EVALUATING THE TEACHING DIFFICULTIES OF A PHYSICS TOPIC USING THE CLASSROOM PRACTICE DIAGNOSTIC FRAMEWORK (CPDF): A FOCUS ON CLASSROOM INTERACTIONS AND DISCOURSE

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Abstract
This paper report on a qualitative case study conducted in the Johannesburg district of education. The purpose of the study was to evaluate the teaching difficulties of a physics topic using the classroom practice diagnostic framework (CPDF) with a focus on classroom interactions and discourse. One participant who perceived projectile motion topic to be difficult to teach was interviewed and observed teaching the topic. The result from this participant show that the kinds of interactions and discourse were the following; Type and pattern of discourse which was IRF and Authoritative discourse; Teacher questioning which was for Lesson development and Evaluation; Communicative approach which was Interactive-Authoritative. This kind of interactions and discourse do not advance opportunities for students to make meaningful learning of the topic projectile motion. It is also suggested that there is a need for further research with more teachers to derive a broad and holistic view of the teaching difficulties emanating from classroom interactions and discourse in the teaching of physics topics.

Keywords: interactive, discourse, teaching difficulties, physics

1. Introduction

McDermott (2006) advocates that teachers need to understand the topics they are going to teach at a deeper level. This is so because having taught a particular physics topic does not necessarily improve the comprehension of that topic. Besides, she indicates that many teachers lack an understanding of very basic concepts in physics. These assertions are applicable to the South African teacher. Many of the teachers were trained in the former colleges of education and as such have limited content knowledge (Rollnick et al., 2008). They were not taught such that they have a deeper understanding of what they were going to teach.

Teachers usually think that the ability to solve quantitative problems is an indication of good mastery of the subject matter. According to McDermott (2006) it is not an indication of strong command of concepts and representational skills. Emphasis should be on reasoning required in the development and application of concepts (McDermott, 2001 and 2006). To avert the challenges in the teaching of physics many higher institutions of education (HEI) in South Africa adopted a system wherein pre-service students are taught physics content in the physics

department or by lecturers who are knowledgeable in the physics content. Hence, the DoE (2006) emphasized the need for teachers to further their studies in physical science content. In-service training for CTPD was also instituted to enhance deeper understanding of the science topics. However, the in-service trainings organised for teachers mostly focus on enhancing the content knowledge of the topics to be taught at high school. There is little or no focus in helping the teacher to know how we know and what we know to make science meaningful to students (McDermott, 2006). Moreover, according to Scott (1998) it is not only the activities that physical science teachers bring to the classroom to facilitate learning that make students learn but teacher-student talk around the activities and the subject matter also influences learning.

So, Physics can be challenging to teach depending either on how the teacher teaches it, how he was prepared, how he is in serviced or because of the nature of the content itself. However, Gunstone et al. (2009) indicate that a teacher with a more informed view of learning tends to appreciate the teaching difficulties of a topic and uses the kind of discourse and interactions with students that facilitate meaningful learning. A point also emphasised by McDermott (2006) when she said that a teacher with a deeper and broader content knowledge and PCK should help students to learn meaningfully. On the other hand, Rollnick et al. (2008:1382) indicate that "it is only when difficulties are known to exist that teaching difficulties may be fully explored and understood". Consequently, this paper presents the teaching difficulties of the topic projectile motion which is perceived to be difficult to teach by some teachers with a focus on interactions and discourse in the classroom. Hence, the investigative question was; what are the teaching difficulties in the teaching of the projectile motion topic with a focus on interactions and dicousre?

Due to the nature of the subject, difficulty in teaching can happen when teachers fail to make the *means* to achieve the *end*. In science teaching *means to an end* refers to achievement by students, meaningful learning, developing inquiry skills and problem solving skills in students (Abd-El-Khalick & Akerson, 2009). In this study difficulty meant not being able to advance or do something with lost hopefulness. Therefore, teaching difficulty is the teacher's classroom practices which did not advance meaningful learning, misconception dissonance, development of inquiry and problem solving skills which influence student achievement.

