Improving Pedagogical Content Knowledge On Rational Numbers Of Cambodian Teacher Trainers

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Abstract

Despite adequate facilities and several education reforms, most Cambodian teacher trainers fail to provide sufficient content knowledge and student-centered pedagogy. Many also lack the skills to diagnose pre-service teachers' misconceptions and to propose adequate solutions. Dictating lessons with little feedback or applied activities or having pre-service teachers copy off the board for extended periods, suggests low-quality instruction (Tandon & Fukao, 2015). To tackle this, the Flemish Association for Development Cooperation and Technical Assistance (VVOB- *education for development*)[1] developed a 3-year (2014-2016) programme in close collaboration with the Cambodian Ministry of Education, Youth and Sport (MoEYS). The programme was rolled out in all primary teacher training colleges (PTTCs). One of the interventions in this programme aimed at improving both Pedagogical Content Knowledge (PCK) and Content Knowledge (CK) on rational numbers of mathematics teacher trainers, with a focus on 1) mathematics content knowledge, 2) the use of representations to enhance pre-service teachers' understanding, 3) assessing pre-service teachers' learning, and 4) addressing misconceptions. A total of 54 mathematics teacher trainers participated in this intervention. Their capacity was built through training, coaching, mentoring and try-outs with pre-service teachers. The impact of the intervention was measured through a pre-test post-test design, enriched by qualitative data collected during 97 lesson observations. After the intervention, 91% of the teacher trainers had significantly increased their score on the PCK test and 94 % had improved their teaching strategy in at least two of the three criteria of PCK. In this paper, the design and impact of the intervention are explained, and suggestions for further research are provided.

Keywords

Content Knowledge, Pedagogical Content Knowledge, Teacher Education, Misconceptions, Coaching, Mentoring, Teacher Trainer, Mathematics, Pre-service teachers

Introduction

Since the end of the Pol Pot regime, the curriculum of general education in Cambodia has gone through several major reforms. In the early 1980s, Cambodia's education systems were restructured, and this progress was marked as the country's recommitment to socio-economic development and expanding educational opportunity (Dy, 2004).

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In the period 1979-1986, the general education system consisted of 10 years (4+3+3): four years of primary education, three years of lower secondary education, and three years of upper secondary education (Hang, 2016). In the 1986-1996 period, the system changed into an 11-year (5+3+3) trajectory. From 1996 onwards, the general education system contained 12-years in school (6+3+3). There has been a shortage of qualified teachers throughout these reforms and the recruitment of teachers and teacher trainers was not well-structured.

As stated in Hang (2016), teacher training in the early eighties consisted mainly of short courses to upgrade the knowledge of former teachers, students and educated individuals who had survived the Pol Pot regime. The duration of these training courses varied between one and three months. In 1983, the Ministry of Education published teacher standards for preservice preschool and primary schools. In the first phase, becoming a primary school teacher involved the completion of grade 7 followed by one year of teacher training. Due to the lack of teachers, these standards were reduced in some disadvantaged and remote areas to one year of teacher training after completing grade 5 or even grade 3.

Between 1986 and 1996 the requirements for graduating as a primary school teacher were changed: pre-service teachers needed at least nine years of basic education to enter a two-year teacher training course, for lower secondary it was 11 years plus 2 additional years, and for upper secondary teachers a foundation of 11 years schooling was needed to enter a 3 -year teacher training course.

Since 1996, the trajectory to become a primary school teacher is 12 years of general education (9 years for disadvantaged and remote provinces) followed by 2 years of teacher training. Teacher Training Centers (TTCs) in Cambodia are comprised of four categories: (1) teacher training for pre-school teachers at the Pre-School Teacher Training Center (PSTTC); (2) teacher training for primary school teachers at Provincial Teacher Training Centers (PTTCs); (3) teacher training for lower-secondary teachers at Regional Teacher Training Center (RTTC); and (4) teacher training for upper secondary teachers at the National Institute of Education (NIE).

The Teacher Policy Action Plan (MoEYS, 2015) is a multiyear plan intended to bring Cambodian education into the 21st century. This ambitious plan includes, among other changes, a reform of the teacher training curriculum into a 4-year bachelor, the development of Teacher Educator Provider Standards and the establishment of a Teacher Career Pathway, all elements in the educational reform intended to bring Cambodian education closer to the inspiring level of several Association of Southeast Asian Nations (ASEAN)[2] countries.

