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Assessing the Rigour of the Mathematics Courses Being Used to Prepare Primary School Teachers

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It was perceived that a good place to start in understanding why teacher graduates were not demonstrating expected levels of conceptual knowledge (CK) and skills, and pedagogical content knowledge (PCK) is to examine the written curriculum used in teacher preparation institutions. This study utilised a mixed methods approach to evaluate the courses that are used in five teachers' colleges in Jamaica. Four content courses and one methodology course were collected from the Joint Board of Teacher Education (The accrediting body for Teacher Education in Jamaica). Four raters independently ranked each course objective on Webb's Depth of Knowledge model in order to determine the number of the objectives that are focused on the development of CK and skills. They also matched the course objectives of the methodology course against Shulman's description of PCK in order to determine the number of course objectives that focussed on PCK. Also, N=6 teacher educators were interviewed to gain a deeper understanding of the findings that emerged from the curriculum evaluation. The findings show that 0% of the methodology course addressed PCK, making it likely for teachers to exit preparation programmes without being provided with adequate opportunities to develop PCK.

Keywords: pedagogical content knowledge, conceptual knowledge, mathematics, course evaluation, teacher preparation programme

INTRODUCTION

Background

Since the 1980s it was realised that two critical requirements for ensuring high-quality mathematics instruction are that teachers must have mastery of: (i) the content they will teach and (ii) the knowledge and understanding of how to teach the content for it to be easily understood by students (Shulman,1986). However, further observations of the outcome of the teaching and learning of mathematics during the 1980s and beyond have demonstrated that many children across the globe, including Jamaica, were merely able

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to reproduce facts and procedures without having knowledge and understanding of mathematics concepts and skills (NCTM, 2014; Ministry of Education, 2013). One consequence of this is students at the end of secondary school were not able to use the mathematics they have learned to contribute to society's growth and development (Bell-Hutchinson, 2008; Ministry of Education, 2013). They were unable to use "school mathematics" to solve real-world problems and create innovations. It was further recognised that learners who understand the core concepts that underpin the mathematics algorithms they learned in school were able to use their mathematics knowledge to respond to circumstances outside of those that were illustrated in their classrooms (NCTM, 2014). Consequently, like other countries, Jamaica has recognised the need for its teachers to possess knowledge and understanding of mathematical concepts (The United Nations Educational, Scientific and Cultural Organization [UNESCO], 2021). The data in Jamaica showed that less than 20% of secondary school graduates have achieved qualifications in mathematics and less than 53% of primary children are leaving primary schools without competencies in basic mathematics ideas (Ministry of Education, 2013; Ministry of Education 2019)

Currently, Jamaica's National Mathematics Policy Guidelines advocate for mathematics teachers to have not only knowledge of content as it relates to having the ability to reproduce algorithms that produce correct answers but to also have knowledge of concepts (conceptual knowledge), along with knowledge of best practices to teach mathematics topics (pedagogical content knowledge) (Ministry of Education, 2013). This requirement is consistent with those of other countries where students experience high mathematics achievement, and the requirements are well in alignment with research findings (Mullis, Martin, Foy, Kelly, & Fishbein, 2020). Further, there is consensus within the research community that teachers with high levels of conceptual knowledge and skills, and pedagogical content knowledge (PCK) achieve greater success in the mathematics classroom (Ministry of Education, 2013; NCTM, 2014). Therefore, the request from the Jamaican Ministry of Education for its teachers of mathematics to have conceptual knowledge and pedagogical content knowledge appears logical and practical (Ministry of Education, 2013).

It seems reasonable to accept that a teacher who does not understand the concept of 'volume' might find it challenging to help students understand this. Likewise, a teacher who struggles with choosing teaching approaches that are appropriate for a particular mathematics topic; selecting appropriate examples, identifying appropriate illustrations and diagrams as well as understanding what makes the topic difficult is likely to fail at helping students to achieve their full potential in mathematics.

Based on the premise that conceptual knowledge and pedagogical content knowledge are essential knowledge that teachers need to possess to successfully teach mathematics, it seems reasonable to expect that the courses that are offered within teachers' colleges would be designed with a great focus on these types of knowledge. However, the undesired outcome of the preparation of teachers of mathematics (low levels of CK and PCK) provides a rationale to question whether the courses are designed with the focus being placed on these knowledge and skills. In addition, a review of the literature has

revealed that although research has been done that examined the courses used in teacher preparation programmes (Morales-Lopez, 2017; Ruiz, 2017), there remains an absence of literature that examined the extent to which the courses used in teacher preparation programmes focussed on the development of CK and skills, and PCK. It is against this backdrop that this research was conceptualised and conducted.

