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Understanding Teaching Difficulties of the Projectile Motion Topic from the Teachers' Viewpoints and Classroom Practices
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RUNNING HEAD: TEACHING DIFFICULTIES FROM TEACHERS VIEWS AND CLASSROOM PRACTICES

KEYWORDS Art, Teaching, Science, Nature, Challenges

ABSTRACT This paper presents teaching difficulties on the projectile motion topic and why it is perceived to be difficult to teach. It is an empirical case study within an intrepretatoive paradigm. Three grade 12 teachers participated in the study. Data was collected through intreviews and classroom observations. Amongst others, teachers indicated that the lack of mathematical skills and language hampers the teaching of the topic. Furthermoreteachers had challenges with the language too, the content knoclege and also the creation of the environment wherein learners can make meaningful learning of the topic.the aper concludes with recommendations for all the stake holders.

I. INTRODUCTION

The study investigated the problem of some Grade 12 Physical Science teachers from the Johannesburg Central district of education in the Gauteng Province, South Africa. Teachers had a perception that projectile motion is difficult to teach, hence students' poor performance in the topic. The aim of this study was to investigate the teaching difficulties from an examination of the teachers' classroom practices. It was also the aim of the study to explain

why teachers believe projectile motion is difficult to teach. The following research questions guided the research in an attempt to achieve the purpose of the study:

1. What are the teaching difficulties of the "projectile motion" topic?
2. Why do teachers perceive "projectile motion" as a difficult topic to teach?

II. METHODOLOGY

The nature of the investigation required contact with teachers in their schools to elicit data that enabled the research questions to be answered; therefore, the qualitative approach was chosen. It was imperative for this study that close interaction with teachers was established because the teaching difficulties had to be understood from the teachers' viewpoints and classroom practices.

As there was more than one teacher to be considered, a multiple case study method (Stake, 2006) was chosen. This was so because teachers work in different environments with different students. Furthermore, their knowledge is also different as well as experiences. Hence, each teacher was considered a case. With the teacher as a case (Thomas, 1998) his/her in-depth individual conceptions and teaching practices of the topic of projectile motion were analysed. The study was not about a comparison of the individual participants but focused on the descriptions of the phenomenon under inquiry and inferences from classroom practices; hence it was a descriptive multiple case study of three teachers teaching projectile motion.

The research was underpinned by the interpretive research paradigm which accepted that reality is a construct of the human mind (Cohen, Manion & Morrison, 2007). Hence, even though the analysis of data and inferences was embedded in what the teachers pronounced in the interviews and observations only, the researcher's experiences of teaching projectile motion, attendance at workshops and cluster meetings and marking NSC examinations also influenced the resultant interpretations of the analysis and inferences. The paradigm allowed the researcher to look at teachers as individuals, each with their own contextualised teaching difficulties. Teachers were studied in their natural world of work, namely the classroom. As a result, the phenomenon under inquiry was not detached from the researcher (Gall, Borg & Gall, 1996).

The research was undertaken in the Republic of South Africa. The government has two national education departments, namely the Department of Basic Education (DBE) and the Department of Higher Education and Training (DHET). The setting of this study was in the DBE. There are nine provinces, each with its own Provincial Department of Education (PDE)

which is made up of districts. This study was undertaken in the Gauteng Province, which also had the lowest Physical Science average performance (32.2 %) since 2008 when compared to other subjects (DBE, 2011c:70). The province had 14 districts at the time of research.

Besides the fact that teachers who reported that projectile motion is difficult to teach came from the Johannesburg Central District, the performance statistics of its schools were also readily available. This is so because in other districts the performance statistics were for the overall performance in the NCS results rather than performance per subject per school. So this district had information dating back from 2008. It had 53 high schools of which 45 offered Physical Science. Most of the high schools in the district had black students only who mostly came from previously disadvantaged families and suburbs. The district had facilitators for each subject who organised cluster meetings wherein information was disseminated from the provincial office or national office. Furthermore, the Physical Science facilitator's observable role was to ensure that policy and programmes about subject frameworks were strictly followed.

