Responding to students’ contributions in the mathematics classroom: the case of Saudi trainee primary teachers.

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This ongoing doctoral study focuses on five case studies of Saudi primary trainee mathematics teachers of grades five and six (11 and 12 year olds). It aims to identify and explore the relationship between the trainee teachers’ subject matter and pedagogical content knowledge, and their response to their students’ contributions in mathematics lessons. The teachers were observed and videotaped while teaching to identify how they responded to students’ contributions. This was followed by individual semi-structured interviews in which selected episodes were discussed in order to investigate the teachers’ rationales for their actions. In this paper we introduce preliminary analyses informed by Rowland and colleagues’ Knowledge Quartet of an episode from one lesson.

Keywords: teacher’s knowledge, knowledge quartet

Introduction

Research into mathematics teachers’ knowledge has developed rapidly in the last three decades. Recently, the focus of research has been to “investigate the nature of the knowledge teachers possess and approaches to support further development of the knowledge they hold or lack” (Chapman, 2013, p.238). The work of Shulman (1986, 1987) can be considered to be the theoretical starting point of the research trend into mathematical knowledge in teaching (Barwell, 2013). After Shulman’s (1986, 1987) work, the research of the Michigan university team (e.g. Ball, Thames, & Phelps, 2008) emerged and expanded Shulman’s ideas of mathematical knowledge in teaching. Other scholars have developed and reformed Shulman’s ideas in various directions. For example, some researchers have investigated the influence of teachers’ knowledge on practice (e.g. Rowland, Martyn, Barber, & Heal, 2000). Others have investigated the nature of the knowledge needed in teaching (e.g. Ball et al., 2008).

This study focuses on connections between Saudi teachers’ mathematics content knowledge [both subject matter knowledge (SMK) and pedagogical content knowledge (PCK)], and their handling of students’ contributions. Unlike this research, most of the research in mathematics education in the Saudi context has been quantitative and descriptive, focusing on students rather than teachers and the majority used questionnaires for data collection (Almoathem, 2009).

Research design and methodology

This project develops the case studies of five Saudi trainee teachers specialising in mathematics in their final term of their four year course. They were on placements in three primary schools in Arras city during the second term of the academic year 2012-13. Data from one of these studies will be considered in this paper.

The teachers were observed and videotaped while teaching to identify how they responded to students’ contributions in their lessons. Selected episodes were discussed with them in individual face-to-face semi-structured post-lesson interviews. Collected data, which consists of videos of lessons and recorded interviews, was analysed by applying the Knowledge Quartet framework described below.

Theoretical framework: the Knowledge Quartet (KQ)

The Knowledge Quartet identifies three *categories of situations* in which teachers' mathematics-related knowledge is revealed in the classroom: transformation, connection and contingency (Rowland, Huckstep, & Thwaites, 2005). *Foundation*, which comprises a teacher's mathematical content knowledge and theoretical knowledge of mathematics teaching and learning, supports each of these categories of situations. *Transformation* is the category most similar to Shulman's conceptualization of pedagogical content knowledge, that is, how a teacher takes his/her own content knowledge and transforms it into ways that are accessible and pedagogically powerful to pupils. This category pays special attention to the teacher's use of representations, examples, explanations, and analogies. A third dimension is *Connection*, which is whether a teacher makes instructional decisions with an awareness of connections across the domain of mathematics (as mathematics is not, after all, a subject that contains discrete topics) and an ability to sequence experiences for pupils; anticipate what pupils will likely find 'hard' or 'easy'; and understand typical misconceptions in a given topic. Since not all aspects of a lesson can be planned for ahead of time, *Contingency* is the dimension that focuses on how a teacher must think on his/her feet in unplanned and unexpected moments, such as how to respond to pupils' statements, answers, and questions. Within each of the four dimensions there exists four to eight codes which give specific aspects of mathematics teaching to consider in regard to planning, reflection, and evaluation. These are listed below in Table 1:

Dimension	Contributory codes
Foundation:	awareness of purpose; adherence to textbook; concentration on procedures; identifying errors; overt display of subject knowledge; theoretical underpinning of pedagogy; use of mathematical terminology.
Transformation:	choice and use of examples; choice and use of representation; use of instructional materials; teacher demonstration.
Connection:	anticipation of complexity; decisions about sequencing; making connections between procedures; making connections between concepts; recognition of conceptual appropriateness.
Contingency:	deviation from agenda; responding to students' ideas; use of opportunities; teacher insight during instruction.

