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Content Knowledge Mastery and Gaps of Technical Sciences Teachers in Fezile Dabi Education District

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Abstract

This study investigated subject content knowledge mastery and gaps in topics related to Technical Trades subjects of Technical Sciences teachers in the Fezile Dabi Education District. It explores the Pedagogical Content Knowledge (PCK) of Technical Sciences teachers to implement the Technical Sciences curriculum in the classroom as well as the extent of content knowledge mastery and gaps in six topics related to Technical Trades subjects. In view of previous research studies that highlighted the relationship between subject matter knowledge and PCK, a theoretical framework was developed. Researchers have identified many characteristics of 'good' science teaching, establishing strong links to the level and quality of content knowledge teachers hold. Subject matter knowledge that teachers master directs the content that teachers will teach and what learners will learn from the content matter prepared by the teacher. A quantitative method was used to do a case study using purposive sampling that involved teachers teaching Technical Sciences. Teachers were firstly given a questionnaire to rate themselves and were then assessed on six topics in the Technical Sciences curriculum that are related to the Technical Trades subjects across the FET phase. Statistical data analysis was used to assess findings. The research study revealed that teachers generally rated themselves as partially knowledgeable in the six topics instead of knowledgeable which is not the trend as per tests administered to them. In tests that were administered, the highest performed topic was Forces with an average of 35% and the lowest performed topic which is Viscosity and Hydraulics at an average of 15% which is an indication that teachers have subject content knowledge and PCK gaps in the six topics. The overall content mastery of teachers in these topics was 22% and content knowledge as well as PCK gaps were at an alarming 78%. A conclusion was drawn that Technical Sciences teachers struggle to understand content knowledge in the expertise of Technical Trades subjects. It was found that teachers' level of content knowledge influences the PCK they possesses and poor subject content knowledge results in teachers being unable to effectively teach the content matter to learners, which causes poor PCK that becomes a hindrance to effective learning.

How to Cite

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INTRODUCTION

Technical Sciences is a subject that was introduced in Technical and Comprehensive Secondary Schools in South Africa in 2016. It is a subject that is meant to strengthen and support the learning of Technical Trades subjects learners are taking.

According to the Curriculum and Assessment Policy Statement (CAPS) for Technical Sciences "The main aim of Technical Sciences is to support learners in three Technical Specialisations in the FET band, namely Mechanical Technology, Electrical Technology and Civil Technology Caps, 2018).

The significant role of the learners is highlighted in the curriculum learners will complete Grade 12 with a qualification pitched at the National Qualification Framework level 4 (Caps, 2018). Due to scarce skills in Technical Sciences, the school management teams in most schools have allocated non-qualified Technical Sciences teachers to teach the subject. The latter indicates that schools do not have a uniform understanding of which teachers are supposed to teach the subject. This poses a prominent question that requires some answers i.e. Are Physical Sciences qualified teachers equipped with content knowledge and pedagogical skills to effectively implement the Technical Sciences curriculum in the classroom, particularly the topics that are more related to topics taught in the Technical Trades subjects?

Since practical work forms an integral part of the Teaching and learning process of Technical Sciences, it is evident that teachers should be well trained to meet the practical demand of this subject and also for teachers and learners to integrate theory with practical work. It furthermore implies that learners in a class whose teachers have practical knowledge gaps may lack some of the content knowledge to be acquired (Cook, Taylor, 1994) .

According to Buabeng and Winter (2016) it is also well known that in the technical and engineering working industry, there is a greater demand for highly skilled labourers and not just labourers who possess only the theoretical framework.

Buabeng et al(2016) states that, "Perspectives of physics teachers nationally indicated that in general, teachers considered themselves not well prepared in some content areas including electronics, modern physics, atomic and nuclear physics."

This happens since teachers have usually gained their content knowledge from an undergraduate science degree. The same applies to teachers teaching Technical Sciences in South African schools and may have content gaps in topics such as electronics which may prove to be adverse in learner attainment as such topics are related to Technical Trades subjects. Atkin,Black and Coffey (2001) states that the National Research Council's education standards "recommend that teachers of mathematics and science should have a strong knowledge of mathematics and science concepts to enable them to guide students to explore these concepts." Hence, Technical Sciences teachers may not be able to realise the aims of the Technical Science curriculum if content mastery is lacking.

Russell ,Bell ,McGuigan, Qualter, Quinn and Schilling(1992) assert that teachers need to possess a particular level of science understanding and a certain amount of science subject matter knowledge is a must-have in order to be able to implement the curriculum.

Ball(1990) explains that subject matter is a vital component of teacher knowledge. They further indicate that as teachers will be teaching learners, they must understand what they will be teaching to learners. Nixon et al (2017)indicate that for a teacher to be able to understand learner's challenges with the subject matter at hand or for teachers to be able to identify the teaching methodologies for a specific topic requires that the teacher must know and understand the subject matter knowledge prior.

