Analysis of David's Classroom Practice: In Search of Teacher-Demonstrated Pedagogical Content Knowledge in Statistics Teaching

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Abstract

One of the teacher requirements for improving learners' achievements in mathematics is pedagogical content knowledge (PCK). Mathematics teachers need to possess adequate PCK in order to conduct efficient and quality classroom practice to enhance learners' achievement in statistics. But little is known about teacher-demonstrated PCK that could inform the quality of classroom practice for improving learners' performance in statistics. This article draws on the findings of a study on the PCK demonstrated by a teacher of statistics. For the purposes of this article, the teacher is referred to as David. Initially six mathematics teachers were chosen based on their school's performance over two years in the senior certificate examination in mathematics. Four were then selected from the results of a conceptual knowledge exercise (CKE) in statistics. Lessons taught by one of the teachers were used to determine the teacher-demonstrated PCK in statistics. The study adopted a qualitative research method. The data on teachers' PCK were collected through lesson observation, questionnaires, interviews, video recordings, teachers' written reports and document analysis. The results indicated that the mathematics teachers demonstrated topic-specific subject matter content knowledge, knowledge of instructional skills and strategies, knowledge of learners' conceptions and learning difficulties in statistics teaching. It is concluded that an analysis of David's classroom practice provided us with an opportunity to identify the PCK that he demonstrated during statistics classroom practice.

1. Introduction

In terms of classroom teaching, there does not appear to be consensus as to what effective teaching is in research and practice circles**.** One school of thought defines effective teaching as what teachers themselves consider effectual teaching to be all about (Cabrera & Nasa, 2012). According to these authors, instructional dimensions such as knowledge of the subject, enthusiasm for teaching and for the subject, and sensitivity to, and concern with class level and progress, in that order, play an important role. A second school of thought indicates that sensitivity to, and concern with class level and progress, teacher's preparation and organisation of the course, as well as teacher's stimulation of interest in the course and its subject matter, are the best instructional approaches (Cabrera & Nasa, 2012). A third school of thought regards effective teaching as those instructional techniques and practices that teachers and students agree to be effective (Cabrera & Nasa, 2012). From these definitions, it can be deduced that authors define classroom teaching practices according to specific standards and the learning outcomes they have set, implemented and accomplished, which display teacher pedagogical content knowledge (PCK) of the subject. And yet discrepancies seemed to exist between the teacher and the students when learners are assessed on what they were taught during classroom practice and these results are published (DoBE, 2012). Several authors, including Ijeh (2013) and DoBE (2012), have noted that the teacher may not have exhibited enough PCK to enhance learners' achievement in the subject. In this study, the intent of the researcher is to explore teacher-demonstrated PCK by analysing David's classroom lesson in statistics.

Effective classroom teaching practice and pedagogical content knowledge in statistics teaching

Benjamin Bloom divides the way people learn into three domains. One is the cognitive domain, which emphasises intellectual outcomes. This domain is divided into categories, which are arranged progressively from the lowest level of thinking, simple recall, to the highest, that is, creating new ideas (Anderson & Krathwohl, 2001). The categories include remembering, understanding, applying, analysing, evaluating, and creating (DoBE, 2012). Teachers and learners were expected to consider these categories during classroom practices for effective teaching as well as when developing questions for assessments that support higher-order thinking.

In effective mathematics classroom teaching, the teacher should identify and define what learners are expected to know and be able to do at the end of the lesson. In fact, teachers should develop learning goals based on curriculum expectations and share them with students during classroom practice (MoE, 2010). Descriptions of successful attainment of learning goals developed by teachers and based on certain criteria can be discussed and agreed with students. Success criteria may be revised and revisited, as students progress toward achieving the learning goals as developed by the teacher.

Effective classroom practice should allow for appropriate assessment procedures and descriptive feedback. Individual and peer assessment methods can be employed to determine how well learners have understood the concept taught by the teacher. Assessment techniques such as classwork, assignments, homework, investigations, projects, tests and examinations were used in the mathematics classroom practice in which this study was conducted (DoBE, 2012). The purpose of providing feedback is to reduce the gap between the learners' current level of knowledge and skills and the learning goals. Descriptive and timely feedback helps learners by providing them with precise information about what they are doing well, what needs improvement, and what steps they can take to improve (MoE, 2010; DoBE, 2012).