Table 1: The Knowledge Quartet – dimensions and contributory codes

The case study

Abdullah, a 22-year-old trainee elementary teacher, was observed teaching grade five and six (11 and 12 year old) students for five lessons each week. He was visited by his academic supervisor and his cooperating teacher. An incident from one of his lessons has been selected to illustrate the application of the KQ in the following section.

The lesson description

Abdullah taught a lesson with the textbook entitled 'Perimeters of Polygons' to a grade 5 class. The lesson took place in a dedicated mathematics teaching room in the school. Abdullah projected the lesson pages from the textbook onto the board using a document camera. He followed the textbook content closely. Abdullah began by introducing the definition of the concept ‘polygon’. He wrote the formula for the perimeter of a polygon (the sum of its sides) on the board and showed an example. Then the class proceeded to the next part of the chapter, about the perimeter of a square. They began with the activity described in the incident below.

Incident 1

After finding the perimeter of a polygon, Abdullah asked the students to do the activity: ‘fill in the table below (Table 2) and describe the relationship between the perimeter of the square and its side length then write its formula’.

Square	1	2	3	4
Side length	1			
Perimeter	4			

Table 2: side lengths and perimeters of squares

This dialogue happened during the activity:

1	Abdullah	[Pointing to the square 1] Here the side length is how much?
2	Students	Two
3	A	[Silent]
4	Students	One
5	A	Good. What is the perimeter of the first square?
6	Students	Four
7	A	How we find it four?
8	Student 1	Because it is the sum of the side lengths
9	A	That would be right for the polygon but this is a square not a polygon [Writes on the board ‘the perimeter of a square =’]
10	Student 2	I know the answer, it is because one side is one, so the others are one too
11	A	All of these squares are different [Pointing to the table]
12	Student 2	I mean the first square has four sides of one, so it is one, one, one and one.
13	A	Do not add the sides because that was correct for the polygon. [Repeats the question] How do we find the perimeter equal to 4 for the first square?
14	Student 3	[Stands and goes to the board and touches the sides of the first square and says] we add one, one, one and one.
15	A	No. [Reads the formula of the perimeter of a square written below the table and writes ‘the perimeter of a square= 4x (letter x)’] what is the perimeter of a square?
16	Students	it is four x
17	A	What does x refer to?
18	Students	One, two, litre, millilitre, rectangle, square, angles, polygon and the length.
19	A	[Listening and moving from one student to another]It is the length, so the first square has a side of one and its perimeter should be?
20	Students	Four
21	A	Good, we multiply the side of one by four and get four, what about the second?
22	Students	Two times four equals eight.
23	Student 4	Teacher, what is the perimeter?
24	A	Right, you do the same thing to the two squares three and four and you will find that the perimeter will be?
25	Students	Twelve and sixteen.
26	A	Right, memorise the formula to use it elsewhere.

Applying the Knowledge Quartet

Foundation

Abdullah's adherence to the students' book was a strong influence on his teaching. Teachers tend to use textbooks closely as a result of a limitation of time, availability of resources, the influence from colleagues and cooperating teachers (Nicol & Crespo, 2006) and district (government) and school policies (Sosniak & Stodolsky, 1993). Abdullah adhered to the textbook as a response to the Saudi educational system which requires that all teachers follow the same book for every stage and every subject. As he said in the interview, (IV) "I was told by my supervisor [the cooperating teacher] to try to cover as much as I can from the book so I do not have time to use an example from outside the book…" He emphasised that the limitation of time, the authority of the sources, the education system and the cooperating teacher all played an external role in his adherence to the textbook.

Moreover, teachers' beliefs about the nature of the subject and how it can be taught affects their use of textbooks (Chavez–Lopez, 2003; Nicol & Crespo, 2006). It seems that Abdullah's belief and knowledge, and probably his lack of experience, influenced his use of the textbook. He believes that mathematics is a challenging subject that requires concentrating on procedures and roles, and that the teacher should focus on the students' performance. He said:

> I love mathematics because I feel it challenges me all the time…I am keen to teach the students how to do things rather than confusing them with many details of the concepts. I prefer to give them the steps to solve the exercise before asking them to solve the exercise by themselves as this avoids them getting stuck.

Abdullah's lack of knowledge may also have affected his use of the textbook. Teachers' knowledge, skills and experience shape the use of textbooks (Chavez–Lopez, 2003; Sosniak & Stodolsky, 1993). Similarly, teachers' understanding of the content influences their use of textbooks (Nicol & Crespo, 2006). Abdullah showed some indication of weak subject knowledge in different parts of the lessons which, according to Nicol and Crespo's findings (ibid.), may have influenced his use of the textbook. For instance, in this incident, he was not sure about the status of the square as a polygon, and he said "this is a square not a polygon" [9]. Abdullah seemed not to connect the additive perimeter concept to finding the perimeter of a square, as he asked the students to find it just by using the formula [15]. He made a small change in the order of the textbook to disguise his uncertainty of the method needed to find the perimeter of a square by adding its side lengths. Moreover, he probably stuck to the book in order to avoid making mistakes.