An additional consideration in conducting this study is the perceived contribution that this research will add to the body of literature on this topic within Jamaica, the Caribbean, and internationally. This study will provide insights into a possible methodological approach that can be used to measure the extent to which course objectives used in teachers' colleges focus on the development of conceptual knowledge and skills and pedagogical content knowledge. An extensive review of the literature revealed that although pre-service teachers' levels of CK and PCK have been measured using tests, surveys, observations and interviews, scant research has been done on measuring the level of focus of CK and PCK of the courses that are offered in teachers' colleges with the intent to provide insights into whether teacher preparation programmes provide enough opportunities for teachers to develop these knowledge and skills.

Problem

Teachers at the end of their preparation are not demonstrating expected levels of conceptual knowledge and skills, and pedagogical content knowledge (Bell-Hutchinson, 2008; Benjamin 2013; Ministry of Education, 2013). One consequence of the teachers inadequate levels of CK and skills, and PCK is students at all levels of the education system are underachieving in mathematics (Ministry of Education, 2013). Teachers low levels of conceptual knowledge and skills, and PCK at the end of their preparation begs one to consider whether the courses offered in teachers' colleges in Jamaica were designed to provide adequate opportunities for teachers in preparation to develop such types of knowledge and skills. In Jamaica, there had been a lot of speculations that the teacher preparation programmes, offered in institutions might inadequately address these issues, but there still remained a need for empirical data to confirm or disconfirm the speculations. Consequently, this research intended to provide evidence that can lead to definitive conclusions of a possible area that might need to be improved as a means of preparing better teachers of mathematics.

Research Purpose

The purpose of this research is to examine the written curriculum to determine the extent to which it was designed to adequately support the development of conceptual knowledge and skills, and pedagogical content knowledge. It is against this context that the following research questions were developed.

1. To what extent the written curriculum was designed to enable pre-service teachers to develop conceptual knowledge and skills?
2. To what extent the written curriculum was designed to enable pre-service teachers to develop pedagogical content knowledge?
3. What assertions explain the outcome of the curriculum evaluation?

Significance

The findings of this work provided stakeholders of teacher preparation programmes with significant insights into the programme design issues that were impacting the outcome of teacher preparation. Accordingly, they are now able to identify and determine the appropriate remedy for the problem. It is also perceived that this study has the potential to benefit any education system with a similar context to that found in Jamaica. Specifically, teacher educators, teachers and students will gain the reward when any deficiencies with the design of the courses used in teachers' preparation institutions, are illuminated to enable appropriate remediation.

Conceptual Framework and Literature Review

To determine the lens through which conceptual knowledge and skills can be examined several models were examined such as The National Assessment of Educational Progress (NAEP) and Webb's Depth of Knowledge (DOK) Model. However, Webb's Depth of Knowledge model (Webb, 1997) was selected for use in this study since it is currently being used in Jamaica to support the newly introduced National Standard-based Curriculum. Webb's Depth of Knowledge (Webb, 1997) model has four levels:

Level one focusses on basic recall and reproduction of information. This includes the recall and reproduction of facts such as definition of terms, algorithms, applying formulae and the listing of the properties of shapes. One example of an appropriate objective for level one is one that requires learners to calculate the area of a triangle given the base and perpendicular height using the formula, *½ b* x *h.*

Level two focusses on conceptual knowledge and skills where learners are provided with an understanding of why the algorithms work. For example, an objective that focusses on the concept of 'area' as being the number of square units that cover a surface, rather than merely being given a formula. Additionally, level two focusses on skills such as estimation, conversion and measurement.

Level three focusses on engaging learners in higher-order thinking. This includes objectives that concentrate on having learners evaluate, analyse and solve real-world problems. For example, an objective that requires learners to evaluate the number of tiles of a specific size to cover the surface of a room of a specific size would be appropriate for level three.

Level four focusses on engaging learners at the highest level of cognitive demands and requires learners to pull on their knowledge and understanding of several topics. This includes engaging learners in project-based and performance tasks.