An analysis by Jadama (2014)indicates that it is crucial for teachers to know and understand the content to be taught because teaching is about instilling content knowledge, skills and values to learners

In this research study it was noted that according to Weiss,Banilower, McMahon and Smith (2001), research indicates that it proves very challenging to measure the extent to which teachers in a country understands the concepts that they are teaching

It was hoped that the results of this research study would elucidate whether Technical Sciences teachers are equipped with the content knowledge needed to implement the Technical Sciences curriculum in the classroom. The idea was to find out if there were content knowledge gaps and the extent of the gaps in topics related to Technical Trades subjects, per topic. The aim was to identify which topics teachers showed mastery as well as the extent to which they mastered the topics.

As per the background of Technical Scien-

ces teacher content knowledge and pedagogical content knowledge, the following research question is answered in this paper:

What subject content knowledge mastery and gaps do Technical Sciences teachers have on topics related to Technical Trades subjects in the Fezile Dabi Education District?

Against this research question, the following research sub-questions that guided the study are intensely answered: What are the teachers' content knowledge gaps and or mastery in Technical Sciences topics related to Technical Trades subjects in the Fezile Dabi Education District?; How can problems be addressed regarding content knowledge gaps in Technical Sciences topics that are related to Technical Trades subjects?.

This study is based on previous studies related to teachers subject matter knowledge as well as pedagogical content knowledge, however in the context of Technical Sciences knowledge mastery and or gaps possessed by teachers in topics related to Technical Trades subjects. Content knowledge and subject matter knowledge are two terms that are often used interchangeably. In this regard, Rollnick and Mavhunga(2014) assert that content knowledge is less unpacked as compared to pedagogical content knowledge, because it is more of a concept that easily explains itself. Ball et al(2008)define content knowledge as the knowledge of a given subject and the structure that organises it. Rollnick ,Bennett ,Rhemtula M., Dharsey N, Ndlovu T (2008) conclude that in many countries that are well developed, it is usually assumed that the content knowledge possessed by teachers is adequate.

Pedagogical content knowledge and its importance

According to Abell 2008 pedagogical content knowledge provides a theoretical framework for understanding the knowledge and skills that a teacher possesses. Kind (2009)states that "Pedagogical content knowledge (PCK) in science education has received extensive research attention since inception in the mid-1980s, but remains unnoticed by many science teachers."

Rollnick et al(2008) describe pedagogical content knowledge as, "how teachers engage in the business of teaching their subject by accessing what they know about their subject, the learners they are teaching, the curriculum with which they are working and what they believe counts as good teaching in the context of the situation in which they are operating

The relationship between subject matter knowledge and pedagogical content knowledge

Research studies which strive to understand how teachers' content knowledge affects their classroom practices indicate that content knowledge influences their pedagogical content knowledge; they show that teachers with poor content knowledge move away from implementing inquiry-based teaching. Adams et al(1997) indicates that teachers with content knowledge gaps use closed and constrained pedagogical skills. Rollnick et al(2008) asserts that subject matter knowledge is important for the development of teachers' pedagogical content knowledge

Social Constructivism

According to Fox (2001), social constructivism is a theory which explains that learning and acquisition of content knowledge is built or constructed actively. Târziu(2017) states that, "Scientific practice is a social practice, and every enterprise of knowledge in general exhibits important social dimensions". Târziu(2017) further states that social constructivists, science should be understood as embedded within a certain socio-cultural context that determines its features

For this research study social constructivism also plays a huge role in that current Technical Science teachers need to take into consideration that learners have preconceived ideas about certain aspects of the topic and are not merely empty vessels, thus in the six topics under investigation it is important to measure the content knowledge mastery and gaps that teachers have as this will have an impact on how teachers implement the subject in class and assist learners to construct the science knowledge

METHOD

To intensely answer the research and research sub-questions a quantitative approach was employed.

In this research study purposive sampling was used to gather data as the study was restricted to identified delimitations. The participants were teachers teaching Technical Sciences in comprehensive sand technical secondary schools in Fezile Dabi Education District. The sampling method used for this case study was random and quota sampling.

The population was identified schools in the Fezile Dabi Education District. Only three schools were part of the research of all the School in Fezile Dabi. The latter means only three schools were sampled for the purpose of this research study. Furthermore, only three teachers per

school participated and that totals nine teachers participating in this research study in the district. The chosen schools were sampled, because these are the main schools that offer Technical Sciences as a subject, whereas other schools are neither comprehensive secondary nor Technical High Schools and thus do not offer Technical Sciences.

The following figure, Figure 1, provides insight about the nature of respondents that formed part of this research study. It can be noted that the respondents that were selected were all currently teaching Technical Science in the FET phase.