Due to the impact of Pol Pot's regime and the above described reforms in general education and teacher training, the background of today's teacher trainers at the PTTCs is very diverse. Some of the teacher trainers started their career as primary school teachers before entering PTTC. Others finished only lower secondary school (grade 7, or 8 or 9) while some finished upper secondary school (grade 11 or 12) and graduated from the two-year teacher training programme from either PTTCs or RTTCs. Some teacher trainers graduated from university with a bachelor's degree and continued a one-year pedagogical training at NIE. These different levels of qualifications are also reflected in teacher trainers' understanding of math. Research shows different levels of CK and PCK. Literature suggests that to provide insightful instruction, CK is not sufficient; it requires PCK, which involves teachers' understanding which combines knowledge of subject content, of students' understanding, and of pedagogy (Ball, Lubienski, & Mewborn, 2001; Baumert et al., 2010; Kunter et al., 2013; Rowan et al., 2001).

In addition, there is a significant

relationship between the PCK of primary school teachers' and grade 3 learners' achievements in Cambodia (Ngo, 2013). PCK of teachers has the largest impact (of several elements defined as part of 'teacher quality') on learning outcomes, even when you control for learner and school characteristics. However, in the lowest quintiles of pupil scores, teacher quality is not as significant as student background or school characteristics in predicting student achievement. These findings strongly suggest that, compared to other elements of teacher quality, teacher PCK is a strong predictor of learners' achievement in mathematics. Learners will benefit from having a teacher who is able to identify pupil errors and who has deeper knowledge of mathematical reasoning. In addition, previous studies suggest that teacher training and professional development system for teacher trainers strengthen both subject and PCK (Benveniste, Marshall, & Araujo, 2008; Kleickmann et al., 2013).

Despite the evidence of the importance of teachers' PCK for pupils' learning outcomes, the PCK of mathematics teacher trainers in Cambodia was reported to be very limited (Tandon & Fukao, 2015). Tandon and Fukao (2015) also found that many teacher trainers had even lower knowledge of math than grade 9 pupils, which resulted in limited capacity to diagnose students' mistakes and to generate effective learning of future teachers. An essential teacher ability is to understand students' mathematical thinking, including common errors made by students, and the importance of students' misconception of their progress and achievement in the test (Hill, Ball and Schilling 2008; Sarwadi & Shahrill, 2014). Many teacher trainers did not have the skills to diagnose misconceptions and to propose adequate solutions for their pre-service teachers. Low quality instructional methods are still used by many teacher trainers, such as dictating lessons with little feedback or applied activities, and having pre-service teachers copy off the board for extended periods (Tandon & Fukao, 2015).

To tackle this, VVOB developed a 3-year (2014-2016) programme in close collaboration with the Cambodian Ministry of Education, Youth and Sport (MoEYS). One of the interventions in this programme aimed to improve both PCK and CK on rational numbers of mathematics teacher trainers. The impact of the intervention was measured through a pre-test post-test design, enriched by qualitative data collected during lesson observations.

Description of the Intervention

The VVOB-MoEYS Cooperation Program was designed to strengthen the quality of pre-service teacher training for primary education in Cambodia. This intervention fits in with the overall objective, to strengthen primary school teacher education in order to improve learning outcomes in mathematics for all learners. To ensure the quality of primary teacher education, PTTCs play an important role in training the prospective primary teachers. The intervention programme, therefore, included all mathematics teacher trainers from 18 PTTCs.

The intervention described in this paper aimed at improving both PCK and CK on rational numbers of mathematics teacher trainers, with a focus on 1) mathematics content knowledge, 2) the use of representations to enhance students' understanding, 3) assessing pre-service teachers' learning, and 4) addressing misconceptions following the concepts of Shulman (1986). Rational numbers are amongst the most difficult topics in the elementary school curriculum, and teaching that topic requires an adequate knowledge base for teachers to properly deal with students' difficulties, so it was selected for the intervention.

A total of 54 mathematics teacher trainers participated in this intervention. The capacity building trajectory started in May 2014 and was completed in August 2016. The course took 23 days consisting of 15-day input training and 8-

day refresher training. Try-out sessions with pre-service teachers were embedded in all trainings.