Pedagogical Content Knowledge

Webb's (DOK) model was used to measure conceptual knowledge and skills, but it was not viewed as an appropriate lens to evaluate pedagogical content knowledge (PCK). Therefore, Shulman's (1986; 1987) description of pedagogical content knowledge is used as the frame from which PCK was determined. According to Shulman (1986;1987), PCK is described as knowledge of the most appropriate analogies, useful

forms of representations, illustrations, examples, explanations and demonstrations that can be used to represent the content for it to be easily understood by learners. Additionally, PCK represents an understanding of what makes a particular subject content difficult or easy to learn. Further, PCK can be interpreted as theoretical knowledge that might be evident in practice. Consequently, the courses would be examined on the basis that the objectives that are focussed on the development of PCK would be aligned with Shulman's description.

Difference between Pedagogical Content Knowledge (PCK) and Pedagogical Knowledge

Shulman, (1986) argues that some educators often struggle to accurately distinguish between pedagogical knowledge and pedagogical content knowledge. It is perceived that since this research is focussed on evaluating the courses for PCK, then this distinction must be clearly understood and articulated to prevent a situation where pedagogical knowledge is mistakenly identified as PCK. Since PCK was described earlier, only the description of pedagogical knowledge will be expressed. Shulman (1987) describes pedagogical knowledge as professional knowledge that focuses on knowledge of the principles and strategies for classroom management and organisation that are cross-curricular. This includes general knowledge of teaching strategies such as collaborating groups and differentiated instruction, and behaviour management techniques.

The Development of Conceptual Knowledge (CK) and Pedagogical Content Knowledge (PCK)

Conceptual knowledge is developed when learners are put in a position where they explore the concept that undergirds a topic or when learners are directly taught mathematics concepts (NCTM, 2014). This suggests that the curriculum objectives and/or learning outcomes used in teacher preparation institutions should be articulated in a way that indicates to teacher educators that attention must be placed on the development of knowledge of concepts, "why the algorithm works", rather than building computational fluency.

On the other hand, PCK is developed when pre-service teachers are given the opportunity to explore best practices, grounded in contextual considerations, for teaching the curriculum topics for which they are being prepared to teach (Kilic, 2011). This perspective is supported by Alimuddin et al (2020), as they have defined PCK as the teacher's knowledge of how to effectively deliver a subject's content in the classroom. Additionally, PCK is developed when pre-service teachers are mentored by a content expert in a practice environment, as well as when they engage in learning activities that allow them to critically analyse teaching episodes (Loughran, 2006).

Curriculum Assumptions

A curriculum is usually designed based on certain assumptions about knowledge acquisition, as well as what is worth learning and experiencing (Deng, 2022). In the context of the preparation of teachers of mathematics, it seems reasonable to assume that

during the design of a teacher preparation programme, considerations would be given to the types of knowledge that teachers would need to effectively facilitate mathematics learning. Accordingly, the assumption is that the courses offered in teacher preparation institutions would address a subject matter (Conceptual and procedural knowledge) as well as knowledge about best practices for teaching the mathematics topics (PCK). Additionally, the expectation is the knowledge and understanding garnered from empirical evidence on how teachers in preparation come to acquire the specific types of professional knowledge should be explicitly articulated in the courses as the pedagogy that should guide the classroom practice of teacher educators.

According to Loughran (2006), the pedagogy that should guide the practice of teacher educators is *explicit modelling*. Explicit modelling requires teacher educators to not only model the type of teaching they expect from pre-service teachers but to also invite student-teachers to critically analyse their practice. Teacher educators are expected to invite student-teachers to examine and reflect on why certain decisions about the teaching episode were taken over others, what actions worked and what might need to be revised and be the focus for the next lesson. It is believed that the Explicit modelling pedagogy will help pre-service teachers gain an understanding of the rationale for teaching a specific topic using a particular approach as well as provide insights into what teaching practices work and why they work or don't work.

Curriculum Evaluation

Worrell, Brabeck, Dwyer, Geisinger, Marx, Noell, & Pianta, (2014) warned that the evaluation of the written curriculum is ideal to determine whether the content covered within the teacher education programme was sufficient to prepare high quality teachers. However, they postulate that course outlines do not always reflect issues relating to pedagogy, assessment and teaching practice. What is reflected on the written curriculum is often left to interpretation by educators, and for that reason, in some cases, the written curriculum was not necessarily delivered as intended. Consequently, the evaluation of the course document solely, can only draw conclusions about the content that is offered in teacher preparation and not about the quality of teacher preparation.