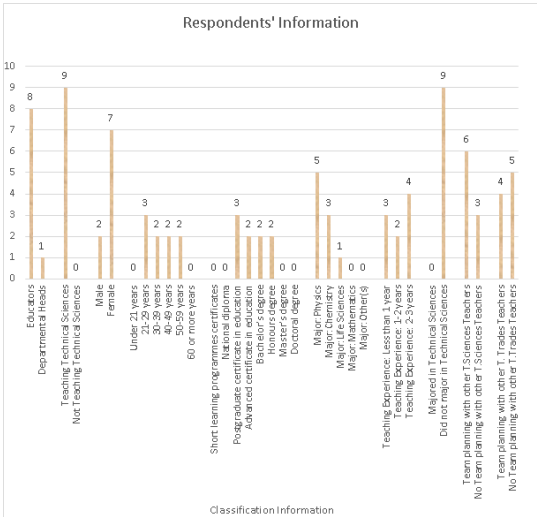

Figure 1. Respondents' information

The first form of data collected was in the form of a questionnaire that sought to measure the confidence of teachers in the teaching of the Technical Sciences curriculum content topics related to Technical Trades was developed and the researcher adopted a rating scale which teachers used to rate themselves. The questionnaire was used by 9 teachers to rate which topics they had content gaps in. Furthermore, teachers rated themselves to indicate which topic they master. The information from the questionnaire was verified through a quantitative method when teachers were assessed. The questionnaire was hand-distributed, completed by all 9 teachers in the presence of the researcher and collected immediately after completion.

For this study, teachers were assessed on topics covered in the Technical Sciences curriculum that are related to the Technical trades across the FET phase. The topics which were assessed are: Forces, moments of forces, Elasticity, Viscosity, Hydraulics and Electronic Properties of matter.

All teachers were exposed to the same conditions for the purpose of this research study i.e: Same assessment task per topic; Same duration for completion of the assessment task; Assessment tasks were administered at the same time of the day; Same teachers participated for the entire research and administered assessment tasks; and Controlled conditions were adhered to when the assessment task were administered i.e. the researcher invigilated.

Teachers' scripts were marked by the researcher, currently teaching Technical and Physical Sciences in Grade 12.The marked scripts were used to calculate and determine the extent to which teachers had content knowledge mastery and gaps in the topics identified.

Upon completion of collection of data through the administered questionnaire and 6 assessment tasks on topics in the Technical Sciences curriculum that are related to Technical Trades subjects, data was analysed using computer assisted software applications such as Microsoft excel to generate graphs as well as performing advanced calculations to measure and draw conclusions on content mastery and or gaps in these topics. The latter is important in that Giles et al(2014) defines analysis as a process performing analysis of relationships or analysing differences that support or conflict with an original or new hypothesis that should undergo statistical tests of significance to determine validity of data that can culminate in conclusions.

From the data gathered after marking of assessment tasks given to teachers, marks per topic could indicate the extent to which the teachers mastered content and moreover the general extent of mastery of the identified topics by Technical Sciences teachers. Furthermore, marks per topics assessed could indicate the extent to which teachers showed gaps in content knowledge. The statistical data analysis assisted in making recommendations and concluding statements about the state of content knowledge of Technical Sciences teachers in Fezile Dabi Education District

RESULT AND DISCUSSION

Spaull (2013)states that, "While it must be acknowledged that the confidence levels of teachers in most developing countries were higher than those in developed countries, the point remains that South African teachers overestimate their ability to impart the curriculum. This has important ramifications when considering the demand for teacher training, since teachers who believe that they possess adequate content knowledge or are sufficiently adept at teaching are far less likely to seek out professional development opportuni-

ties".

From the questionnaire, the following data was gathered based on self-rating of teachers on each topic they were going to be assessed on.

Teachers' self-rating on Forces

The trend was also that teachers' self-rating showed that at least 3 (33.3%) have minimal content mastery in defining forces, drawing force and free body diagrams.

Teachers' self-rating on Moments of Forces

Overall teachers' rating indicated that on the topic moments of forces, a greater percentage of teachers were knowledgeable on writing a formulae to calculate torque and the greater percentage of teachers where they rated themselves as having content gaps is in the realm of performing calculations on moments of forces and performing practical work

Teachers self-rating on Elasticity

Five (55.5 %) of the teachers rated themselves as partially knowledgeable in each of the following subtopics defining the term 'elastic limit' and 'stress', 'calculating the stress and strain on an object' as well as 'stating units of stress'. The lack of knowledge proves that teachers were aware that their content knowledge on these topics was limited.

Teachers' self-rating on Viscosity

Regarding viscosity, the trend observed is that there was more or less an equal distribution of teachers that rated themselves as not knowledgeable when compared to those that were partially knowledgeable together with those that indicated that they were knowledgeable

Teachers' self-rating on Hydraulics

It emerged that 3 (33.3%) and 4 (45.5%) of the teachers rated themselves as partially knowledgeable in stating Pascal's law and performing calculations on hydraulic lifts respectively. In particular, for this topic, there were a great number of content challenges in some subtopics and to a greater extent some teachers indicated that they were partially knowledgeable in most aspects of the topic.