The 23-day course consisted of:

- A 5-day module on rational numbers, based on the Basic Education and Teacher Training manuals (MoEYS, 2011)
- A 5-day module on how to produce and use teaching aids for math in primary education and a 4-day refresher training
- A 5-day module on formative assessments for primary education and a 4-day refresher training

The training was facilitated by a core team of 12 experts in mathematics, attached to different departments within the Cambodian Ministry of Education (Teacher Training Department, Department of Curriculum Development, Primary Education Department and Provincial Teacher Training Colleges). Participants were divided into groups of 25 and 30 participants per two facilitators. PTTC management in charge of technical teaching were invited to these training sessions in addition to math teacher trainers. Beside sessions on understanding specific math topics, participants had a chance to tryout the content with their pre-service teachers and their peers, to apply peer learning, and to share their experiences during subject group meetings in their own Teacher Training College.

The second part of the learning trajectory consisted of coaching and mentoring sessions, based on lesson observations. The same mathematic core team observed the lesson of teacher trainers in each PTTC. After each lesson observation, they provided coaching and mentoring to the teacher trainers to encourages collaborative and reflective practice. Coaching allowed teacher trainers to apply their learning more deeply, frequently, and consistently than working alone. Each teacher trainer was observed twice during the learning trajectory. The focus of these follow-up visits was on: assessment of learning, addressing the misconceptions, and using the representation in the mathematics lesson. In the meantime, teacher trainers also reflected and translated content of their lessons into how prospective teachers apply the instructional strategies. Each observation was a part of coaching process consisting of constructive feedback, following the structures of the 6 feedback steps (MoEYS, 2016). Recordings were also used to analyze the challenges of math teacher trainers; these issues were tackled during the following training or reflection sessions.

Measuring the Impact of the Intervention

Assessment Tools

1. Pedagogical Content Knowledge and Content Knowledge Test

Depaepe et al. (2015) developed the test in line with the Cambodian context to gather information about the level of mathematics teacher trainers' CK and PCK. Depaepe et al. (2015) defined CK of rational number as conceptual and procedural knowledge about the rational numbers domain, as well as, PCK as knowledge of students' misconceptions and buggy procedures about rational numbers and of multiple representations to prevent and/or remedy these misconceptions and buggy procedures. The definitions of PCK and CK are in alignment with Shulman's conceptualization of PCK (Shulman, 1986).

The test was composed of 48 questions with 50% PCK questions and 50% CK questions. Depaepe et al. (2015) distinguished between two types of PCK items, namely (1) knowledge of students' misconceptions and (2) knowledge of instructional strategies and representations. In addition, questions were categorized in two domains of rational numbers: fractions (50%) and decimal numbers (50%). More detailed information is shown in Table 1. Each item has a maximum score "1", for an entirely correct answer. In case of an incorrect answer, "0" was assigned. On the questions related to operation, answers were scored "1/2" if they were partly correct. This is shown in Table 1.

2. Lesson Observation Checklist

The forms used to observe lessons consisted of two parts. The first part of the observation checklist captures parts of the lesson linked to each of the following categories: (1) Teaching methodologies, (2) Teaching aids, (3) Learning content and lesson objective (knowledge, skills, attitude), (4) Student assessment strategies, (5) Pupil's behaviour (level of involvement and activity), (6) Pupil's learning outcomes (remembering/ understanding/applying/analysing/creating/judging) and (7) General lesson characteristics (structure, build-up, etc). The information written down in this checklist was used for the reflection after the lesson.

The core team would use written notes as the base for the reflection sessions which followed, including coaching, mentoring and providing constructive feedback. The coaching sessions were structured using 6 steps: 1) introduction, 2) the coaches shares the results of their teaching, 3) coach give feedback, 4) the coach ask the coachees to respond to the feedback, 5) both parties discuss the ways for improvement, 6) Round up: remaining questions and making an appointment for the next meeting (MoEYS, 2016). Each session took 30 minutes and gave the teacher trainer the chance to reflect on their lesson and teaching strategy.

The second part of the observation form consisted of a scoring grid (see snapshot below). Based on the information collected in part one and the discussion after the lessons, the core team gave a score to three selected PCK criteria: assessment, misconception, and representation. The assessment part had 4 sub-criteria with a total score of 12, the misconception part

Table 1

Design of the CK and PCK test: distinguished subdomains and number of items

Domain	Sub-domain		CK	PCK	
				Misconception	Instruction
Fractions	Concept		4	2	2
	Operations	Addition	2	1	1
		Subtraction	2	1	1
		Multiplication	2	1	1
		Division	2	1	1
Decimal numbers	Concept		4	2	2
	Operations	Addition	2	1	1
		Subtraction	2	1	1
		Multiplication	2	1	1
		Division	2	1	1
	Total		24	24	

had 3 sub-criteria with a total score of 9, and representation had 4 sub-criteria with a total score of 12. The scoring table described clearly what needed to be observed for every level, and for each score. All sub-criteria were scored from 1 to 3, with a score of "1" being the lowest score, "2" the medium score, and "3" the highest score. The table also allowed for adding a justification for the score given, by adding examples in the 'Proof' column.

