achievement did result in significant change in later attitude (Ma and Xu [37], p. 274). In this regard, we can claim that the lower confidence in learning mathematics might be accounted by these Hong Kong pre-service teachers' unsatisfactory prior learning experience before university learning. We urged that in the teacher education program, both emotional support and subject matter knowledge courses are important for enhancing those pre-service mathematics teachers' sustainable professional competence.

In this current study, the mean difference in confidence, effectance motivation and mathematics anxiety scales is found to be with respect to program difference. The PSTs from two programs from the University of Hong Kong and one program from Chinese University of Hong Kong tend to have a higher confidence and motivation in learning mathematics and lower mathematics anxiety than their peers from the two programs nurturing future primary mathematics teachers, i.e., BU-PT-PDGE(P) and HKIED-PGDE(P)_year 1. In the meanwhile, PSTs from the integrative teacher training programs (i.e., CU-BEMD and MAIE) seemed to have lower confidence and motivation, and higher mathematics anxiety than their peers from HKU and CUHK. One possibility is that those PSTs from both HKU and CU-PGDE programs are all from PGDE programs, which intend to recruit candidates who desire to pursuit a career in education. Those candidates should have graduated with either a B.Sc. or B.A. degree or obtained an equivalence academic qualification. We suspect that the success of their undergraduate studies might enhance their confidence in responding the questionnaires compared to other PSTs who have not graduated by the time of participating surveys. For example, those PSTs, from CU-BEMD, HKIED-MAIE and CU-BEMD, were in their early stage of study of teaching training program. As for PSTs from HKIED-MAIE program, a few of them had mentioned that mathematics courses provided by UST are so difficult that they can hardly reach an average GPA of 3.0 (where 4.0 is the highest). This might indicate that the challenges and struggles they met in involving current academic studies in some extent brought them mathematics anxiety and discouraged their confidence and motivation of being a mathematics teacher.

In addition, gender difference is found to have a significant effect on SMK performance yet not on four affective scales. However, provided that this study has limited sample size, this claim is tentative. We should note that the recruiting female PSTs for taking the second survey on SMK became a difficult task. Besides the fact of biased portion between male and female PSTs in those educational programs, i.e., less female than male PSTs in those programs, the type of question designed for SMK questionnaire, i.e., many open-ended questions, can also be a factor that affecting female PSTs' willingness of participating such a study as mentioned by previous studies (e.g., Fennema et al. [18] and Casey et al. [16]). Thus, the effect of gender difference on pre-service teachers' SMK and affective performance needs to be further tested by follow-up studies, such as the effect of gender difference in SMK performance with respect to different problems and content area.

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References

[1] A. S. Bretscher, P. L. Dwinell, N. S. Hey and J. L. Higbee, Success or failure: variables affecting mathematics performance, Paper presented at the National Association of Developmental Education, Cincinnati, OH (ERIC Document Reproduction Service No.: ED 304340), 1989.

[2] C. Charalambous, Preservice teachers' mathematical knowledge for teaching and their performance in selected teaching practices: exploring a complex relationship, Ph.D dissertation, University of Michigan, United States-Michigan, 2008.

[3] I. Mullis, M. Martin and P. Foy, TIMSS 2007 International Mathematics Report: findings from IEA's trends in international mathematics and science study at the fourth and eighth grades, TIMSS and PIRLS International Study Center, Boston College, 2008.

[4] I. Mullis, M. Martin, E. Gonzalez and S. Chrostowski, TIMSS 2003 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades, TIMSS and PIRLS International Study Center, Chestnut Hill, 2004.

[5] I. Mullis, M. Martin, E. Gonzalez, K. Gregory, R. Garden, K. O'Connor and T. Smith, TIMSS 1999 International Mathematics Report: Findings from IEA's repeat of the Third International Mathematics and Science Study at the Eighth Grade: International Study Center, Lynch School of Education, Boston College, Chestnut Hill, MA, 2000.

[6] W. H. Schmidt, M. T. Tatto, K. Bankov, S. Bloemeke, T. Gedillo, L. Cogan and J. Schwille, The preparation gap: teachers education for middle school mathematics in six countries mathematics teaching in the 21st century (MT21), MSU Center for Research in Mathematics and Science Education, East Lansing, 2007.