According to the Curriculum, Assessment and Policy Statements (CAPS), instructional guides and other publications, teachers need in-service professional support with the statistics knowledge required to implement the new mathematics curriculum (DoBE, 2012). Thompson (2005) indicated that in order to implement the new curriculum effectively, teachers need subject matter knowledge, pedagogical knowledge, and pedagogical content knowledge (PCK).

Subject matter knowledge refers to disciplinary knowledge obtained through formal training at colleges and universities, while pedagogical knowledge pertains to knowledge of instruction and learning that the teacher needs in order to deal with everyday classroom educational tasks (Vistro-Yu, 2003). Such tasks involve the use of various teaching styles and strategies and the management of learning processes in the classroom (Ijeh, 2013). These skills and competencies are normally acquired through formal training and teaching practice.

Simply described, PCK is about the overall knowledge the educator has of the subject matter content that learners should master in a particular topic or subject, and how it should be taught, so that effective and efficient learning takes place (Ijeh, 2013). In short, PCK is an amalgam of subject matter content and pedagogy, which is uniquely the province of teachers, and involves their own form of professional understanding for good teaching (Jong, 2003).

PCK is specific to teaching and differentiates between expert teachers in a particular subject and subject area experts (Griffin, Dodds & Rovengno, 1996). To illustrate, mathematics teachers differ from mathematicians, not necessarily in the quantity and quality of their subject matter knowledge, but in the way in which knowledge is organised and used (Cochram, De Ruiter & King, 1993). An experienced mathematics teacher's knowledge of the subject is organised from a teaching perspective, and is used as a basis for helping learners to understand certain concepts. A mathematician's knowledge, on the other hand, is normally organised from a research perspective, and is used mainly to develop new knowledge in the field. This implies that PCK may be something that beginner or inexperienced teachers may not necessarily learn only from textbooks or from short courses. From the literature, it appears that little is known about the way in which PCK is developed or even facilitated in the context of teaching statistics (Godino, Batenero, Ortiz, Roa & Wilhelmi, 2011; DoBE, 2012; Jong, 2003). This study attempted to explore the PCK that David demonstrated during classroom practice.

The topic of statistics was chosen because it is new in the mathematics curriculum, and many teachers may not have adequate experience in teaching it, let alone in dealing with the difficulties learners face. Until the introduction of the topic of data handling in mathematics and mathematical literacy in 2006, statistics was not taught in high schools (DoBE, 2012). Many teachers of mathematics do not have formal knowledge of statistics, let alone knowledge of learners' preconceptions, which need to be addressed in teaching and learning statistics. The assumption is that few in-service teachers would have developed the PCK needed to teach the topic effectively (Ijeh, 2013). Therefore, it would be useful to study how mathematics teachers go about teaching a new topic in statistics, and to document what they have and do as they prepare and teach those data-handling lessons.

According to Shulman (1986), PCK is a specific category of knowledge that goes beyond the knowledge of subject matter per se to include the dimension of subject matter knowledge for teaching. It refers to teachers' interpretations of subject matter in the context of facilitating learning. In consequence, PCK is one of the seven categories in Shulman's (1986) categorisation of a knowledge base for teaching. The key elements of Shulman's conception of PCK are:

i. Knowledge of the representation of the subject matter for teaching
ii. Knowledge of relevant instructional strategies
iii. Knowledge of learners' conceptions (preconceptions and misconceptions)
iv. Knowledge of learners' learning difficulties

For the purpose of this article, these four elements appear to be most appropriate in defining the PCK that may be used for teaching statistics in school mathematics. They cover the views and constructs of PCK used by various researchers in this domain, such as Jong (2003), Shulman (1986), Halim and Meerah (2002), Jong et al. (2005), Rollnick et al. *(*2008), Hill (2008) and Toerien (2011). In this paper, PCK therefore refers to an amalgam of subject matter content knowledge, pedagogical knowledge, knowledge of learners' conceptions, and knowledge of learners' learning difficulties (Ijeh, 2013).

Methodology

The methodology consisted of two phases. In the first phase, the six mathematics teachers undertook a written exercise that assessed their conceptual knowledge. The results of this exercise were used to select the four best-performing teachers for the second phase of the study. The lesson of one of them (David) was analysed to determine the PCK which he demonstrated in his statistics classroom practice.