Teachers' self-rating on Electronic Properties of Matter

Seven (77.7%) teachers rated themselves as not knowledgeable on the subtopics differentiating between n-type and p-type semiconductor as well as discussing the construction and working of a p-n junction diode which indicates a relatively high scale of content gaps on this topic. Important to note is that only two (22.2%) of the teachers rated themselves as being partially knowledgeable in differentiating between n-type and p-type semiconductor as well as discussing the construction and working of a p-n junction diode.

Teachers performed well in calculations involving collinear vectors with an average percentage of 75 %. Subtopics such as resultant of forces, forces at equilibrium and the effect of increasing an angle on the magnitude of weight rendered results indicating that teachers performed moderately well with an average percentage of 50%. Teachers performed poorly in the topics that tested their level of content knowledge in stating the parallelogram of two forces, defining an equilibrant in which they performed at an average percentage of 33%. A 25% average performance of teachers was indicated regarding the section using graphic representation to draw collinear vectors and determining the resultant force using the parallelogram law which is sometimes called the tail-to-tail method. The 75 % content gap existed in this subsection. The average percentage of 0% exists in other subtopics on Forces.

Teachers' performance on Moments of Forces

The graph below indicates how teachers performed in the controlled test on moments of forces.

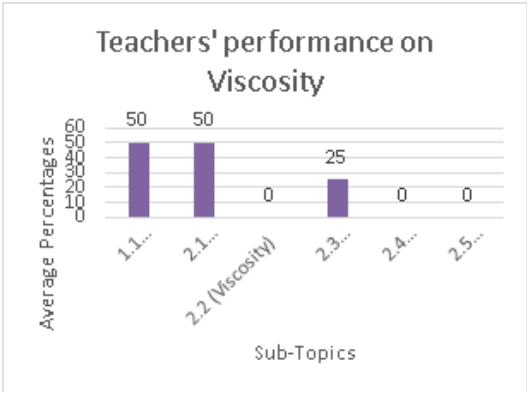

Figure 2. Teachers' performance on Moments of Forces

Teachers performed moderately well in stating the law of moments at an average percentage of 50 and Force Calculations on a beam at an average percentage of 40. The latter indicates that teachers had 50% content mastery in stating the law of moments and therefore it equated to a 50% content gap in this topic. Teachers showed 40% content knowledge mastery in performing force

calculations on a beam which then left a massive content gap of 60%.

Teachers performed poorly in the section of labelling a beam at an average percentage of 33% and 0% average percentage in classifying a lever. The above-mentioned means that a content gap of 67% existed with regards to labelling a beam and an alarming 100% content knowledge gap existed for classifying a lever.

Teachers performed at an average percentage of 0% on the section defining, calculating and ways to increase the mechanical advantage of a lever. The average percentages are equal and this is high because the three subtopics are interrelated. The 100% content knowledge gap in this subtopic is extreme and indicates that this content needs to be dealt with extensively to equip teachers.

Teachers' performance on Elasticity

The graph below indicates how teachers performed in the controlled test on Elasticity.

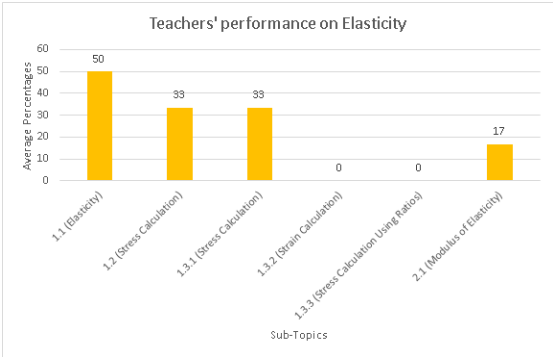

Figure 4. Teachers' performance on Elasticity

Regarding the topic of Elasticity, teachers performed moderately well in defining the term elasticity and scored an average percentage of 50%. This signifies that teachers only possessed 50% content knowledge on mastering this aspect and a 50% content gap was attributed to incorrectly defining and or partially defining the term elasticity.

Teachers performed at an average percentage of 33% in both calculations of the stress on an object. Most teachers could write the stress formula but could not perform calculations and conversions of area and force to calculate the stress on an object which accounts for the 67% content knowledge gap in this section of the topic. An average percentage of 0% was evident for calculations of strain on an object which indicates that there was no content mastery on this subtopic of elasticity. Teachers also performed poorly in calculating the modulus of elasticity at an average percentage of 17%, which means the content knowledge gap was 83%.

Teachers' performance on Viscosity

The graph below indicates how teachers performed in the controlled test on viscosity.