Limitations with Curricula used in Teachers' Colleges.

Over the years, researchers have speculated that much of the problems with courses taught in teacher preparation institutions is that they are often outdated and obsolete as they often do not address the changes in society, which cause them to be unresponsive to current demands and issues of current times (Benjamin, 2013; Morales-Lopez, 2017; Ruiz, 2017). Additionally, the courses are, at times, described as highly theoretical and impractical since the teachers in preparation often do not see a direct link between what they are learning as theory and how the knowledge can be applied when they enter the classroom (Bullough, 2005). Consequently, pre-service teachers often describe the theory courses they are required to take as part of their preparation as 'out of touch" and 'irrelevant'.

Furthermore, although few authors have alluded that the methodology courses used in teacher preparation programmes have a weak focus on PCK (Morales-Lopez, 2017;

Ruiz, 2017), the indicators/standards that were used to qualify the courses as "weak" were often unclear. Outside of the foregoing, not much is known about the nature and quality of the mathematics courses used in teacher preparation. Specifically, the extent to which they are designed to develop conceptual knowledge and skills, and pedagogical content knowledge.

METHOD

This paper, a component of a PhD thesis, utilised content analysis and interviews. The courses offered in a teacher preparation programme, at five teachers' colleges, that prepare 70% of the primary school teachers in Jamaica were collected from one of the colleges for evaluation. The five colleges (college A, B, C, D and E) offer the same courses and the student-teachers do the same examinations. All the mathematics courses that were taught in the colleges were collected from The Joint Board of Teacher Education (The accrediting body for teacher education in Jamaica). A total of four (4) mathematics content course documents (course outlines) and one methodology course documents were collected. At the end of the course evaluation, six of the seven teacher educators who taught mathematics to pre-service teachers who will teach at the primary level were interviewed to explain the findings of the course evaluation. All teacher educators in the colleges have at least a master's degree and over 15 years of teaching. College A had 3 lectures who taught mathematics to pre-service teachers who are being prepared to teach mathematics in primary schools. However, only two agreed to be a part of the study. Colleges B, C, D and E each had one teacher educator who taught mathematics to pre-service teachers who are being prepared to teach mathematics in primary schools. The teacher educators who taught in college B, C, D and E all agreed to be a part of the study. It is noteworthy to express that there is a common understanding that the content courses offered in teachers' colleges in Jamaica were designed to develop subject matter knowledge and the methodology course was intended to develop PCK.

To evaluate the courses for their focus on conceptual knowledge and skills, four raters independently affixed either 1, 2, 3 or 4 to each objective of the content courses. The digits represent the levels on Webb's Depth of Knowledge as discussed earlier. The interrater reliability among the raters was calculated using Statistical Package for Social Sciences (SPSS) 22.0, along with the frequency of the number of objectives that falls under each category of Webb's model. Further, using Shulman's description as a guide, the raters affixed a code of one (1) or zero (0) to each objective of the methodology course. An objective that was focussed on PCK was coded with a one (1). The interrater reliability of the coding process was calculated after the frequency of the number of objectives that were coded. In addition, to analyse the data gathered from the interviews, the transcripts were read and assertions that explained the findings of the course evaluation were reached.

Validity and Reliability

Validity was ensured by selecting raters who (i) have a minimum of a first degree in mathematics education (ii) have over five years of teaching experience (iii) would be

available to engage in training as well as to be a part of the actual process of rating the objectives for both the content and methodology courses. The raters were trained to rank items on Webb's Depth of Knowledge and to use Shulman's description of PCK as a frame of reference to determine whether pedagogical content knowledge was addressed in the course document.

Before the training, to ensure the validity of the rating process a *standard* that was established was used to determine whether each rater was interpreting Webb's Depth of Knowledge model and Shulman's description of PCK as intended. To determine the *standard*, a mathematics coach, working with the Ministry of Education (the lead advisor on education in Jamaica) and the primary researcher, discussed the levels of Webb's model and Shulman's description of PCK to ensure there are common interpretations. Once a common interpretation was confirmed, the objectives of the content and methodology courses used in a teacher's college outside of the context of this research were ranked on Webb's Model and against Shulman's description of PCK as a pilot. After ranking the items, the interrater reliability (IRR) between the mathematics coach and researcher was calculated using Statistical Package for the Social Sciences (SPSS) 22.0 using the Intraclass Correlation Coefficient, two way mixed effect model, at a 95% confident interval to be 0.926. Using Koo and Li (2016) as a reference for interpreting interrater reliability, the interrater reliability coefficient of 0.926 suggests high levels of agreement between the mathematics coach and the researcher.