The second phase consisted mainly of a concept mapping exercise (CME), lesson observation, interviews, questionnaires, teachers' written reports and document analysis, designed to produce detailed descriptions of David's PCK in teaching data-handling concepts at school level. The CME was used to indirectly assess his content knowledge and conceptions of the nature of school statistics and how it is to be taught. The qualitative data were analysed to determine the content knowledge of school statistics, related pedagogical knowledge, and how he developed his PCK in statistics teaching. The analysis was based on iterative coding and categorisation of responses and observations in order to identify themes, patterns and gaps in his statistics lessons.

The validity of the CKE was established by giving the exercises to mathematics teachers to ascertain whether the exercise could be used to assess the teachers' knowledge of school statistics and to select participants for the study. The concept map was given to the same teachers to determine whether the CME would allow them to list the topics according to Grades 10, 11 and 12 and arrange them in logical order, such that one topic formed the basal knowledge of the next for each of those grades. Second, they were required to decide whether the memorandum was appropriate for answering the CME. The interview, questionnaire, and teacher written reports were validated by mathematics education experts using a set of criteria to establish whether these instruments contained appropriate information to determine teachers' mathematics educational background for developing PCK as defined in statistics teaching, what the teacher did while teaching statistics, and what made the lesson easy or difficult (Ijeh, 2013).

The reliability of the CKE was established through the Kuder-Richardson split half procedure (KR-20, KR-21). The reliability index was 0.81. The CME and memorandum were given to four school mathematics teachers who did not participate in the research and were physically located outside the research site to avoid contamination. There were consistencies in the responses of the mathematics teachers with the anticipated answers of the CME. The reliability of the teacher interview, questionnaire and written reports was determined by school mathematics teachers who were not involved in the study to determine the extent to which the instruments were likely to yield consistent responses from them (Creswell, 2008) in terms of assessing the mathematics teachers' educational background that may have enabled them to develop their topic-specific PCK in statistics teaching, what the teacher did while teaching statistics, and what made the lesson easy or difficult.

David's Lesson Observation on Statistical Graphs

This section describes one of the David's lessons on statistics. The condition of the classroom is described first, followed by his classroom practice in the construction, analysis, and interpretation of scatter plots.

David is a high school teacher with five years' teaching experience. He teaches mathematics and mathematical literacy in Grades 11 and 12. He holds a BSc degree in mathematics.

Classroom Practice: David's Lesson Observation **Topic: Construction and interpretation of scatter plots. Class: Grade11**	**Categorisation/Themes**
Condition of the classroom Teacher C's classroom was safe and protected. The teacher had a full view of the entire class during lessons. The classroom walls were decorated with science wall charts; the furniture, windows and door were in good condition, with electrical wiring that permitted the use of appliances such as an overhead projector. The individual learners were resourced with textbooks, calculators, exercise books, and graph sheets, as well as construction instruments for the teacher (ruler, protractor, and pair of dividers). There were 45 learners, consisting of 26 females and 19 males, seated comfortably in twos	1) The classroom was conducive to learning, safe and well protected. 2) There were 45 learners in the class, who were seated in double chairs in four columns. .3) The individual learners have all the necessary materials for learning statistical graphs.