2. Interactions and discourse in the science classroom

Interactions and discourse in the science classroom between the teacher and students is fundamental to learning because it is central to the meaning making process (Mortimer & Scott, 2003). Meaning making which is a dialogic process (Scott, 1998) occurs in three phases, the social plane where the teacher presents the new content, the internalisation process where the teacher helps students to make sense of the new content, and the application of the new content. In a dialogic process the appropriate speech genre needs to be used. Thus there is a difference between the everyday social language and the social language of school science. So a science

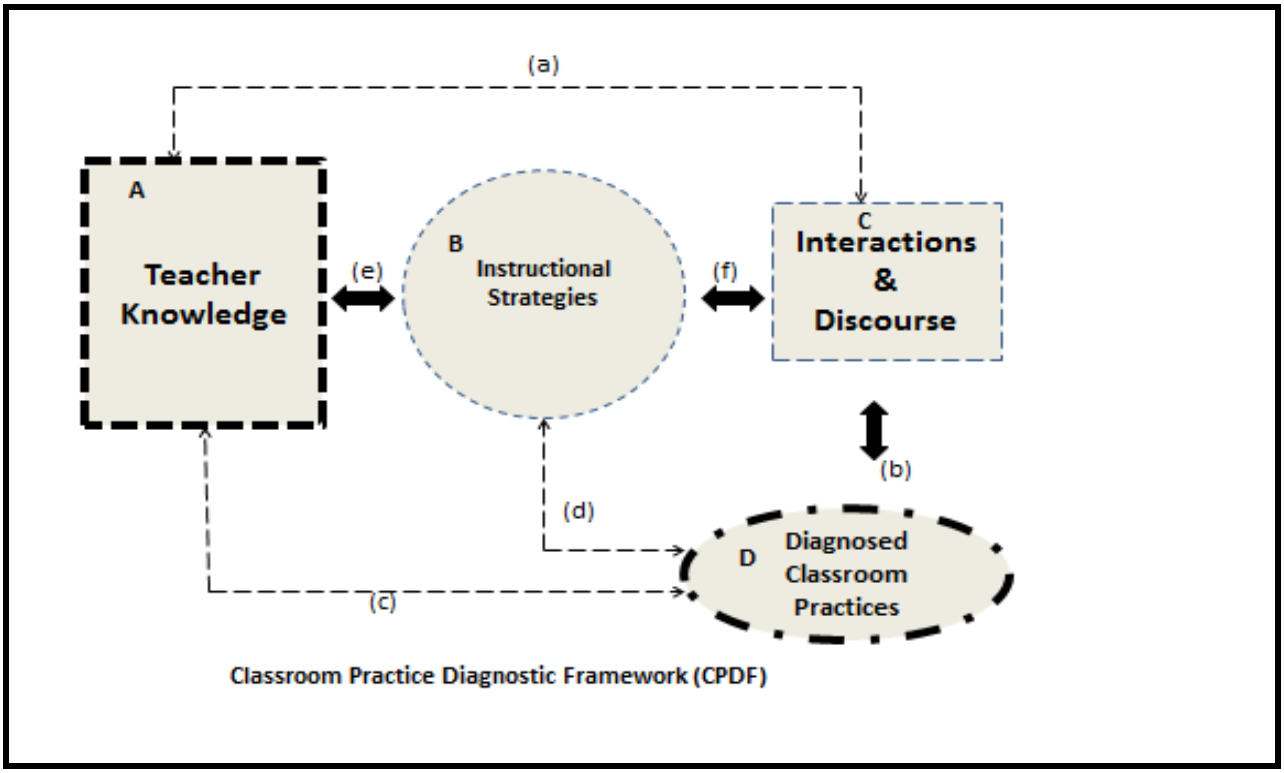
teacher cannot present the content as if it is obvious because students bring ideas of how things are from their ontological perspectives. In the classroom the teacher explains the concepts differently to the way students may have understood them. The teaching of science can be difficult or effective, stemming from the kind of discourse the teacher uses.

Language and discourse are co-dependent. That is, they rely on each other for developing understanding and scientific knowledge. Furthermore, he indicates that language is used to create discourse. Language can also be a gate keeper or a bridge to a science discourse. This point is also emphasised by Reis and Ng-A-Fook (2010), who posit that language is a limiting factor as it is affected by social contexts. Language does not only affect the discourse in the science classroom but can be a barrier to learning. Teachers must have an understanding of the different ways that language shapes discourse. This point is further emphasised by Lee (2005), who indicates that teachers need to have the knowledge of the linguistic abilities of their students to enhance meaningful learning.

3. Theoretical framework

The classroom practice diagnostic framework (CPDF, figure 1) was used as the lenses to evaluate the teaching difficulties of a physics topic with a focus on classroom interactions and discourse.