Table 2
Snapshot of scoring grid for PCK criteria 'Misconception'

Criteria	Code	Grading scale			Proof
		Level 1	Level 2	Level 3	
Misconceptions	B1	The teacher doesn't pay attention to mistakes.	The teacher helps students when they have made a mistake by repeating or referring to procedures.	The teacher tries to understand the students' thinking and helps them by explaining it in a different way. e.g. use of teaching aids to support the weaker students.	
	B2	The teacher doesn't check prior knowledge on the topic.	The teacher checks the prior knowledge of students.	The teacher checks the understanding of prior knowledge. e.g. Why did you put both fractions on the same denominator?	
	B3	The only questions that are used refer to knowledge.	The teacher asks some thinking questions. e.g. Why can't we just add the numerators and denominators?	The teacher asks many thinking questions	

Pre-Post Test Design

All respondents were assessed using a pre-test post-test design on PCK/CK. The pretest was administered in May 2014, the post-test in August 2016. Both were administered by the core team of 12 math experts under the supervision of VVOB project staff. The same team was also responsible for correcting and scoring the test. The testing phase was divided into two parts, the time allowed for each part (24 questions) was 120 minutes. To assure anonymity, VVOB collected all PCK-test forms and names were replaced by code before the correction process started.

In total 54 teacher trainers completed the pre-test, of those only 33 finished the post-test. The attrition was caused by different reasons such as retirement, workplace change, and job promotion. Besides assessing the tests, the project team also observed a lesson of each teacher trainer before, during and after the intervention to measure the progress and impact. In total 97 lessons were observed during thethree-year program. The forms used for these observations were the same as the observations tools used during the intervention for the follow-up visits, but on these occasions, not used with a coaching purpose. The focus of the pre-post observations was on using representations, misconceptions, and assessment.

Data Analysis

Descriptive and inferential statistics were conducted on data set. Percentage and frequency were used to describe respondents' information background related to the qualifications, years of experience, socio-demographic information, and the progress of achievement scores from lesson observation focusing on how to apply the formative assessment techniques, to addressing the misconceptions, and use of the representation. Moreover, another achievement was measured by pre and post-test of PCK. A paired t-test was performed to compare the mean score of both tests. Achievement was measured to determine if post-test scores increased significantly compared to pre-test scores, at significant level $\alpha = 0.05$.

Results

As described above the impact of the intervention was measured through a pre-test - post-test design; a group of 33 teacher trainers completed both tests. The paired-sample T-test found that the mean of the overall score on the post-test (M=33.2, SD=7.5) of teacher trainers is significantly higher than their score in pre-test (M=27.3, SD=7.5), with significant increase of 5.9 (95%CI: 3.94-7.93, $p<0.001$, $t(32)=6.044$).

The preliminary analyses show a great disparity between the scores of the teacher trainers. Descriptive data analysis showed that female teacher trainers performed better than their male peers in both pre-test and post-test, however this difference was not significant.

We also saw that the mean scores of (young) teacher trainers with less years of teaching experience, was higher than their senior peers in both pre-test and post-test. A clarification for this result could be found in the educational background of the teacher trainers. All young teacher trainers had graduated from university with a bachelor's degree, while most of the senior teacher trainers graduated from a 2-year programme at a teacher training college.

Table 3
Mean score by gender, years of experience and qualification

Categories of participants		Number	Mean score before intervention (SD)	Mean score after intervention (SD)
Gender				
	Male	28	26.8 (8.0)	32.1 (7.9)
	Female	5	28.2 (5.7)	36.6 (5.1)
Years of experience				
	Less or equal to 5 years	6	27.6 (6.5)	35.2 (5.0)
	Equal or more than 6 years	27	27.2 (7.8)	32.8 (7.9)
Qualification				
	Master	10	27.3 (8.6)	35.9 (8.0)
	Bachelor	13	28.5 (7.3)	33.7 (5.7)
	Teacher Training certificate	10	25.7 (7.0)	29.9 (8.5)
Overall score*		33	27.3 (7.5)	33.2 (7.5)