in four columns of double chairs and desks.	
Line 1: The learners had previously been taught how to construct a scatter plot. The lesson began with marking and checking homework on the construction and interpretation of scatter plots to identify learners' knowledge and conceptions of the topic. David then gave the correct answers, while the learners wrote the corrections in their notebooks.	David used the **instructional strategy** of checking learners' homework on scatter plot construction and interpretation to identify their knowledge and preconceptions (line 1).
Line 2: David wrote the topic, 'Construction and interpretation of scatter plots' on the chalkboard and presented a photocopied exercise containing different types of scatter diagrams to the learners.	**Teacher content knowledge** of scatter plots was utilised to indicate the topic of the lesson and set activities to ascertain learners' comprehension of scatter plot constructions (line 2)
Line 3a: They were asked to work in groups and to determine by analysis and interpretation of the scatter plots which of the scatter diagrams had a positive correlation, a negative correlation, or no correlation. They Line 3b: Learners worked in groups to analyse the scatter plots, to determine the nature of the points plotted and the lines of best fit.	Learners worked in groups (**instructional strategy**) to analyse and interpret scatter plots as a way of identifying how well they had grasped how to construct a scatter plot from their previous lesson (lines 3a and 3b).
Line 4a: After the analysis, groups were asked to interpret the graph by indicating their conclusions: whether the diagrams showed a positive correlation, a negative correlation, or no correlation. Line 4bi: Learners through their spokespersons for each group indicated, '*The first diagram displays a positive linear relationship.'* Another group concluded, *'The second diagram displays a graph of negative relationship, but not linear*.' Some of the groups did not seem satisfied with the answers presented for two of the graphs B and C (see Figure 1). Line 4bii: David monitored the way in which learners were analysing and interpreting the scatter plots in groups. '*In terms of analysis, you were expected to know the values of Y and the corresponding value of X as used in constructing the scatter plots,*' he said. He continued, '*Based on the relationship between X and Y values, one can say whether there is positive correlation, negative correlation, or no correlation, as previously explained***.'** He recognised that some learners appeared to be experiencing difficulties in interpreting a negatively correlated scatter plot as having no correlation. This could indicate that they lacked understanding or that the teacher's previous lesson explanation on scatter plot construction was not sufficient to enable them to grasp the topic, David handed out another photocopied exercise (from their supplementary textbook) showing a table of values reflecting the age and mass distribution of players in a rugby game. He asked one of the learners who appeared to have interpreted the diagram more efficiently, *'Plot the numbers of players against the masses to construct a scatter plot. Can I see you do that on the chalkboard*?' The learner constructed the scatter plot efficiently. David decided again to assess learners' conceptions in scatter plot construction using an extra-class activity. David used his topic-specific content and pedagogical knowledge to assess the learners' understanding of scatter plots using additional activities in order to improve their grasp of the this topic. In this activity from their textbook, David plotted some points using the frequency table that he had provided and requested learners to complete the remaining points. He said, '*Let someone complete the scatter plot?'* Line 4c: More learners volunteered and were requested individually to plot other points on the graph on the chalkboard, while the other learners watched. Line 4di: David completed the graph that the learners had been plotting, and explained algorithmically how to construct a scatter plot. He then analysed it by reading the value on the vertical axis and the corresponding value on the horizontal or data axis. '*From this analysis, the meaning of what the graph intended to convey about the relationship between the number of players and their masses (correlation or no correlation) was determined*,' the teacher said. Line 4dii: Some of the learners seemed dissatisfied, because they shook their heads. More explanations were offered by David, who utilised a conceptual approach to again demonstrate scatter plot construction and interpretation using the classwork. For instance, David explained; '*The characteristics (nature of points and shape of line of best fit) of a linear positive correlation with its line of best fit moves from right to left through the origin, and related it to diagrams A and E of Figure 1. In a linear negative correlation the line of best fit drops down from the vertical axis to the horizontal axis, as in diagrams B and C, Figure 1. And a scatter plot with no correlation has all the points spread through the vertical to the horizontal axis as in diagram F, Figure 1* '. '*Diagram D shows a positive correlation, but it is not linear because the points spread through the origin from right to left, but not in a straight line,'* the teacher concluded	Learner activity on data handling and interpretation by responding to class activities was undertaken in groups (line 4bi). **Teacher instructional strategy** of monitoring classwork on scatter graph interpretation was used to identify learner knowledge and conceptions (line 4a). Learners misinterpreted a scatter plot owing to insufficient comprehension of scatter plot construction as a result of inadequate teacher explanation of how to determine the relationship between X and Y in a scatter plot (**learning difficulty**) (Line 4bii). A negatively correlated scatter plot was interpreted as having no correlation owing to an outlier. **Teacher content knowledge** was used to explain (**instructional strategy**) the construction and interpretation of a scatter plot (lines 4di and 4dii) and design an instructional task using the supplementary textbook (line 4bii). **A procedural approach** of drawing the axes, choosing scale, labelling axes, plotting the points and drawing the line of best fit was used to describe and complete the scatter plot (line 4di). **Graph construction skills** were used to create a scatter plot (line 4di). David provided further explanation **using conceptual knowledge** to address learners' difficulties, showing that he had insight into them, hence the strategy he adopted to provide clarification and reinforce understanding (line 4dii)