Teachers obtained an average percentage of 50% for understanding the concept of lubrication by oils as well as functions of lubricants. The latter signifies content mastery at 50% and content knowledge gaps at 50%.

At an average percentage of 0% is defining what viscosity is. This represents teachers having content knowledge mastery at 0% and 100% lacking thereof.

Teachers also obtained an average percentage of 0% in explaining how a 2-stroke and 4-stroke engine are lubricated. This is a very technical aspect of the content and teachers were unable to comprehend this calculation. The difference between monograde and multi-grade oils was also not well answered as teachers obtained a 25% average in performance. The staggering 75% in content knowledge gap alarms that poor understanding and misconceptions existed.

Teachers' performance on Hydraulics

The graph below indicates how teachers performed in the controlled test on Hydraulics.

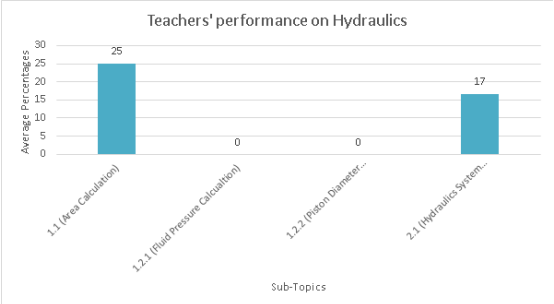

Figure 5. Teachers' performance on Hydraulics

Teachers' performance in all subtopics of hydraulics was substandard with the highest performed average percentage at 25% and the lowest at 0%. Teachers performed at 25% in area calculations involving hydraulics objects. The calculation is a basic for hydraulic systems and teachers showed 75% poor content knowledge.

Teachers also performed poorly in hydraulic system calculations in which they had to apply Pascal's law to determine the input force as the average percentage of performance is at 17.

Teachers obtained an average percentage of 0% for two subtopics i.e. fluid pressure and pis-

ton diameter calculations. The latter means the content mastery is non-existent and thus a content knowledge gap of 100% was detected.

Teachers' performance on Electronic properties of Matter

The graph below indicates teachers' performance in the controlled test on electronic properties of matter

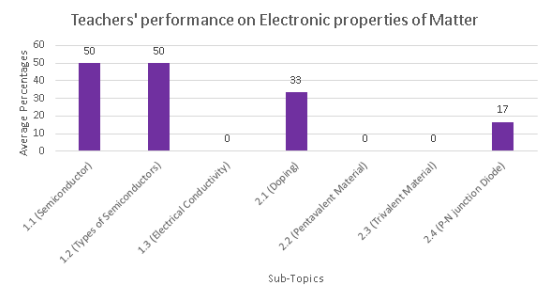

Figure 6. Teachers' performance on Electronic Properties of Matter

Teachers performed moderately well by obtaining an average of 50% in defining a semiconductor and giving types of semiconductors. This signifies a content knowledge mastery of 50% and content knowledge gap of 50%.

Teachers showed extensive content knowledge gaps in the subtopic doping with an average of 33% and the effect of an increase in temperature on the electrical conductivity of semi-conductors as well as examples of pentavalent and trivalent material which were at an average of 0%.

The 67% content knowledge gap in explaining doping is due to lack of understanding of what doping is and how it is performed. Teachers also showed poor content knowledge in drawing a labelled

Overall teachers' performance per topic

Teacher performance was also analysed to establish the overall average performance per topic and to do a comparative study on the performance per topics they were assessed on. The following graph represents the mark distribution per topic for all nine teachers that were part of this research study followed by the graph.

Teachers' performance was at average of 35% in the topic: Forces and the most poorly performed topic is Viscosity and Hydraulics at an average of 15% which signifies that the range in teacher's average performance in all 6 topics is between a minimum of 15% to a maximum of 35%

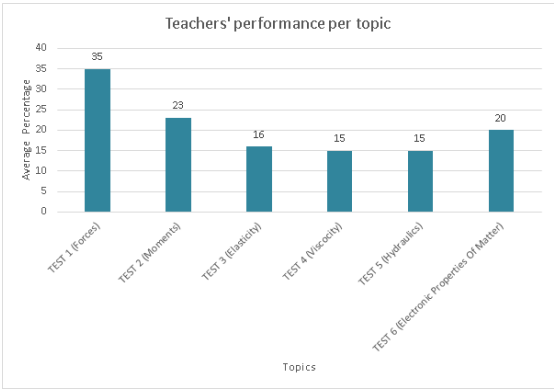

Figure 7. Teachers' performance per topic

Discussion

The poor self-rating of content knowledge by teachers in the six topics is an indication that teachers are not confident about teaching the six topics in the Technical Sciences curriculum that are related to Technical Trades subjects.

Similar studies on content knowledge of teachers have been done before. The following findings were made by Ramnarain et al(2013) reporting that he interviewed teachers in his mixed-methods study and found that they were battling to interpret the new topics.