After the interrater reliability between the mathematics coach and the primary research was determined, a discussion was initiated to discuss and agree on the objectives that they did not agree on initially. Once an agreement was reached on all the objectives that were used as a pilot the rating agreed on by both became the *standard* by which each rater's rating was calculated to determine consistency. After the *standard* was established the training was organised.

The training included discussion of the description and examples of each level of Webb's DOK, as well as having each rater rating objectives from courses that were collected for the pilot from the teacher preparation programme outside of the programme that was selected for this research. After, rating the objectives the interrater reliability was calculated for the rating of each rater against the *standard* that was established between the mathematics coach and primary researcher. Using Koo as a reference, the results using ICC estimates, with a two-way mixed effect model, with a 95% confidence levels are 0.779, 0.892, 0.777 and 0.803 were within the acceptable reliability range which suggests that the raters were interpreting Webb's model and Shulman's description as intended.

FINDINGS

To answer research question one: To what extent the written curriculum was designed to enable pre-service teachers to develop conceptual knowledge and skills of the content they will teach?

Table 1 provides the frequency for the objectives of the four content courses at each level of Webb's (DOK) model. In evaluating the table, the percentage of the objectives that addressed conceptual knowledge and skills against the total number of objectives can be determined.

Table 1
The frequency of content course objectives that addressed conceptual knowledge and skills

Depth of Knowledge Levels for Course Objectives					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Recall and Reproduction	85	38.5	38.5	38.5
	Concepts and Skills	105	47.5	47.5	86
	Strategic thinking	31	14	14	100
	Total	221	100	100	

The findings show that 105 (47.5%) of the 221 objectives which were evaluated from the content courses were focused on developing conceptual knowledge and skills in mathematics. These findings show that the content courses focused on the development of pre-service teachers' conceptual knowledge and skills. The reliability of the ranking done by the four raters was determined and produced an interrater reliability, with a 95% confidence interval, using a two-way mixed effect model produces a result of 0.922.

Additionally, the mathematics strands and topics that are addressed in the four content courses offered in the teachers' colleges are the same ones that are taught in primary schools. Table 2 provides a listing of the mathematics strands and topics.

Table 2
Courses and topics taught in teachers' colleges

COURSES	Number concept one	Number concept two	Algebra and Problem Solving	Geometry and Measurement
TOPICS	Four basic operations	Sets	Expressions	Conversion
	Place value	Fractions	Linear equations	Perimeter
	Types of numbers	Decimals	Gradient	Area
	Probability	Percentage	Transposition	Volume/ Capacity
	Graphs	Ratio	Problem-solving process	Plane shapes
	Charts	Probability	Problem-solving strategies	Nets of solids

To answer research question two: To what extent the written curriculum was designed to enable pre-service teachers to develop pedagogical content knowledge. The findings show that 0% of the objectives of the methodology aligned with Shulman's description of PCK. That is, none of the course objectives focussed on having pre-service teachers explore the knowledge of the most appropriate analogies, useful forms of

representations, illustrations, examples, explanations and demonstrations that can be used to represent the mathematics topics for it to be easily understood by learners. The following are examples of objectives that were addressed in the methodology course:

1. *student-teachers will explore the various teaching approaches – problem solving, differentiated instruction, cooperative learning, direct instruction.*
2. *student-teachers will explore various learning theorists – Vygotsky, Piaget, Brunner, Dienes.*
3. *student-teachers will explore technologies that can be used to teach mathematics.*
4. *student-teachers will examine the types of mathematics knowledge -procedural ad conceptual.*

Based on Shulman's description of general pedagogy, it appears that the methodology course objectives are more aligned to the description of general pedagogical knowledge and not pedagogical content knowledge.