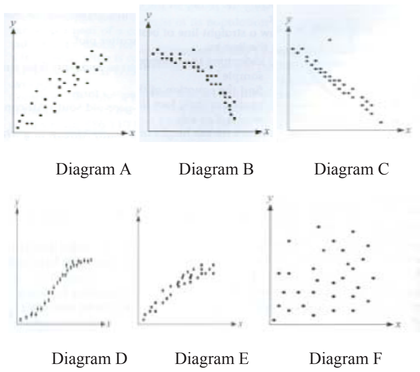

Figure 1: Scatter diagrams showing different kinds of correlation between X and Y

Line 5a: A learner asked, ‘*Do we need to draw the line to show how the two variables X and Y are correlated?’* This question demanded a conceptual explanation, which was provided in line 4dii, but the learner may have developed misconceptions about drawing the line of best fit in a scatter plot from the earlier procedural explanation Another misconception was, ‘*There were no lines of best fit in Figure 1 which* we *had worked on earlier*,’ the learner indicated. The learner had posed a legitimate question seeking clarification because the teacher did not provide a conceptual explanation for the different scatter plots as indicated in the introductory exercise for the lesson and in line 4di.
Line 5b: David answered, ‘*Yes*’ and repeated what he had said in line 4dii by explaining the characteristics of scatter plots, how their correlation can be determined and how they related to each other, as in the diagrams in Figure 1.

This learner’s question displayed a lack of understanding of how to construct and interpret scatter plots – precisely because of inadequate explanation, using learned rules to explain. The question is how the teacher makes the leap from the algorithmic to the conceptually meaningful explanation (line 5a).

Line 6: Teacher C observed that in the graphs the learners analysed in groups, they misinterpreted diagram C (Figure 1) as a graph with no correlation between X and Y, owing to outliers. ‘*Using one point alone to indicate that diagram C had no correlation may not be adequate as there are other clustered points that would display the correlation between X and Y.*’ This was the misconception of using the nature and shape of a scatter plot with no correlation to interpret a graph of negative linear correlation. In addition, some learners indicated in their exercise books that the line of best fit meant a change in X caused by a change in Y, as in a line graph, which means if Y increases, then X increases by the same percentage. ‘*Yes, when X increases, Y also increases, which means X and Y are related,*’ one of the learners stated. In a scatter diagram, *‘the line of best fit only indicates the association or connection between X and Y, as indicated in diagrams A and B,’* the teacher explained. He continued, ‘*And depending on how clustered the points are close to the line of best fit, one can say that it is strong, moderate of weak correlation ... You were expected to analyse and interpret the scatter plots to determine the relationship between X and Y.’*

Teacher content knowledge was used to address learners’ misinterpretation of scatter plot (line 6) by explaining why diagram C could not be adjudged to have a negative correlation. A more conceptual explanation was provided of how to describe the relationship between X and Y in a scatter plot and indicate the kind of correlation that the scatter plot is showing (line 6).

Line 7: David corrected the misconceptions of using the characteristics of a scatter plot with no correlation to interpret a scatter plot with a negative linear correlation, as well as interpreting a linear scatter plot as if it were a line graph, as in lines 5 and 6, and diagram C of Figure 1. He provided more activities on the construction and interpretation of scatter plots. For example, he said, ‘*In this exercise, you were required to construct a scatter plot and indicate the relationship between test 1 and test 2 (see Table 2 below). The data in the frequency table give the marks (out of 20) that 12 learners attained in the two tests.’*
Line 8: Teacher C gave out the classwork as shown below.

Table 2: Frequency table showing the distribution of learners’ performance in two tests

Learner	A	B	C	D	E	F	G	H	I	J	K	L
Test 1	10	18	13	7	6	8	5	12	15	15	10	20
Test 2	12	20	11	18	9	6	6	12	13	17	10	19

a) Draw a scatter plot and describe by means of two examples whether there is a positive or a negative correlation in the learners’ performance in the tests.
b) How do you account for the outliers, if any?

The **topic-specific content and instructional strategy** of providing more examples was used to address the learners’ misconceptions concerning outliers and interpreting a linear correlated scatter plot as if it were a line graph (line 7). Topic-specific **content and pedagogical knowledge** were utilised to address learners’ misconceptions.