[7] M. Tatto, J. Schwille, S. Senk, L. Ingvarson, R. Peck and G. Rowley, Teacher education and development study in mathematics (TEDS-M): policy, practice, and readiness to teach primary and secondary mathematics, Conceptual Framework, IEA, Amsterdam, 2008.

[8] K. Afamasaga-Fuata'i and L. Sooaemalelagi, Student teachers' mathematics attitudes, authentic investigations and use of metacognitive tools, Journal of Mathematics Teacher Education 14(4) (2014), 331-368.

[9] A. D. Albano and M. C. Rodriguez, Examining differential math performance by gender and opportunity to learn, Educational and Psychological Measurement 73(5) (2013), 836-856.

[10] D. L. Ball, H. C. Hill and H. Bass, Knowing mathematics for teaching: who knows mathematics well enough to teach third grade, and how can we decide? American Educator 29(3) (2005), 14-17, 20-22, 43-46.

[11] Albert E. Beaton, Ina V. S. Mullis, Michael O. Martin, Eugenio J. Gonzalez, Dana L. Kelly and Teresa A. Smith, Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS), Chestnut Hill, Boston College, MA, 1996.

[12] M. Bekdemir, The pre-service teachers' mathematics anxiety related to depth of negative experiences in mathematics classroom while they were students, Educational Studies in Mathematics 75 (2010), 311-328.

[13] P. Brady and A. Bowd, Mathematics anxiety, prior experience and confidence to teach mathematics among pre-service education students, Teachers and Teaching 11(1) (2005), 37-46.

[14] M. Bursal and L. Paznokas, Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science, School Science and Mathematics 106(4) (2006), 173-180.

[15] L. Burton, Confidence is everything - perspectives of teachers and students on learning mathematics, Journal of Mathematics Teacher Education 7(4) (2004), 357-381.

[16] M. B. Casey, R. L. Nuttall and E. Pezaris, Spatial-mechanical reasoning skills versus mathematics self-confidence as mediators of gender differences on mathematics subtests using cross-national gender-based items, Journal for Research in Mathematics Education 32(1) (2001), 28-57.

[17] K. Ercikan, T. McCreith and V. Lapointe, Factors associated with mathematics achievement and participation in advanced mathematics courses: an examination of gender differences from an international perspective, School Science and Mathematics 105(1) (2005), 5-14.

[18] E. Fennema, T. P. Carpenter, V. R. Jacobs, M. L. Franke and L. W. Levi, A longitudinal study of gender differences in young children's mathematical thinking, Educational Researcher 27(5) (1998), 6-11.

[19] E. Fennema and J. A. Sherman, Fennema-Sherman mathematics attitudes scales: instruments designed to measure attitudes toward the learning of mathematics by females and males, Journal for Research in Mathematics Education 7(5) (1976), 324-326.

[20] K. K. Fleming, The effect of self-efficacy, gender, self-concept, anxiety, and prior experience on a model of mathematics performance, University of Kansas, Psychology and Research in Education, Ph.D dissertation 1998.

[21] H. J. Forgasz, G. C. Leder and P. Kloosterman, New perspectives on the gender stereotyping of mathematics, Mathematical Thinking and Learning 6(4) (2004), 389-420.

[22] M. S. Hannula, Motivation in mathematics: goals reflected in emotions, Educational Studies in Mathematics 63(2) (2006), 165-178.

[23] J. S. Hyde, E. Fennema and S. J. Lamon, Gender differences in mathematics performance: a meta-analysis, Psychological Bulletin 107(2) (1990), 139-155.

[24] G. C. Leder, Mathematics and Gender: Changing Perspectives, D. A. Grouws, ed., Handbook of Research on Mathematics Teaching and Learning, National Council of Teachers of Mathematics, USA, 1992, pp. 597-622.

[25] X. Ma, A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics, Journal for Research in Mathematics Education 30(5) (1999), 520-540.

[26] J. G. Martinez, Preventing math anxiety: a prescription, Academic Therapy 23(2) (1987), 117-125.

[27] D. B. McLeod, Research on Affect in Mathematics Education: A Reconceptualization, D. A. Grouws, ed., Handbook of Research on Mathematics Teaching and Learning (A Project of the National Council of Teachers of Mathematics), Macmillan, New York, 1992, pp. 575-596.

[28] D. Monk, Subject area preparation of secondary mathematics and science teachers and student achievement, Economics of Education Review 13 (1994), 125-145.