Apart from the interview responses, the questionnaires also confirmed this problem. The teachers who participated in his study reported that they enjoyed the new, interesting curriculum but experienced challenges with the new terminology and concepts and needed additional training. They reported that their inadequate knowledge hindered them from teaching confidently. One teacher said she started to ask learners to answer the questions they were having problems with. The teacher also reported that she had to adopt a teacher-centred approach to stay in control of the class as her uncertainty and activity-based approach posed problems. Teacher driven classes were reported to hinder learners to ask questions on aspects they needed assistance with. The latter was also observed to happen when involving the performance of Technical Sciences teachers in six topics that are related to Technical Trades subjects.

Research studies conducted by Henze et al(2007) revealed that when there are several new topics that are included into a new curriculum, teachers usually become uncertain about their content knowledge which then affects how they implement the curriculum. The latter applies to the current Technical Sciences curriculum, because it has several topics including the six that are investigated in this research study which te-

achers are unfamiliar with.

Teachers' performance was at an overall average of 35% in the topic: Forces. This is a topic where teachers performed better than all the topics that they were tested on. However, the average of 35% means that content mastery of teachers in this topic is substandard as the content knowledge gap is at a high of 65%. The latter means that teachers know less than what they did not know. This topic is particularly related to Fitting and Machining Technical trades subjects where learners deal with forces on objects and to a good extent in Welding and Metal work which is also a technical trade subjects that fall under Mechanical Technology. The results indicated that teachers show 35% content knowledge mastery in forces and 65% content knowledge gap in forces which highlights what the objectives of this research study were.In comparison to how teachers rated themselves on the topic on Forces, content gaps are far greater than how they rated themselves which is evident in the performance as seen on the test administered.

The performance of teachers in Moments of forces is at a very low 23% and is the second highest performed topic after forces. The average performance shows that teachers' mastery of overall content is at 23% and content knowledge gaps that exist are at 77% which is almost 3.5% times more than what they master. The extensive content gaps have a negative impact on the understanding of the topic as well as delivery of the topic during teaching and learning. This topic is critical for learners that are taking Construction as a Technical Trade subject which falls under Civil Technology. The poor performance in the CAPS requirements of content knowledge by teachers signifies that there were content gaps in this topic that is related to Technical Trades and only 23% of the content is well mastered by teachers. The latter was insufficient to enable learners to perform well in their Construction subject.Futhermore,this poor content knowledge gap noted in the performance if the administered tests,aligns with how teachers rated themselves as having major content knowledge gaps in this topic.

Electronic properties of matter were performed at an average percentage of 20% which indicates that content mastery was very poor and content knowledge gaps were at a high average of 80%. The content knowledge gaps are so high and alarming in that they signify that the situation is critical in this technical sciences curriculum topic. With Technical Sciences Curriculum being regarded as important for Electronics as a Technical Trade subject, the content knowledge gaps of teachers may not assist in this regard. The topic in itself is practical in nature in order to understand it and the poor content knowledge is attributed also to the fact that if teachers are unable to comprehend theoretical work then they will be unable to do practical work, hence the challenges. The scope of this research study was to look into content knowledge gaps and mastery of teachers in these topics that are related to Technical Trades and it can be seen from the results that extensive content knowledge gaps and minimal content mastery existed on Electronic Properties of Matter.77.7% of teachers rated themselves as not knowledgeable in Electronic properties of matter which is supported by the results from the test administered that 80% content knowledge gaps exist.It is evident that teachers acknowledge the content gaps which they have.

Performance in elasticity was at an average of 16%, which means content mastery of this topic was very low and content knowledge gaps were at 84%. The minimal content knowledge had adverse effects on learners that are taking Fitting and Machining as a Technical Trade subject as this topic is meant to assist them in the subject. It is noted that this topic is extensively dealt with in Technical Trades subjects and with various practical work that is encompassed with the learning of this topic. It can be clearly seen that this topic which is more of a technical topic, is problematic for teachers that are currently teaching Technical Sciences.

The average performance in Viscosity and Hydraulics was the lowest (15%) when bearing in mind all the topics. The latter means content mastery of these topics is at 15% and content knowledge gaps were at 85% which is extremely high. The above-mentioned topics fall under Automotive, formerly called Motor Mechanics which falls under Mechanical Technology. The topics are extensively dealt with in Automotive and are the expertise of Automotive teachers. The results show that these two topics which are related to Technical Trades subjects are particularly difficult for current Technical Sciences teachers as the content mastery is minimal. The self-rating of teachers in content mastery in the two topics is contrary to the performance in the administered test as they performed poorly at an average percentage of 15% but have on average rated themselves at 45% knowledgeable in the topics.