Line 9: As he monitored the learners’ classwork, he discovered that some of them had completed the classwork efficiently. He gave those learners a second classwork activity involving a frequency table of the age distribution of persons infected with HIV/Aids in two towns. They were to work on their own to construct a scatter plot showing the relationship between the age distributions of persons infected with HIV/AIDS in the two towns.

Instructional strategy of using real-life context based examples to assess learners’ conceptual understanding of the construction and interpretation of scatter plots and address their learning difficulties (line 9). Several class activities were used to reinforce learners’ grasp of how to construct

	and interpret scatter plot (line 9)
Line 10: Learners carried out the exercise individually. A few still experienced difficulties in drawing the line of best fit and determining the type of correlation.	An individualised or independent learning strategy/approach was used to evaluate how well learners had learned the construction of a scatter plot (line 10).
Line 11: After the classwork, oral questioning, and homework (as in line 8) were used by David to further assess learning. For instance, he asked a learner, '*What is an outlier?*' '*An outlier is a data value or point that lies apart from the rest of the data'*, the learner replied. David adjudged the learner to be correct and instructed the learners to answer other questions on the photocopied exercise as homework.	**Oral questioning** and the homework assignment constituted the instructional strategies used to assess how well learners had grasped the concept of constructing scatter plots (line 11).
Line 12: At the end of the lesson, some learners asked more questions about the work that they had done, especially misinterpreting a negative linear scatter plot and interpreting the line of best fit in scatter plot as if it were a linear algebraic graph. David held individual discussions with a few learners about diagram C, and asked the others to see him after school the following day.	**Teacher content knowledge and instructional strategy were used to** clarify the misinterpretation **in a post-teaching discussion** (line 12).

Discussion of Results

During classroom practice, David taught his planned lessons scatter plots as laid out in the work schedule (DoBE, 2012). He used the recommended and supplementary mathematics and statistics-related textbooks as sources of information for planning and teaching his lessons on data handling (statistics) (line 4bii). David also displayed evidence of a procedural approach rather than a conceptual one in teaching the construction of scatter plots (line 4di). Teachers need to possess conceptual and procedural knowledge of mathematics to be able to provide learners with clear explanations (Engelbrecht et al, 2006; Star, 2002). Schneider and Stern (2010) view conceptual knowledge as knowledge of the core concepts and principles and their interrelations in the mathematics domain. It is rich in relationships. On the other hand, procedural knowledge allows learners to solve problems quickly and efficiently because to some extent it is automated through drill work and practice. Procedural knowledge can thus be viewed as consisting of rules and procedures for solving mathematics problems.

David demonstrated the requisite knowledge and skills for constructing scatter plots in a step-by-step manner in teaching scatter plots (line 4di). In his teaching, he moved from the algorithmic to the conceptually meaningful stage. He began his lesson on scatter plots by identifying the learners' prior knowledge (line 1). This process depicted a rule-oriented procedural approach. His procedural knowledge in teaching scatter plots (which was understandable to his learners) is believed to have been developed as a result of his five years' mathematics teaching experience, using the recommended lesson plan and work schedule of the Department of Basic Education (DoBE, 2010). The result of the teacher interview and questionnaire confirm the use of recommended lesson plans, work schedule and textbooks during lessons. From the above explanations, the teacher's lesson appears to be dominated by the use of a procedural knowledge approach rather than a conceptual one. David may have taught scatter plots in a particular order or sequence because of the way in which the learning outcome of data handling is stated in the mathematics curriculum (DoBE, 2010). The document indicates that competency in graphing requires that the learner is able to construct, analyse, interpret statistical and probability models to solve related problem. The construction of graphs as stated entails scaling, drawing the axes, labelling the axes, plotting points, and joining the line of best fit (Flockton *et al*, 2004**)**. David followed this sequence (lines 4bi and 4dii). In the lessons observed, the teacher gave a full explanation of how to construct a scatter plot before demonstrating how to analyse and interpret it. The learners did their classwork in groups. They were presented with exercises from their textbooks and photocopies from related materials, and were requested to analyse and interpret the plots to determine whether there was a correlation between the variables X and Y (lines 3a and 4a).

David's preferred procedural approach in the teaching of the topic was confirmed in the learners' workbooks, portfolios and teachers' written reports. Owing to the lesser use of the conceptual knowledge approach than the procedural approach, it did not come as a surprise that some of the learners displayed certain misconceptions and learning difficulties in the analysis and interpretation of the scatter plots (line 6).