[29] S. Morony, S. Kleitman, Y. P. Lee and L. Stankov, Predicting achievement: confidence vs self-efficacy, anxiety, and self-concept in Confucian and European countries, International Journal of Educational Research 58 (2013), 79-96.

[30] C. Pearlman, The effects of level of effectance motivation, IQ, and a penalty/ reward contingency on the choice of problem difficulty, Child Development 55(2) (1984), 537-542.

[31] J. Relich, Gender, self-concept and teachers of mathematics: effects on attitudes to teaching and learning, Educational Studies in Mathematics 30(2) (1996), 179-195.

[32] W. H. Schmidt and T. Tatto, Developing subject matter knowledge in mathematics middle school teachers: a cross-national study of teacher preparation as a follow-up of TIMSS (PTEDS), East Lansing, Michigan, Center for Research in Mathematics and Science Education, Michigan State University, U.S.A., 2006.

[33] A. H. Schoenfeld, Toward a theory of teaching-in-context, Issues in Education 4(1) (1998), 1-94.

[34] L. Stankov, J. Lee, W. Luo and D. J. Hogan, Confidence: A better predictor of academic achievement than self-efficacy, self-concept and anxiety? Learning and Individual Differences 22(6) (2012), 747-758.

[35] T. Tosun, The beliefs of preservice elementary teachers toward science and science teaching, School Science and Mathematics 100(7) (2000), 374-379.

[36] M. C. Tse, Mathematics teachers are no longer intimidated by students' questions - the mathematics knowledge required for primary and secondary teachers, N. Y. Wong, ed., Mathematics Cabinet Series 14 (2012), 1-91.

Retrieved from http://www.edb.gov.hk/attachment/tc/curriculum-development/kla/ma/res/Cabinet%2014.pdf

[37] X. Ma and J. Xu, Determining the causal ordering between attitude toward mathematics and achievement in mathematics, American Journal of Education 110(3) (2004), 256-280.

[38] P. Youngs and H. Qian, The Influence of university courses and field experiences on Chinese elementary candidates' mathematical knowledge for teaching, Journal of Teacher Education 64(3) (2013), 244-261.

[39] E. Zakaria and N. M. Nordin, The effects of mathematics anxiety on matriculation students as related to motivation and achievement, Eurasia Journal of Mathematics, Science and Technology Education 4(1) (2008), 27-30.

[40] R. Zan, L. Brown, J. Evans and M. S. Hannula, Affect in mathematics education: an introduction, Educational Studies in Mathematics 63(2) (2006), 113-121.

Appendices

Appendix A. Section B of Survey 1 measuring non-cognitive variables

	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
1. I could be happy to get top grades in mathematics.					
2. I do not think I could do advanced mathematics.					
3. Generally I have felt secure about attempting mathematics.					
4. I do as little work in math as possible.					
5. Being first in a mathematics competition would make me pleased.					
6. I have a lot of self-confidence when it comes to math.					
7. Mathematics usually makes me feel uncomfortable and nervous.					
8. Once I start trying to work on a math puzzle, I find it hard to stop.					
9. I do not like people to think I am smart in math.					
10. I am sure that I can learn mathematics.					
11. Math does not scare me at all.					
12. I am challenged by math problems I cannot understand immediately.					

13. Being regarded as smart in mathematics would be a great thing.
14. I am not the type to do well in math.
15. Mathematics makes me feel uncomfortable, restless, irritable, and impatient.
16. I would rather have someone give me the solution to a difficult math problem than to have to work it out for myself.
17. If I got the highest grade in math I could prefer no one knew.
18. I think I could handle more difficult mathematics.
19. I get a sinking feeling when I think of trying hard math problems.
20. The challenge of math problems does not appeal to me.
21. It would make me happy to be recognized as an excellent student in mathematics.
22. I can get good grades in mathematics.
23. A math test would scare me.
24. It would be really great to win a prize in mathematics.
25. I am sure I could do advanced work in mathematics.
26. Mathematics makes me feel uneasy and confused.

27. When a question is left unanswered in math class, I continue to think about it afterward.	
28. If I had good grades in math, I would try to hide it.	
29. I am no good in math.	
30. My mind goes blank and I am unable to think clearly when working mathematics.	
31. When a math problem arises that I cannot immediately solve, I stick with it until I have the solution.	
32. I could be proud to be the outstanding student in math.	
33. Most subjects I can handle O.K., but I have a knack for flubbing up math.	
34. I almost never have gotten shook up during a math test.	
35. I like math puzzles.	
36. People would think I was some kind of a grind if I got A's in math.	
37. Math has been my worst subject.	
38. I usually have been at ease in math classes.	
39. Figuring out mathematical problems does not appeal to me.	
40. Winning a prize in mathematics would make me feel unpleasantly conspicuous.	
41. I usually have been at ease during math tests.	
42. It would not bother me at all to take more math courses.	