Overall, the average score in all six tests was 22%). This means Technical Sciences teachers' content knowledge mastery on topics related to Technical Trades subjects was 22% and 78%

indicated content knowledge gaps. The latter means Technical Sciences teachers struggle with comprehending content knowledge in these topics which are extensively dealt with in Technical Trades subjects that are a speciality of Technical Trades teachers. Many factors come into play to explain why Technical Sciences teachers as respondents showed such minimal content knowledge but extensive content gaps.

Rogan (2003) indicates that most of South Africa's Grade 11 and 12 teachers only have at least one if not two years after matric study in the subjects they are teaching at schools which results in them teaching various content matter at a lower degree than expected. The latter supports the results obtained in that teachers average percentages were low i.e. below 50% in all six topics which indicates that the content knowledge they possessed was insufficient and poorer than expected, implying that even in the classroom the extent to which the topics was taught was substandard.

Rollnick et al.(2008) indicates that teachers in countries which are well developed have sufficient subject matter knowledge. This is however not the case when studying the statistics from the questionnaire, since it can be inferred that teachers teaching Technical Sciences in South Africa, lacked content knowledge and gaps were at a staggering 78% on topics that are related to Technical Trades subjects. Furthermore, the high degree of content knowledge gaps experienced by teachers were an indication that subject matter knowledge was poor and therefore, Technical Sciences teachers showed a lack of pedagogical content knowledge needed to teach six of these topics that are related to Technical Trades subjects. As a result of the latter, learner achievement will also be adversely affected by such poor content knowledge and pedagogical content knowledge of teachers, because teachers may not implement the curriculum effectively in the classroom during teaching and learning.

The extensive content knowledge gaps i.e. 78% is an indication that content knowledge of the respondents was still lacking and had not been well developed. This is also attributed to various factors such as a lack of opportunities that teachers had to develop their content knowledge and pedagogical content knowledge. Rollnick et al(2008) state that, "In South Africa, one of the legacies of apartheid is that teachers from traditionally disadvantaged groups often had only limited opportunities to develop their knowledge and understanding of science (and other) subjects."

Similar studies on content knowledge of teachers have been done before. The following findings were made by Ramnarain & Fortus(2013). He reports that he interviewed teachers in his mixed-methods study and found that they were battling to interpret the new topics. Apart from the interview responses, the questionnaires also confirmed this problem. The teachers who participated in his study reported that they enjoyed the new, interesting curriculum but experienced challenges with the new terminology and concepts and needed additional training. They reported that their inadequate knowledge hindered them from teaching confidently. One teacher said she started to ask learners to answer the questions they were having problems with. The teacher also reported that she had to adopt a teacher-centred approach to stay in control of the class as her uncertainty and activity-based approach posed problems. Teacher driven classes were reported to hinder learners to ask questions on aspects they needed assistance with. The latter was also observed to happen when involving the performance of Technical Sciences teachers in six topics that are related to Technical Trades subjects.

Research studies conducted by Henze et al(2007) revealed that when there are several new topics that are included into a new curriculum, teachers usually become uncertain about their content knowledge which then affects how they implement the curriculum. The latter applies to the current Technical Sciences curriculum, because it has several topics including the six that are investigated in this research study which teachers are unfamiliar with.

In view of content knowledge gaps identified in this research study on six topics that are in the Technical Sciences curriculum which are related to Technical Trades, one can see that the status quo is alarming. A research study by Ramnarain et al(2013) showed that 43.7% of teachers believed that topics which are new are cumbersome and challenging. Furthermore, the research study by Ramnarain et al(2013) however, found that 81% of teachers agreed that these new topics make the learning of science by learners more significant and relevant.

Ramnarain et al.(2013) reports that, in his study six of the 10 teachers revealed they experienced challenges with their PCK on the new topics. They also reported challenges with the presentation of their content knowledge to students. Teachers said they were not familiar with the new topics and could not find concrete examples to explain the content to their learners. One teacher

mentioned the example of capacitance. The findings of the former study correspond with the findings of the current study. It emerged from the study that teachers were unfamiliar with the new topics and battled to make it more accessible to the learners. In the current study 78% Technical Sciences teachers showed content knowledge gaps that revealed the poor pedagogical content knowledge.

Rollnick et al (2008) assert that PCK is indispensable for subject matter content delivery. It also surfaced that in deprived contexts, teachers' subject matter is even more crucial. It can therefore be concluded that teachers are not effectively teaching the topics i.e. Forces, Moments of Forces, Elasticity, Viscosity, Hydraulics and Electronic properties of matter due to extensive content knowledge gaps they possess which impact their pedagogical content knowledge adversely. For effective teaching and learning to take place, teachers must possess a high degree of content knowledge and pedagogical content knowledge of the topic as this will also influence the variety of teaching strategies that the teacher may employ in the classroom.