Figure 1: The Classroom Practice Diagnostic Framework (CPDF)



In the classroom interaction and discourse frame; the emphasis was on the types and patterns of discourse, communicative approach and teacher questioning. Types of discourses comprised the authoritative, dialogic and reflective discourses. Some of the actions or activities are spontaneous [this part is accommodated in the link (a) between A and C]. The analysis or diagnosis of teaching difficulties focuses mainly on what happens in frame. The three types of science classroom discourse namely authoritative, dialogic and reflective discourse as expounded by Chin (2006) and Mortimer and Scott (2003) are discussed next

Authoritative discourse is based on one voice, has a fixed intent and outcome and "student utterances are often given in response to teacher questions", whilst dialogic discourse involves many voices and flexible intent and outcome (Chin, 2006:1317). In an authoritative discourse the teacher conveys information and his utterances are often made up of instructional questions and factual statements, whilst dialogic discourse encourages debates and challenges (Chin, 2006). An alternation between the authoritative and dialogic discourse is desirable for the development of conceptual thinking (Chin, 2006). In reflective discourse teachers use a process of negotiation of alternative ideas rather than transmission or confrontation to assist students in understanding the concepts (Chin, 2006).

The communicative approach focuses on ways in which the teacher works with the students to address ideas and concepts. There are four classes of communicative approach, namely interactive/authoritative, interactive/dialogic, non-interactive/dialogic and non-interactive/authoritative (Mortimer & Scott, 2003). According to Chin (2006), in an interactive/authoritative communicative approach the teacher invites responses but discounts them if they are incorrect as the teacher focuses only on correct answers. The teacher uses a series of questions and answers to reach a specific viewpoint. In contrast, in the interactive/dialogic approach students' views are taken into account even though they may be alternative to the accepted scientific meaning. Chin (2006) also indicates that the non-interactive/authoritative approach is best represented by the formal lecture, where ideas are presented in a monologue. In a non-interactive/dialogic approach the teacher does not invite other points of view from the students but in his/her teaching makes statements that also address other points of views in addition to the formal ones (Chin, 2006).

In school science discourse teacher questioning is prominent (Chin, 2006). For the purposes of this study two kinds of teacher questions are explained. In traditional lessons the purpose of questions is for evaluation of what students know and in constructivist based or inquiry orientated lessons teachers use questions to help students construct understanding and /or generate meaning. Thus teachers use questioning "to diagnose, and extend students' ideas and scaffold students' thinking" (Chin, 2006: 1319). It follows then that using questions for

evaluation is related to an authoritative discourse whilst using questions to generate meaning is related to dialogic and reflective discourse.

The framework was used to diagnose how the teacher supported the meaning making process (Leach & Scott, 2003 and Mortimer & Scott, 2003). The focus was on the kind of the communicative approach and discourse the teacher used in the social plane wherein s/he introduced the new subject matter knowledge. This was based on the notion that knowledge is constructed during social interaction (Carr et al., 2004; Lemke, 2001; Kim, 2001 and Davydov, 1995). Furthermore, the framework was used as a basis to diagnose how the teacher's classroom interactions and discourse facilitated internalisation of the subject matter knowledge by the students. This was so because according to Vygotsky (1978: 128) "the process of internalisation is where individuals appropriate and become able to use for themselves conceptual tools first encountered on the social plane". So it is the role of the students to internalise the new knowledge (Leach & Scott, 2003) and for teachers to support the process.

The final phase in the process of meaning making is the application phase. So the framework was used as the reference point to diagnose the kinds of interactions and discourse the teacher used to create opportunities for students to answer questions, solve problems and discuss the knowledge (Hausfather, 2001) to reinforce knowledge development. This was so because according to Nola (1997: 59) "only when they can go through the steps of reasoning by themselves and thereby make fully explicit to themselves the reasons for the answer will they have knowledge". The framework was also used to diagnose the kinds of interactions and discourse the teacher used to promote the development of inquiry and problem solving skills.

4. Methodology

This qualitative case study research was underpinned by the interpretive research paradigm. Hence, even though the analysis of data and inferences was embedded on what the teacher 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 research focused on one teacher from a cluster in the Johannesburg district of education in South Africa who perceived projectile motion to be difficult to teach. The teacher was interviewed prior to the teaching of the topic and after teaching the topic. He was also observed whilst teaching the topic. Data was presented in tabular format wherein themes which were derived inductively were used to organise data. The tables contained raw data from interviews and observations. Only instances that would relate to interactions and discourse were included. The interpretation of data for meaning was reached by two processes (Hitchcock & Hughes, 1995) namely: direct interpretations of the individual instances and/or aggregation of instances where in an interpretation was reached after aggregating instances.

5. Results and discussion

Table 1 contains the characteristics of the theme classroom interaction and discourse. The focus was on the type and pattern of discourse demonstrated by the teacher, the purpose of his questions as well as the nature of his communicative approach.