To answer research question three: "*What assertions explain the outcome of the curriculum evaluation?* Three assertions were drawn from the interviews that was done with teacher educators. The interviews intended to explain the findings that emerged from the curriculum evaluation. The assertions are as follow:

Assertion 1: 47.5% of the course objectives in the teacher preparation programme focussed on the development of conceptual knowledge and skills because the teacher educators believe that conceptual knowledge and skills are developed when pre-service teachers are directly taught mathematical concepts. Mr. Hills, a teacher educator at college A, explained:

> *We have to teach them the concepts they will teach when they go into the schools. If we don't teach them, they will not know*.
>
> Mr. Hill's belief was confirmed by all teacher educators in the study. Mrs. Willis, a teacher educator from college C, explains:
>
> *The students don't come to us with conceptual knowledge. We just have to teach them the concepts, that's the only way they are going to learn them.*

Assertion 2: Conceptual knowledge and skills are the focus of the curriculum since teacher educators believe that primary school teachers need to teach for conceptual understanding. Ms. Candy, a teacher educator from college A, explains:

> *If we want them to go out there and teach concepts then we have to teach them about concepts. The children need to learn mathematics concepts so that they do not struggle in high school.*

Mr. Hill's perspective was similar to Ms. Candy's. He explained:

> *The primary years is where children should learn mathematics concepts. It is the foundation for learning mathematics well.*

Assertion 3. Pedagogical content knowledge is not reflected in the course document of the methodology course because teacher educators believe that pre-service teachers will develop pedagogical content knowledge when they model best practices. Ms. Zen, a teacher educator at college E, explained:

> *We were instructed to deliver the content in such a way that students (*pre-service teachers*) could learn how to teach from how we are teaching.*

Ms. Zen's understanding of her role in pre-service teachers' development of pedagogical content knowledge was echoed by her colleagues, a teacher educator at college D, explained:

> *It was established, from the beginning, that we would have to teach how we would expect them (*pre-service teachers*) to teach when they go into the classroom.*

DISCUSSION

This discussion is organised in relation to the research questions that the study sought to address. Following the discussion are the implications, recommendations and conclusion of the study.

Research Question One. *To what extent the written curriculum was designed to enable pre-service teachers to develop conceptual knowledge and skills of the content they will teach?*

The findings show that close to half of the number of objectives (47.5%) of the content courses addressed conceptual knowledge and skills. This suggests that great focus in being placed on ensuring that pre-service teachers are taught the concepts they will teach at the end of their preparation. This finding is contrary to the findings of other researchers who concluded that the courses offered in teacher preparation programmes are often outdated and obsolete (Morales-Lopez, 2017; Ruiz, 2017). The National Mathematics Policy of Jamaica stipulates that the courses offered in teacher preparation programme in the country should be designed to help preservice teachers develop conceptual knowledge and skills of the mathematics content they will teach. Perhaps this stipulation by the Jamaican Government is what has accounted for a high number of course objectives being focussed on CK and skills. During the interviews, the teacher educators explained that since pre-service teachers did not enter teacher preparation with high levels of conceptual knowledge and skills, then one way to ensure that they possess CK at the end of their preparation is to teach it. Further empirical data is needed to understand fully the thought process of teacher educators and philosophy that influenced the design of the teacher preparation programmes.

Additionally, it seems reasonable to conclude that the 47.5% focus of the curriculum on CK and skills did not provide any explanation into why "*teachers at the end of their preparation are not demonstrating expected levels of conceptual knowledge and skills*. However, as explained by Worrell et al. (2014), evaluation of solely the curriculum document used in the colleges is inadequate in providing evidence on the quality of the teacher preparation programme. Although the curriculum document is focussed on certain competencies and knowledge there is no guarantee that pre-service teachers, at the end of their preparation, will possess such competencies and skills (Worrell et al. 2014).

Research Question Two: *To what extent the written curriculum was designed to enable pre-service teachers to develop pedagogical content knowledge?*

The evaluation of the one mathematics methodology course that is offered in the colleges, provide a surprising finding. The finding shows that 0% of the objective was focussed on the development of PCK. This finding is consistent with other studies (Morales-Lopez, 2017; Ruiz, 2017) that found that the methodology courses used in teacher preparation programmes reflected weak focus on PCK. The teacher educators explained that the methodology course was not designed with a focussed on PCK since they are expected to teach in the way they expect pre-service teachers to teach. Assuming the literature provides an accurate account on how PCK is developed, then having teacher educators modelling the type of teaching they want from pre-service teachers is insufficient to develop appropriate levels of PCK (Loughran, 2006). According to Loughran (2006) PCK is developed when teacher educators *explicitly* model they types of teaching that they require of pre-service teachers. That is, teacher educators should model the type of teaching they expect from pre-service teachers while inviting pre-service teachers to critically analyse what they are observing. Teacher educators are expected to invite their students to examine and reflect on why certain decisions about the teaching episode were taken over others as well as what actions worked in the classroom. Since teacher educators assumed that adequate levels of PCK would be developed by merely modelling best practice to teachers in preparation, it seems reasonable to conclude that there is a missing piece in the teacher educators' understanding of how PCK is developed. Teacher educators inadequate understanding of how PCK is developed has provided insights into a possible factor that could account for teacher graduates low levels of PCK.