Ramnarain et al (2013) found in his study that teachers' PCK on content knowledge can be linked with familiarity with the topic as those who reported a lack of PCK also indicated that they were unfamiliar with the topics. His study also revealed a gap in content delivery strategies, which caused teachers to pay more attention to lesson planning than assisting them with problems. In summary Ramnarain et al (2013) found that several teachers had difficulties understanding new topics even though they supported their inclusion in a new curriculum. This content knowledge gap affected their teaching negatively

From a social constructivist point of view, teachers with such extensive content knowledge gaps may not be able to employ a variety of teaching strategies to assist learners in the understanding and construction of science knowledge effectively Târziu (2017). Furthermore, the knowledge gaps will result in the teacher not being able to offer extended opportunities to learners to use their social backgrounds e.g. culture, values and previous knowledge to construct science knowledge and for meaningful interactions.

According to Ramnarain et al(2013), "Apart from making the learning of science more relevant to the students and generating interest in the subject, the interviewed teachers also believed that the new topics invite critical thinking and engage students in debate on issues which affect their lives either directly or indirectly."

The hypotheses have been proven to be true based on the minimal content mastery of teachers and major content gaps in Technical Trades related topics as they performed below 50% in all topics

CONCLUSION

Based on the results of the questionnaire that gave teachers an opportunity to rate which topics they have content gaps in and to state which topics they master, the trend is that teachers generally rated themselves as partially knowledgeable in the six topics instead of knowledgeable which is not the trend as per tests administered to them.

Based on the average performance of teachers in six of these topics which are related to Technical Trades subjects, i.e. the highest performed topic is forces with an average percentage of 35 and the lowest performed topic which is Viscosity and Hydraulics at an average percentage of 15% is an indication that teachers have content knowledge gaps in all these six topics, thus hypothesis 1 which states that "Technical Sciences teachers in Fezile Dabi Education District show content knowledge gaps in six Technical Trades related topics that are part of the Technical Sciences curriculum" is accepted. Technical Sciences teachers struggle with understanding content knowledge in these topics which are the expertise of Technical Trades subject teachers.

It is also known from literature that teachers level of content knowledge influence the pedagogical content knowledge the teacher possesses and that poor subject content knowledge results in the teacher being unable to effectively teach the content matter to learners and hence poor pedagogical content knowledge. Sub-research question 1 of this study i.e. What are the teachers' content knowledge gaps and or mastery in Technical Sciences topics related to Technical Trades subjects in the Fezile Dabi Education District? has been fully answer by the findings which indicate that the average percentages in all six topics are very low with the highest at 35%.

Overall, the average percentage in all six tests is at 22% which is a clear indication Technical Sciences teachers content knowledge mastery on topics related to Technical Trades subjects is at 22% and content knowledge gaps is at 78%. Thus, hypothesis 2 which states that "The level of content knowledge mastery of Technical Sciences teachers in Fezile Dabi Education District in six topics related to Technical Trades subjects is poor" is accepted. Furthermore, it can clearly be concluded that content mastery of topics related

to Technical Trades subjects of Technical Sciences teachers in Fezile Dabi Education District is poor and alarming and that content knowledge gaps are high.

A conclusion is also made that poor subject matter knowledge and pedagogical content knowledge will result in teachers being unable to use a variety of teaching methodologies that will assist learners to socially construct knowledge. Sub-research question 2 of this study i.e. To what extent do Technical Sciences teachers show content mastery and gaps in topics related to Technical Trades subjects?, has been fully answer by the findings which indicate that content knowledge mastery is at 22% and content knowledge gaps is at 78%.The hypotheses is therefore accepted.

According to (Diaz-Maggioli & Russell et al (2003) teachers should take part in well planned self-directed learning programmes, coaching amongst peers, action research, study groups and other activities that will enhance their knowledge, skills and performance in the curriculum. A Technical report states that "while teaching resources and learner support materials are important, unless teachers have the knowledge and competence to interpret and utilise these effectively, we will never be in a position to provide quality education in this country [Departments of Basic Education and Higher Education and Training, 2011]. Current efforts to support teachers to implement the school curriculum mainly focus on short workshop interventions that target generic knowledge, work at the level of curriculum information-sharing, and do not assess or evaluate teacher learning".

Teachers as learners of subject matter, should be regarded as having preconceived ideas when content knowledge is presented to them. Thus, professional development courses should be structured such that there are metaphysical and epistemological considerations. The latter means social constructivism is integral to the development of teachers.

It is recommended that the national, provincial and district department of education monitor and support teachers to ensure that the content that teachers are currently possessing on topics related to Technical Trades subjects of Technical Sciences teachers in Fezile Dabi Education District is sustained and that the content knowledge gaps that teachers have in these topics are addressed. Supporting teachers to improve their content knowledge will have a positive impact in helping them improve their pedagogical content knowledge. The latter will ensure that Technical Sciences teachers can then effectively implement the curriculum during teaching and learning the classroom. All processes will require full participation of all stakeholders i.e. teachers, education officials as well as experts from the industry and various academic institutions.

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