David also displayed evidence of a conceptual approach consisting of providing the reasons that make the algorithm and formula work, understanding the relationships between important statistical concepts as well as explaining the mathematical connection between them during the lessons on scatter plots (line 4dii). It was significant that more learners seemed to possess a better grasp in which they were able to construct and interpret ogives by means of this approach rather than the procedural approach (line 9). In the lessons observed, he explained the mathematical connections, characteristics, nature and relationship between X and Y in a scatter plots (line 6). In doing so, David could be regarded as having displayed progressively more adequate PCK in teaching scatter plots.

In his pedagogy David used activities from everyday-life situations, as observed in the learners' workbook. The use of everyday examples is in accordance with the views held by Shulman (1987) and Kreber (2004) that transformation of the subject matter by the teacher into a form that is more easily understood by the learners involves explanation with examples and instructional selection of teaching methods that are adaptable to the general characteristics of the learners.

David gained knowledge of learners' learning difficulties mostly during classroom practice. The results of this research show that David apparently had no knowledge of learners' preconceptions. As observed, learners revealed previous knowledge of scatter plots from their responses to the homework. For instance, at the beginning of the lesson, he checked and marked learners' homework and corrected errors. While he was correcting their work, he did not show any indication of having anticipated learning difficulties. Instead, he presented the corrections procedurally with no emphasis on how learners' errors could be avoided during the lesson or later. The learning difficulties that were identified through monitoring and analysing the learners' responses to classwork (line 4bii) should have been taking into consideration during lesson planning on scatter plot construction. Penso (2002) opined that practising teachers should consider learners' thinking and prior knowledge during lesson planning in order to avoid possible learning difficulties during the lesson. Hill et al (2008) also reported that the sequence of teaching and learning may be altered if learners' prior knowledge is not considered during lesson planning and presentation. David addressed the learning difficulties by using a conceptual knowledge approach, and reviewing the learners' homework to reinforce their understanding, and conducted post-teaching discussions during and after scatter plot construction lessons (line 12).

The learners followed the teacher after the lesson, demanding further clarification. He had not sufficiently addressed their learning difficulties, which means that his PCK with regard to teaching construction of scatter plots is not comprehensive enough to cater for the learners' learning difficulties (Westwood, 2004). He subsequently addressed learning difficulties experienced by the learners in post-activity discussions, a strategy that he used frequently in his lessons (line 13). Capraro *et al* (2005) note that competent mathematics teachers should be able to exhibit progressively more PCK in their lessons since they have acquired more experience from formal education programmes and plan their lessons to pre-empt learning difficulties.

Conclusion and Recommendation

In conclusion, David's PCK profile may be construed as an amalgam of the various components of PCK, as defined earlier. His presumed PCK in teaching data handling topics lies in his ability to use the learners' homework to identify their preconceptions, as well as to use construction skills and recommended mathematics and statistics-related textbooks to plan how to teach the topic. A combination of procedural and conceptual approaches, as well as the use of everyday situations and examples in teaching them, constituted the instructional strategies that he employed. By identifying learners' learning difficulties using monitoring and analysing learners' responses to classwork, David can be said to have knowledge of learners' learning difficulties. But these difficulties are not always followed up in terms of taking them into consideration in planning the next lesson to identify the learners' preconceptions on the new topic.

How do teachers develop their PCK in statistics teaching? Precisely, David's PCK on the construction of scatter plots could have been developed through classroom practice and learning experiences over time. In terms of his formal education, David received further training on the teaching of mathematics after his initial teacher training programme. He holds a BSc degree, majoring in mathematics, and specialises in teaching mathematics. His qualifications may have informed the reason that his content knowledge of the subject matter can be considered adequate.

David has five years' mathematics teaching experience. His instructional strategies over the years in teaching statistics would have involved lesson planning and the use of the recommended work schedule, and of recommended textbooks in school statistics, delivering lessons and checking and making learners' responses to homework. Other sources of PCK included review of his teaching portfolios and learners' workbooks. These activities may have contributed to the development of topic-specific PCK in statistics teaching.

David attended workshops arranged by the DoBE. Most of these workshops focused on data handling and how to teach it. There is a need to further investigate why a teacher with over five years' teaching experience in statistics has no knowledge of learners' preconceptions in statistics teaching.

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