Research Question Three: *What assertions explain the outcome of the curriculum evaluation?*

The outcome of the curriculum evaluation are (i) 47.5% of the objectives of the content courses addressed CK and (ii) 0% of the objectives of the methodology course addressed PCK. The assertions that explain these outcomes are (i) the courses used in the preparation programme focussed on the development of conceptual knowledge and skills since the teacher educators believe that conceptual knowledge and skills are developed when there are directly taught (ii) a high percent of the objectives of the content courses used in the colleges addressed conceptual knowledge since teacher

educators believe that primary school teachers need to teach for conceptual understanding and (iii) pedagogical content knowledge is not reflected as objectives in the methodology course because teacher educators believe that pre-service teachers will develop pedagogical content knowledge when they model best practices. The assertions labelled (i) and (ii) mentioned earlier in this paragraph, based on the literature (NCTM, 2014), reveal that the teacher educators have accurate thinking on the need for primary school teachers to have Conceptual Knowledge of mathematics they will teach as well as how Conceptual Knowledge is developed. However, it is evident, based on assertion (iii), that there are gaps in teacher educators' understanding about PCK is developed. There appears to be a lack of awareness of the *explicit* modelling approach being documented as a more effective way of developing PCK.

IMPLICATIONS

This study was conducted to gain insights into what accounted for graduates of teacher preparation institutions not demonstrating expected levels of conceptual knowledge and skills and PCK. This study highlighted an issue with the design of the written curriculum and how such an issue could account for teachers' inadequate levels of PCK. Specifically, the written curriculum was designed with 0% focus on the development of PCK, making it likely for pre-service teachers to have insufficient opportunities to develop PCK.

Additionally, this study revealed the way of thinking that would have led teacher educators to not place PCK as a focus on the written curriculum. It revealed that teacher educators thinking about how PCK is developed is not consistent with common research findings, demonstrating the need for teacher educators to become updated about current findings on what is required in practice to prepare effective teachers.

The study also highlights that evaluation of the written curriculum solely is insufficient to gain insights into the factors that account the outcome of teacher preparation. The study demonstrated that almost half (47.5%) of the objectives of the content courses focus on CK and skills yet the teacher graduates were not demonstrating adequate levels of conceptual knowledge and skills. This suggests that further research is needed that explore how the written curriculum is interpreted and delivered by teacher educators.

RECOMMENDATIONS

1. Since the expectation is for teachers to have pedagogical content knowledge to effectively teach mathematics then PCK should be explicitly articulated on the written curriculum document. In this way the use of approaches that focussed on the development of PCK would not be left up to the discretion of each teacher educator.

2. Teacher educators need the training to gain a deeper understanding on how PCK is developed.

3. Evaluators of teacher preparation programmes need to evaluate all components of the programme. That is, the evaluator should assess: the

courses, instruction that is provided, pre-service teachers field experience and the assessments that are used in the institutions, in addition to assessing the alignment of all the components of the preparation programme.

CONCLUSION

This paper sought to gain insights into possible reasons teachers at the end of their preparation were not demonstrating conceptual knowledge and skills as well as PCK. The evaluation of the curriculum documents used in the five teachers' colleges revealed an issue (0% of the course objectives focussed on PCK) with the design of their programme. Although the finding of this research cannot be generalised across all context, identifying the issue with the design of the written curriculum is shedding light on an area that might need to be addressed in other programmes to ensure high quality mathematics teachers are available to all students. Additionally, identifying that there are gaps in teacher educators' thinking about how PCK is developed has created awareness that continuous professional development is needed to get teacher educators to become current about best practices in teacher education as well as that it should not be taken for granted that teacher educators know what they need to know to make good decisions about the design, delivery and assessments of the courses offered in teacher preparation institutions.

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