The district had clusters of schools. A cluster was made up of Physical Science teachers from neighbouring high schools. Each cluster was made up of smaller clusters whose roles were to assure quality of students' tasks. In the cluster meetings teachers engaged amongst themselves in discussing the progress and performance of their students. At the first meeting early in the year, the cluster would discuss the previous year's results to determine the reasons for the students' performance. A cluster also wrote its own standardised tests for continuous assessment to ensure that all teachers in the cluster were adhering to the subject framework. It follows then that a lot happened in the cluster meetings and teachers were more at ease to discuss their achievements and challenges in Physical Science there.

The sample of the study was from a cluster that had teachers who had a perception that projectile motion was difficult to teach. This was established during one of the cluster meetings in which the researcher was involved. Teachers were discussing the performance in the NSC Physical Science examination. They noted that projectile motion was always one of the topics identified wherein students did not perform well. Most teachers blamed the poor performance on the difficulty of projectile motion.

It was for this reason that purposeful sampling was used to choose participants (Mason, 2002). The selection of the sample was based on the following criteria: they had to perceive projectile motion as difficult to teach; they also had to be teachers who had worked at their present school for more than three years. This was to ensure that teachers taught the cohort they had taught in the previous grade as it was the norm in the cluster. The practice was to

ensure that students were familiar with the teacher's teaching style. As such the study was a case of experienced teachers who perceived projectile motion to be difficult to teach.

The teachers in the sample also had to be qualified on paper to teach Physical Science at the Grade 12 level. That is, they needed to have studied Physical Science either in a diploma, degree or advanced certificate qualification. This was central to the study; according to Rogan and Grayson (2003), the level of training and qualifications can influence how the teacher teaches. According to the South African Qualifications Authority (SAQA, 2012), a diploma or degree is a qualification at level seven on the National Qualifications Framework (NQF). At this level the teacher should have a detailed knowledge of the subject Physical Science and should demonstrate an integrated knowledge of the subject and the field of science. A teacher who has an Advanced Certificate in Education (ACE) which is at NQF level six should also have a detailed knowledge of the subject (SAQA, 2012). The ACE qualification was designed for in-service teachers in possession of a three year degree or diploma to enhance their pedagogic and content knowledge. A teacher who has an honours degree which is at NQF level eight should demonstrate an integrated knowledge of the subject and engagement in the field (SAQA, 2012). The schools in which the teachers in the sample were based had to have "good practices", a term which refers to the atmosphere in the school being conducive to teaching and learning. A school that was known to be dysfunctional in that it lacked discipline amongst students and with staff members who did not fully respect authority was not considered as it had "bad practices". So, teachers from such schools were not considered to eliminate the factor that the teacher's teaching practices were influenced by the "bad practices" in the school. This criterion was easy to apply because the cluster and the district were very familiar to the researcher and it was easy to eliminate teachers who came from schools that were dysfunctional.

Before one of the cluster meetings, the cluster leader was briefed about the questionnaire to be administered during the meeting. The cluster leader gave permission to administer the questionnaire. During the meeting the researcher was given an opportunity to seek permission from the teachers for them to respond to the questionnaire. Teachers were also asked to volunteer their names using a pencil on the questionnaire and were told that their names would not be divulged to anyone. After analysing the questionnaire it was found that out of 23 teachers who responded, only 15 supplied their names. Formal letters were written to the 15 teachers and their principals to seek permission to conduct research in their schools. Only six teachers and their principals agreed that they could take part in the research.