Transformation

Abdullah's demonstration was influenced by his knowledge, beliefs and adherence to the text book. He introduced the concept of the perimeter of the square in a way that did not emphasize the importance of understanding it or connecting it to the perimeter definition. His explanation of the concept of the perimeter of the square was achieved by requiring the students to use the formula written in the book without explaining it properly, instead of starting with the table then progressing to the use of the formula. He did not allow the students to use their prior knowledge about finding the perimeter of a polygon in a new situation to generate the new concept or formula. In the interview, he justified this by saying "I found a written formula for the perimeter of a square in the student book, so I thought that to find the perimeter of a square the student cannot add the sides; they must apply the formula".

Connection

Abdullah introduced the lesson as it was written in the textbook. He started with the polygon concept and perimeter, and then moved to finding the perimeter of a square and a rectangle without paying attention to the connection between these procedures. There was no link between these formulae and he did not use the procedure of finding the perimeter of the polygon as a base to building up to the formula of the square. For instance, in the incident when the students tried to use what they had just learned about the procedure of finding the perimeter of the polygon in order to find the perimeter of the square ([8], [10], [12] and [14]), Abdullah did not allow them to make this link as he probably believed that there was no connection between them.

Contingency

Abdullah responded to the students' ideas differently. He responded to the students' incorrect answers in the incident by ignoring them and keeping silent ([2] and [3]) then looking for the correct one, as he said (IV) "They gave me a wrong answer and I was looking for a correct one." In addition, he would keep moving from one student to another until he found the correct answer ([18] and [19]). He rationalized that by saying, (IV) "I was looking for the correct answer so I kept moving between the students until I found the right person". Moreover, Abdullah thought some of the correct answers were wrong because he thought the students should stick to the book, so he changed the answers himself. For instance, in the section [8] – [15], the students tried to add the side lengths as they had done with the polygon, which would have been correct, but Abdullah dismissed their answer by saying 'no' and insisting on use of the formula.

However, at times he responded to correct answers with encouraging words such as "good' and 'right' ([5], [21], [24] and [26]). He said (IV) "I should correct the wrong answers and praise the correct answers, for example by asking the students to clap their hands for the one who answers correctly to encourage the students to become more active in the lesson". Also at times he asked for justification of their answers [7]. He rationalized that by saying, (IV) "I want to make sure that they answered based on an understanding, not guessing." Moreover, as a result of his adherence to the textbook, he rejected some correct answers ([8] – [15]) for his own and changed them to another form, even though they both led to the same answer.

Finally, when he was faced with many questions from the students, he answered some of them and ignored others. For instance, in [23] he ignored a fundamental question about the concept of the perimeter which is what the lesson was about.

Discussion and conclusion

In this lesson, Abdullah showed limitations in his subject and pedagogical knowledge, and had some difficulty in teaching mathematics. He showed explicit reliance on the textbook and he emphasised the importance of teaching in a procedural way.

He responded to students' contributions in different ways depending on his knowledge and beliefs. In the incident, Abdullah responded to *correct* answers by asking for justification, usually when he reached the main point in the solution process on which the exercise focused, to check the understanding of that point. For example, when the students answered that the perimeter of the first square was 4 he asked why, as that was the main focus of the lesson. He rejected some of the correct answers as he treated them as incorrect ones because he was not aware that they were correct. This could be, to some extent, related to his lack of mathematical knowledge.

When Abdullah was faced with *incorrect* answers (from his point of view), in the incident he usually rejected them verbally by saying ‘No’ (even though they were correct). He explained and corrected the wrong answers in detail when they occurred in the main idea of the lesson; in other words, when they happened during the focus of the lesson he felt he had to explain more. For example, when the students answered incorrectly during the introduction of the concept of the perimeter of a square, Abdullah rejected their answers and commented on them because the focus of the lesson was finding the perimeter of polygons. Here, some aspect of Abdullah’s PCK may have come into play, such as a lack of awareness of connections between concepts, which may have influenced Abdullah’s dealing of this situation. Moreover, when he got a wrong answer regarding a new concept or idea, like [18], he ignored it and looked around for other answers, as he anticipated the students would face some difficulties and make mistakes on these occasions.

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