*Mean score after intervention is significantly higher than before intervention ($p<0.001$)

When we looked closer at the differences between PCK and CK tests, we noticed teacher trainers scored better in both on the post-test compared to the pre-test. The paired sample t-test showed a significant increase on both mean score of CK ($p<0.001$, $t(32)=4.165$) items with 95% confident interval of difference: 1.03-3.02 and PCK ($p<0.001$, $t(32)=5.493$) items with 95% confident interval of difference:2.45-5.35 after intervention. We noticed the scores on pedagogical content knowledge items increased much more ($t(32)=2.6$, $p=0.014$) , compared to the scores on related to pure content knowledge items. During coaching sessions, teacher trainers indicated that they had more difficulty answering the questions related to PCK than the CK items. Looking closer at the responses within the PCK items, we see teacher trainers struggled more with instructional strategies and representation (mean=6.3, SD=2.7) than explaining students' misconception (mean=8.0, SD=2.4) after intervention($t(32)=-4.64$, $p<0.001$). More details can be found in Table 4.

Table 4
Comparison of PCK test items and CK test items (pre-test and post-test)

Test items categories		Mean score (SD)		Mean Difference (SD)	95% CI	P
		Pre-test	Post-test			
PCK items		10.4 (4.5)	14.3 (4.7)	3.9 (4.1)	2.5-5.4	<0.001*
	Knowledge of students' misconception	5.6 (2.8)	8.0 (2.4)	2.4 (2.7)	1.5-3.4	<0.001*
	Knowledge of instructional strategies and representation	4.9 (2.3)	6.3 (2.7)	1.5 (2.3)	0.7-2.3	0.001*
CK items		16.8 (3.8)	18.9 (3.2)	2.0 (2.8)	1.0-3.0	<0.001*
	Concept	3.9 (2.1)	5.4(1.8)	1.5 (0.4)	0.8-2.2	<0.001*
	Operation	13.0(2.3)	13.1(2.0)	0.1 (1.9)	-0.6-0.8	0.7

* Statistically significant increase, at significant level $\alpha = 0.05$

Table 5
Progress on PCK/CK of fractions

Fraction test items		Mean score (SD)		Mean Difference (SD)	95% CI	P
		Pre-test	Post-test			
PCK items		4.2 (2.2)	6.8 (2.6)	2.6 (2.1)	1.8-3.3	<0.001*
	Knowledge of students' misconception	2.6 (1.3)	3.8 (1.6)	1.4 (1.5)	0.6-1.7	<0.001*
	Knowledge of instructional strategies and representation	1.6 (1.1)	3.0 (1.5)	1.4 (1.3)	1.0-1.9	<0.001*
CK items		7.8 (2.1)	9.0 (2.1)	1.2 (1.9)	0.6-1.9	0.01*
	Concept	1.7 (1.3)	2.6 (1.2)	1.0 (1.6)	0.4-1.5	0.001*
	Operation	6.2 (1.4)	6.1 (1.5)	−0.2(1.4)	−0.7-0.4	0.5

* Statistically significant increase, at significant level $\alpha = 0.05$

Table 5 provides a closer look at the differences between progress made related to understanding and teaching fractions compared to teaching and understanding decimals numbers. Table 5 shows the scores on both PCK and CK items on the questions about fractions. Teacher trainers performed significantly better on both PCK (t(32)=3.73, p=0.01)and CK items(t(32)=6.9, p<0.001) for fractions after intervention. However, no significant increase was found if we consider the scores for CK items related to operations with fractions. This can be explained by already high scores at the start of the intervention, approximately 6 over the scale of 8, in both pre-test and post-test.

Teacher trainers had more difficulty with fraction PCK items than fraction CK items in both pre-test (t(32)=-7.516, p<0.001) and post-test (t(32)=10.34, p<0.001). However, mean scores of fraction PCK (t(32)=6.901, p<0.01) items and fraction CK (t(32)=3.73 ,p=0.01 items were significantly higher after intervention.