One of the six teachers came from a school that was known to be dysfunctional and was not considered. From the five teachers left, only four teachers made themselves available for the research and although the fifth teacher initially agreed to be part of the study, he was difficult to communicate with. One of the four teachers became part of the pilot study. Thus only three teachers were part of the main study. The size of the sample was not a problem in this study as it was qualitative and diverse data could be collected from the three teachers. In this regard, McMillan and Schumacher (2006:322) point out that "There are no easy rules for determining size. It depends on what you want to know, the purpose of the inquiry, what is at stake, what will be credible and the available time and resources"

III. FINDINGS

What are the teaching difficulties of the "projectile motion" topic?

A. Case 1 (Mr Manngo)

The study revealed that Mr Mango's teaching manifested inaccurate subject matter knowledge and misconceptions. This was diagnosed when he was teaching as well as during interviews. Thus the teacher had deficiencies in the content knowledge as well as in its use. Mr Manngo also utilised "children science". Moreover, during teaching Mr Manngo experienced problems with the language of teaching. He used words such that they would create or aggravate misconceptions. Furthermore, the words he used compromised the internalisation phase which is so important for meaningful learning in the construction of understanding of new knowledge.

In presenting the lessons on the topic of projectile motion, Mr Manngo used instructional strategies, interactions and discourse that did not create opportunities for students to interact with the new information and use it to solve problems so that they could develop problem solving and inquiry skills. Mr Manngo did not utilise prior knowledge such that students could achieve meaningful learning from it.

B. Case 2 (Ms Radolo)

This study showed that Ms Radolo did not teach projectile motion in two dimensions in such a way that students could construct understanding. She was focused on showing them how to solve the problems; hence students were spectators to what she was doing. Moreover, there were no opportunities for students to interact with the subject matter. She also did not discuss

the force involved in projectile motion in two dimensions. Ms Radolo presented her lessons on the topic of projectile motion as if it was the first time she was teaching the topic. Hence the claim that she manifested the pre-Newtonian teaching of projectile motion in two dimensions and that she taught like a novice teacher even though she had taught the topic for more than four years.

Ms Radolo did not create opportunities for students to think about the subject matter of the topic of projectile motion or discuss aspects of the topic. She focused more on calculations and on covering the syllabus. Ms Radolo's use of the language could also create misconceptions and hinder understanding. Her language difficulties prevented her from expressing herself clearly which could also hamper comprehension in her students. Learning takes place when the teacher creates a connection between prior knowledge and new information, something which Ms Radolo did not do. Her students therefore might not achieve meaningful learning because of the underutilisation of prior knowledge and experiences during teaching.

C. Case 3 (Mr Mada)

The study revealed that the teacher attempted to infuse prior knowledge in his teaching in terms of direction. However, the way he explained the concept may create misconceptions and hinder the comprehension of the information. In fact it did so, because students had many questions related to direction which showed a lack of comprehension, with the teacher just dismissing them. Mr Mada also planned his lesson and followed it through. However, his focus was on solving problems for examination purposes with little participation from students. This meant that he did not create opportunities for the internalisation of the information so that they could achieve meaningful learning. Even the focus of his lessons did not achieve the curriculum demands as he focused on only three types of problems.

Mr Mada was aware that students experienced challenges in learning projectile motion because of their deficient mathematical skills but during teaching he did not attempt to assess their mathematical skills. When students indicated that they were experiencing problems with some of the mathematical equations he just indicated that these are taught in the mathematics class. Mr Mada had good ideas of how the students learn the topic projectile motion, for example by integrating experiments where necessary to foster understanding. While he could explain how and why he would use strategies like the lecture method and/or demonstrations, in practice he was focused on students gaining experience on how to use equations of motion. Mr Mada indicated that students need to be given many examples of the same problem so that

they get used to how it is solved. Consequently, his empirical epistemological perspective clouded his good intentions.

Why do teachers perceive "projectile motion" as a difficult topic to teach?