43. Math puzzles are boring.

44. It would make people like me less if I were a really good math student.

45. For some reason even though I study, math seems usually hard for me.

46. I have not usually worried about being able to solve math problems.

47. I do not understand how some people can spend so much time on math and seem to enjoy it.

48. Mathematics is enjoyable and stimulating to me.

Appendix B. Sample of questions and corresponding scoring rubrics

Item set 2

Each vector has direction and magnitude, where the directions of λa, where λ is a scalar and a are the same. Students query about the direction of 0? Similarly, they wonder if the direction of 0 is the same as the directions of i and j (since $0 = 0i = 0j$). That means, the directions of i and j are the same.

Q2. As a teacher, which one, do you think, is the best description about the characteristic of 0 vector?

(a) Direction depends on the existence of magnitude, vector 0 has no magnitude, we cannot write 0 in terms of i and j.

(b) Vector 0 is directionally undefined, or the direction of 0 is not well-defined. Hence, the equality $0 = 0i = 0j$ does not imply that $i = j$.

(c) Vector 0 possesses infinite many directions. We cannot say definitely that $0 = 0i = 0j$.

(d) i, j are unit vectors. $v = \alpha i + \beta j \ (v \neq 0)$ is defined for scalars α, β, where they are not both 0. And 0 vector cannot be expressed as $0i$ or $0j$ explicitly.

Topic	*Vectors*	Type	*Multiple choice*	Score	2

Rubric:

The explanation of why "0*i* = 0*j* does not imply *i* = *j*" is the analogue statement "0*a* = 0*b* with *a*, *b* $\in$ *R* does not imply that *a* = *b*".

On the other hand, as it is not well-defined yet if 0*j* = 0 or 0*i* = 0. We cannot say that "*i* = *j*".

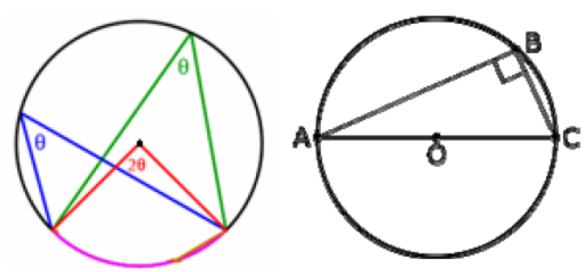
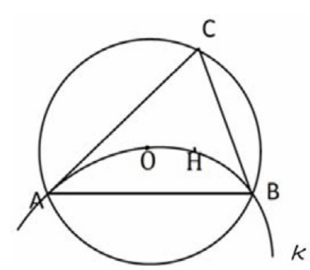
In fact, vector 0 is directionally undefined, or the direction of 0 is not well-defined.

The conceptual misunderstanding can be easily developed when we multiply a scalar with a vector, which is different from the mathematical principles of multiplying two scalars.

Answer: (b).

Source: Tse, 2012. Mathematics Cabinet Series.

<u>Item set 16</u>

<table>
<tr><td colspan="2">You have taught students that in the figures below:

</td></tr>
<tr><td>Students have to solve the following problem:
Let O and H be the circumcenter and the orthocenter of ΔABC, and let A, B, O, H lie on circle k.</td><td>
</td></tr>
</table>

Q16. Find the expressions for $\angle AOB$ and $\angle AHB$ in terms of $\angle ACB$. And explain why AB is not a diameter of k.

Topic	*Plane geometry*	Type	*Short questions*	Score	6

Rubric:

Solution (scores)	Explanation
$\angle AOB = 2\angle ACB$ (1) $\angle AHB = \angle AOB$ (1) $= 2\angle ACB$ (1) Since BH produced cuts AC at 90° (1) $\therefore$ $\angle AHB \neq 90°$ (1) $\therefore$ AB is not a diameter of k. (1)	Since O is the circumcenter. Since A, B, O, H are concyclic.
Total scores	6 marks

Adopted from Schmidt et al. [32] PTEDS. E40.