Table 6 shows that teacher trainers performed significantly better on decimal CK items (t(32)=2.548, p=0.016) and decimal PCK items (t(32)=2.644 , p=0.013) after receiving capacity development. Nevertheless, they still struggled more with PCK items related to decimal numbers than CK items in both pre-test (t(32)=-6.888, p<0.001)) and post-test (t(32)=-7.104, p<0.001)). Teacher trainers performed better on knowledge of students' misconception (t(32)= 3.954 , p<0.001) after intervention, but they made no significant progress regarding the knowledge of instructional strategies and representations (t(32)=0.99 , p=0.922). The high score of CK on operation with decimal numbers (almost 7 on a maximum score of 8) is remarkable, although it is not statistically significant.

Table 7 presents the most challenging PCK items and CK items for teacher trainers, even they have taken a training course on rational number. The teacher trainers had more difficulty putting the fraction into words, and matching this with the corresponding section in the word problem. This challenge indicated that they had limited knowledge about how to translate real-life word problems into number sentences or vice versa, for example PCK item 1 and CK item

Table 6
Progress on PCK/CK of decimal numbers

Decimal test items	Mean score (SD)		Mean Difference (SD)	95% CI	P
	Pre-test	Post-test			
PCK items	6.2 (2.9)	7.6 (2.5)	1.3 (2.9)	0.3-2.3	0.013*
Knowledge of students' misconception	2.9 (1.8)	4.2 (1.4)	1.3 (0.3)	0.6-2.0	<0.001*
Knowledge of instructional strategies and representation	3.3 (1.6)	3.3 (1.6)	0.0 (1.8)	−0.6-0.6	0.922
CK items	9.0 (2.1)	9.8 (1.6)	0.8 (1.8)	0.2-1.5	0.016*
Concept	2.2 (1.1)	2.8 (1.1)	0.5 (0.9)	0.2-0.9	0.001*
Operation	6.8 (1.5)	7.1 (1.0)	0.3 (1.4)	−0.2-0.8	0.271

* Statistically significant increase, at significant level $\alpha = 0.05$

Table 7 The most difficult questions of PCK items and CK items after intervention

PCK/CK	Items	% correct response
PCK	Given: $\frac{3}{5}-\frac{1}{4}=\frac{7}{20}$ 1. Indicate and explain for each of the below mentioned word problems whether you would use them in your classroom to contextualize the above-mentioned operation. a) $\frac{3}{5}$ of a cake was used by dad. Sopheak and Sophy eat together $\frac{1}{4}$ of the remaining part of the cake. How much of the cake have they eaten? b) To fill a water basin we need $\frac{1}{4}$ of a completely filled open well. Today the open well is only filled for $\frac{3}{5}$. How much water remains in the open well after the water basin is filled? c) When frying vegetable dad uses $\frac{3}{5}$ of a small bottle of chili sauce and $\frac{1}{4}$ of a small bottle of soya sauce. How much chili and soya sauce remains?	15.2
	2. These are illustrations of elementary students' solutions. Samnang's solution: $0.5 \times 2.2 = 11$ Champey 's solution: $0.5 \times 2.2 = 1.1$ Malis's solution: $0.5 \times 2.2 = 4.4$ Determine the right or wrong solution. In case of a wrong solution, write down the presumable student's reasoning.	24.4
CK	1. If the rectangle below is $\frac{6}{5}$ of the surface of the original shape, draw the original shape. 	45.5
	2. Write down and solve the mathematical operation with fractions that fits the following problem: Somaly made $\frac{4}{5}$ liter of fresh fruit juice. She gave $\frac{1}{4}$ to her mother. How many liter of fresh fruit juice did her mother receive?	45.5

2 in table 7. After intervention, roughly 15% of teacher trainers answered PCK item 1 correctly and 45% of teacher trainers correctly answered CK item 2. Understanding how to address students' misconception or difficulties remained a challenge for mathematics teacher trainers after the intervention. As a result, approximately one-fourth of them could explain students' reasoning or misconception, when students provided a wrong answer.

After intervention, roughly 15% of teacher trainers answered PCK item 1 correctly and 45% of teacher trainers correctly answered CK item 2. Understanding how to address students' misconception or difficulties remained a challenge for mathematics teacher trainers after the intervention. As a result, approximately one-fourth of them could explain students' reasoning or misconception, when students provided a wrong answer.

In addition, teacher trainers had difficulties understanding the concept of 'fraction'. Only 45.5% could draw the original shape of $\frac{6}{5}$ in the rectangle correctly, CK question 1.

To follow up on the progress of teaching mathematics and coach the teacher during the implementation of the newly acquired skills, 94 mathematics lessons were observed by the expert teams. Each teacher trainer was observed 4 times (2 times as part of the pre-post test, and 2 times as part of the individual coaching sessions) by a team of two experts.