A. Case 1 (Mr Manngo)

It was shown in the study that Mr Manngo perceived the projectile motion topic to be difficult to teach because students do not see the differences and similarities between vertical and horizontal motion. Mr Manngo also indicated that the topic is difficult to teach because students are interested in the calculations but if they get that calculation wrong then the whole sum will be incorrect. He added that the incorrect choice of direction by students also creates teaching difficulties. Finally, the lack of mathematical skills such as trigonometrical ratios necessary for the learning of the topic also creates teaching difficulties.

B. Case 2 (Ms Radolo)

Ms Radolo indicated that the failure by students to differentiate between a horizontal and a vertical motion creates difficulties when teaching the topic of projectile motion. She added that students have difficulty in comprehending graphs and that creates difficulties for her in how to teach them. When probed for other reasons why she perceived the topic to be difficult to teach she said she had none but just repeated that the topic was difficult to teach.

C. Case 3 (Mr Mada)

The study revealed that according to Mr Mada the topic is difficult to teach because those students who take the subject Mathematical Literacy do not have the necessary mathematical skills to learn the topic. He indicated that the lack of Mathematical skills necessary to teach the topic creates teaching difficulties. Mr Mada emphasised that students need not be given theory only but also opportunities to apply the new knowledge, adding that failure to do so creates teaching difficulties. Finally he indicated that prior knowledge is very important for the learning of the projectile motion topic and failure to integrate it creates teaching difficulties.

IV. DISCUSSION OF FINDINGS

Research (Gilbert and Zylbersztajn, 1985) has shown that challenges associated with the projectile motion topic are content related and lie in deficiencies in the understanding of the concept of the projectile motion topic by either the teachers or the students. Furthermore, many misconceptions have been identified in the topic both in the students and the teachers (Bayraktar, 2009; Prescott and Mitchelmore, 2005). Consequently research in the topic has been on teaching strategies to teach students such that misconceptions are corrected and understanding is enhanced (Graham et al., 2012; Dilber et al., 2009; Park & Han, 2002 and Tao & Gunstone, 1999).

In contrast, this study focused on identifying teaching difficulties of the topic projectile motion by examining teachers' classroom practices with a focus on teacher knowledge, instructional strategies and interactions and discourse. Teaching difficulty in this context can be defined as the teacher's classroom practices which did not advance meaningful learning, misconception dissonance, or the development of inquiry and problem solving skills which influence student achievement. In this section the discusion of findings is presented for each case.

A. Case 1 (Mr Manngo)

According to Mr Manngo the reason for the difficulty in teaching the topic of projectile motion was student centred. For example, he pointed out the lack of certain skills to learn the topic as well as failure to comprehend some aspects of the topic. However, during practice the researcher found that some of the teacher's practices did not promote meaningful learning, misconception dissonance or the development of problem solving and inquiry skills. Content knowledge is fundamental for the understanding of students and Mr Manngo had deficiencies in his content knowledge. He did not understand some key concepts, for example weight and mass. Mr Manngo also did not create opportunities for misconception dissonance but created opportunities to reinforce misconceptions or transfer them to students, as shown in his discussion of the concepts weight and mass and force of gravity.

Mr Manngo was also aware of the linguistic challenges of his students but in class he revealed similar challenges himself. The words he used in the classroom did not promote the internalisation of the subject matter by students such that there would be meaningful learning. Furthermore for students to make meaningful learning of the topic of projectile motion there should be a connection between the prior knowledge and the new information. Mr Manngo was aware of this; he indicated that failure to make this link could create a teaching difficulty, yet in the classroom he did not make a connection between horizontal and vertical motion

even though he had indicated that students cannot differentiate horizontal from vertical motion.

The fact that students are more interested in calculation than the theory was found to have been reinforced by the teacher as he focused more on calculations. His instructional strategies and interaction with students as well as the patterns and type of discourse did not promote thinking and reasoning amongst students, something which is fundamental for the development of problem solving and inquiry skills. Mr Manngo was intent on conveying information in an authoritative discourse. This discourse did not promote the social interaction and discussion so vital to the construction of knowledge by students.

From the teacher's practice in the classroom it is clear that the content knowledge, instructional strategies, interactions and discourse did not promote meaningful learning, misconception dissonance, and the development of problem solving and inquiry skills. It follows that students may not achieve good performances in the topic of projectile motion because of the teacher's practices. It was also evident that even though the teacher had knowledge of what could cause difficulties in teaching the topic he did not address those in the classroom. However, this study could not clearly establish the reasons for this.

B. Case 2 (Ms Radolo)

Ms Radolo indicated that the topic is difficult to teach but did not provide any reasons besides saying that students cannot differentiate horizontal motion from vertical motion. In class she addressed this difficulty through the use of symbols to indicate the horizontal and the vertical motion. Ms Radolo had also planned her strategies of how to teach. For example, she introduced the lesson by showing the differences between horizontal and vertical motion. However, as the lessons progressed Ms Radolo's focus was more on algorithmic teaching. There was no emphasis on reasoning and thinking by students in order to develop problem solving and inquiry skills.

Ms Radolo rushed through the lesson, which did not create opportunities for the students to internalise the subject matter. However, the contextual factors could have been the reason: she indicated that she had been given dates from the district office by which the topic had to be covered. Ms Radolo was aware that the English language does hinder adequate student performance, yet her own use of the language created misconceptions. Furthermore, there were instances when she was unable to express herself adequately because of her deficiencies in the language. The researcher is of the view that it was not because she did not know what she was talking about but that she lacked words for proper articulation of her thoughts. Ms

Radolo only tapped into the prior knowledge when connecting horizontal with vertical motion and thereafter she did not exploit the students' prior knowledge. Ms Radolo largely used the lecture method in her class by means of which she conveyed information to students through an authoritative mode of discourse.

It is evident that Ms Radolo's teacher knowledge, instructional strategies, interactions and discourse did not promote meaningful learning, misconception dissonance and the development of problem solving and inquiry skills required to answer questions regarding the topic of projectile motion. However it is important to note that although Ms. Radolo realised that there were teaching difficulties, she could not identify the causes and therefore did not know how to overcome the teaching difficulties she experienced.

C. Case 3 (Mr Mada)

According to Mr Mada contextual factors such as the instructions from the district that students must take mathematical literacy created teaching difficulties in the topic of projectile motion. He also indicated that if prior knowledge was not integrated in the teaching of the topic of projectile motion this would create teaching difficulties. Mr Mada also asserted that students need opportunities to apply the new knowledge so that they can achieve meaningful learning and failure to do so will result in teaching difficulties. It follows that the teaching difficulties, some of which stemmed from learning difficulties, were not only student centred but also reflected on what the teacher was supposed to do.

In the classroom Mr Mada taught in such a way that he was pollinating the creation of misconceptions. For example, students did not comprehend how to identify direction or when to give direction from the way in which he explained direction in a vertical motion. In addition, Mr Mada also taught only three types of problem which, according to Gess-Newsome (1999), could mean that he was not knowledgeable regarding other concepts of the projectile motion topic. He therefore only focused on that which he was comfortable with. Furthermore, Mr Mada did not integrate prior knowledge which would have reinforced meaningful learning.

The instructional strategies which Mr Mada employed were empirical; that is, he was focused on students' gaining experience of how to solve problems. There were no opportunities for them to think and reason about what was taught or to apply the new knowledge. Mr Mada also rushed through the lesson. He was focused on examinations. As such Mr Mada did not create opportunities for the construction of understanding or the development of problem solving and inquiry skills.

Yet, it is important to note that the teacher had initially identified most of the teaching difficulties he exhibited, for example that not integrating prior knowledge can create teaching difficulties. However, he failed to address such difficulties in his teaching. So there was a disjuncture between what he said should be done to avoid teaching difficulties and what he did. Mr Mada's practice reflected exactly what he said should not happen as it created teaching difficulties. However, this study did not go as far as establishing why this was so. Nevertheless, it showed that the teacher's classroom practices did not promote misconception dissonance, meaningful learning and the development of problem solving and inquiry skills.