Descriptive analysis revealed that scores of the lesson observations gradually increased from roughly 69% of total score of 33 at the start of the intervention to 92.4% at the end. Teacher trainers improved most in the field of assessing their students. They also made progress in using representations and detecting students' misconceptions, but the upward growth trend was less pronounced. The percentage of achievement score in each criterion increased in second lesson observation in comparison with the first. Then the achievement score decreased eventually in relation to second observation. The score of the final lesson observation gradually increased in comparison to the previous three. Fluctuations in the score of the third observations were caused by an increase of teacher trainers in the cohort. Those additional teacher trainers were not mentored and coached by the expert team in the first and second lesson observations so their achievement score from lesson observation were lower than their peers included from the beginning in the learning trajectory. This indicated once more the importance of coaching and mentoring for strengthening teachers' capacity. Teachers also confirmed during the evaluation of the programme how beneficial the coaching sessions after each lesson observation were for improving their future teaching.

Looking at the data in Table 3 and Table 6, it becomes clear that the use of representations during math lessons is the most challenging area of PCK. Teacher trainers underperformed during lesson observations, and on the test items related to using representations. It is encouraging that teacher trainers' capacity in this area increased compared to their performance at the beginning of programme.

Discussion and Conclusions

Our findings highlight the urgent need to improve the preparation of future teachers with respect to subject-matter knowledge (CK and PCK). We described an intervention to improve teacher trainers' content knowledge (CK) and pedagogical content knowledge (PCK) on fractions and rational numbers. The results revealed gaps in teacher trainers' CK and PCK for fractions and decimal numbers. Most of these gaps were significantly reduced by the end of the intervention. After the intervention, 91% of the total teacher trainers who were observed by the math expert team had significantly increased their score on the PCK test and 94% had improved their teaching strategy in at least two of three criteria (representation, misconception, and assessment). The results

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Table 8 Progress on mathematics teaching of teacher trainers

Date Follow up	Number Number of lesson observations	Score achievement of PCK areas			total achievement (% of 33)
		Represents (% of 12)	Misconceptions (% of 9)	Assessments (% of 12)	
1. Apr-2014	11	(75.0)	(58.9)	(68.9)	(68.9)
2. Apr-2015	11	(90.2)	(83.8)	(85.6)	(86.8)
3. Jan-2016	36	(83.5)	(81.9)	(88.8)	(85.0)
5..Jul-2016	36	(89.2)	(91.0)	(96.8)	(92.4)

confirmed the importance of coaching and mentoring as key elements of success in strengthening the capacity of teacher trainers.

Limitations

Pre- and post-tests (as well as the intervention itself) were limited to fractions and decimal numbers. There was no control group, which limits the generalizability of the findings. Studies assessing teachers' competence in other domains are required as well as within the domain of mathematics. The high turnover of teacher trainers during the intervention, made comparison of pre- and post-test results difficult, as the size of the sample became too small to make certain conclusions. Another limitation was the creation of the assessment tool. Since no valid PCK test was available for Cambodian teachers, we used a validated PCK test developed by the University of Leuven (Belgium). Giving priority to the reliability of the test, there was little room for modifications of the items, resulting in less opportunity to adjust the items to the Cambodian context. Translation challenges (Dutch-English-Khmer) also complicated the understanding of the items for test administrators and the participants. Finally, by tailoring the learning trajectory to the needs of the teacher trainers, not all math topics tackled during the training were part of the standard PCK test. Conversely, some math items included in the assessment tool, were not part of the learning trajectory.

It would be interesting for future interventions to study the relationship of PCK and CK of teacher trainers with the learning outcomes and teaching skills of pre-service teachers. Research has shown that coaching allows teachers to apply their learning more deeply, frequently, and consistently than teachers working alone, and we strongly believe coaching is important to make teacher trainers reflect and adjust their teaching practices. However more research is needed on how coaching supports teacher trainers to improve their capacity to reflect and apply their learning to their work with pre-service teachers and in their work with each other.

Notes

1. VVOB stands for Vlaamse Vereniging voor Ontwikkelings-samenwerking en technische Bijstand Dutch It means Flemish Association for Development Cooperation and Technical Assistance.
2. The Association of Southeast Asian Nations is a regional intergovernmental organization with the purpose of facilitating economic growth, social progress
and cultural development that includes ten Southeast Asian countries.

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