V. RECOMMENDATIONS

The following are the recommendations of the study, comprising suggestions firstly for the relevant stakeholders and secondly for further research.

A. It is suggested that the Department of Basic Education should be careful of directives such as that projectile motion in two dimensions should be taught but will not be examined. This encourages teacher centred interpretations. Some participants did not pay attention at all to the topic whilst others only spoke about it in passing. It is also suggested that it will be in the best interests of science teachers and students if the impetus theory and other misconceptions are integrated into the subject matter of projectile motion. This could enhance awareness in students and teachers on the possible misconceptions in projectile motion and logically contribute to better teaching and understanding of the topic. The same can be done to other topics in Physical Science.

B. In addition, the issue of deficiencies in students' mathematical skills, even to the extent that students lack the ability to use calculators, has emerged from one of the reports of the DBE. The same issue was patently apparent in this study as a difficulty. However, what was fallacious was the alleged directive from the district offices for students to take Mathematical Literacy to improve the pass rates. The DBE must make regulations that will guide and compel students who take Physical Science also to take Mathematics and not Mathematical Literacy so that teachers are not demoralised and disadvantaged.

C. The study showed that even though there were some deficiencies in the subject matter knowledge, the classroom practices of teachers need a focus when teaching projectile motion.

It is suggested that in-service teacher training must focus particularly on the interactions and modes of discourse in classroom practice. In addition, since the DBE (2009) has indicated that one-size-fits-all support is not yielding the desired results, in-service training must be tailor made to target a particular focus. For example, training or workshops could be planned to develop the interactions and discourse skills of teachers. Training can also be conducted to focus on teachers' questioning skills and classroom activities.

However, this kind of training will require a data base of information on the needs of teachers, which is known as a source for micro foundation for in-service training. Henceforth, it is suggested that districts could train a cohort of Physical Science teachers on the use of the expanded CPDF (Mudau, 2013). The information can be collected via clusters and escalated to the district office which may disseminate it to the provincial office or the national office. The information gathered should help in-service training planners in planning tailor made in-service workshops and training for projectile motion and other Physical Science topics.

D. Recommendation C lends itself as a base for further research. It is suggested that further research can be conducted on the effectiveness of the CPDF. One way of doing this can be a comparative study using the classroom practice diagnostic framework wherein teachers who do not perceive projectile motion as difficult to teach and whose students perform well in the topic and subject are compared to those who perceive the topic to be difficult to teach.

E. It is also recommended that further studies can be done on the intersection between teacher knowledge and the kinds of discourse it promotes. That is the focus can be on the connection between teacher content knowledge and the classroom discourse. Hence the researcher can use the CPDF to analyse the intersection of those from the perspective of teacher action.

F. The issue of language as an impediment also emerged clearly from the study. This is not a new issue in the field. Many studies have shown that language can be an impediment to learning. It is suggested that with the misunderstanding and misconceptions it can create as a vehicle for classroom practices in making learning meaningful, some South African teachers with language challenges such as the participants in this study should be assisted. English language development is imperative so that teachers can articulate their thoughts effectively. The researcher did not suggest the use of the home language because studies in other African countries, for example Nigeria (Okebukola, Owolabi and Okebukola, 2012), have shown that

parents of the students refuse to allow their children to take Physical Science in their indigenous home language other than English.

G. Two of the participants, Mr Manngo and Mr Mada, provided reasons why they perceived the topic of projectile motion as difficult to teach. In practice, however, they did not teach in such a way as to avoid creating teaching difficulties from what they had indicated as the cause. The question arises as to why they did not. This is an avenue which this study did not explore and which needs further exploration.

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