Table 1: Classroom interactions and discourse (Mr M)

Theme	Category	Characteristics
Classroom Interactions and discourse	**Type and pattern of discourse**	• **Mr M** when you start to engage learners (students) and say can you write the answer on the chalkboard it shows that now what they are doing they understand [dialogic] • (*student answered the first question, velocity and acceleration are always in the same direction*) • **First student**: it is true (response) • **Mr M**: why is it false? (initiation, instructional question) • **First student**: because velocity and acceleration are not always in the same direction (response) • **Mr M**: is it always the case? (initiation, instructional question) • **First student** (does not reply) [no feedback] • **Second student**: it is true and it can also be false…it depends… (response, incorrect) • **Mr M**: it cannot be true (response, conveys information, Authoritative) • **Third student**: it is true because the object is coming down (response, incorrect) • **Mr M**: you don't read and understand the question (authoritative) • **Mr M** the answer is false (feedback, factual statement)
		• **Mr M**: which formula can we use? (lesson development, instructional question) • **Mr M**: what is the value of a? (lesson development, instructional question) • **Mr M**: what is the initial velocity? (lesson development) • **Student**: sir I solved the problem using a different formula which means there are other ways of solving the problem

Theme	Category	Characteristics
	Teacher questioning	• **Mr M**: show us what you did [evaluation] • **Student:** solved the problem using the formula ½ (vf-vi) t + v_it and got the same answer as the teacher's (incorrect formula) • **Mr M**: where did you get the formula? (evaluation) • **Student**: there are many textbooks Sir (response) • **Mr M:** in the exam they check the formula and if it is incorrect you will lose marks (conveys information) • **Student**: where will we get the formula?(initiation) • **Mr M**: there is a formula sheet…(response) • **Students**: but not the area one… • **Mr M**: you are taught these formulas in the Mathematics class… (students) but we were not taught, we are seeing them for the first time [conveys information, prior knowledge assumption] • **Student** still insist that if his answer is correct the formula is correct) • **Mr M**: so you are still defending it… if you still have an argument about the equation lets meet each other later (authoritative discourse)
	Communicative approach	• (**Mr M** solved the problem, interactive but authoritative) • **Mr M**: the graph is positive because we are having a straight line [ISMK] • **Student:** is it always the case that if the object is moving downwards that direction is positive? (interaction) • **Mr M**: what is the use of making the direction negative if they are in the same direction (acceleration and velocity) you cannot say the direction towards the ground is negative (Authoritative, dismissive)

Mr M had begun his lessons by asking questions and students responded to these questions. However, the kind of feedback he provided was one dimensional in the sense that only that

which was correct was emphasised and incorrect responses were not interrogated extensively. As such, the provider of the response could not notice why he /she was incorrect. This was necessary because according to Nola (1997) learning occurs through reasoning which enables construction of new meaning (Carr et al., 1994). So if the incorrect response is not engaged with, it creates dissonance in the mind of the student which may hinder the understanding of the new information.

So for instance in one case a judgement was passed that the reason they responded incorrectly was because they did not read questions properly, for example a student that responded to the question that acceleration and velocity are always in the same direction. Even though the teacher interacted with the student about the incorrect response, the emphasis was not on assisting the student but on providing the correct answer as a fact. This was not an isolated incident: throughout the lessons the teacher did the same. The kinds of question he employed were instructional and with the intention to convey information, evaluate and develop the lesson, as shown in Table 4.13 As a result the pattern and kind of discourse in Mr M's classroom was IRF (Carlson, 1990) and authoritative (Chin, 2006). This kind and pattern of discourse does not promote the construction of meaning and debate which is necessary for understanding new concepts.

In another incident a student indicated that although he had used a different formula to solve a problem based on graphs – which the teacher solved using the area formula – he got the same answer as the teacher. The student indicated that he saw the equation from another textbook [$\mathbf{\frac{1}{2}(v_f - v_i)\, t + v_i t}$]. The formula was incorrect but the teacher did not thoroughly engage the student to explain why his formula was incorrect. Mr M indicated that he would engage with the student after class if he still had problems. Other students then indicated that the formula which the teacher used was unfamiliar to them. Mr M indicated that the students were supposed to know that formula as it was taught in the Mathematics class and that it was the area formula. If the teacher had assisted the student who used the incorrect formula in class it would have also assisted other students who questioned the same approach. The teacher then continued to the next problem without further discussion. It follows then that Mr M's communicative approach was interactive but authoritative (Mortimer & Scott, 2003). Although Mr M invited responses he discarded them if they were incorrect and focused only on the correct responses.

When students make meaning from what they are learning it improves the possibilities of performance (Chin, 2006). As the meaning making process occurs in three phases (Mortimer & Scott, 2003), that is, the social plane, internalisation and application process, Mr M's students were largely exposed to the social plane where aspects like velocity, acceleration and using equations of motion were dealt with. The teacher also used the social language of school science which was appropriate and at the level of the students. However, the internalisation phase was compromised as there were limited opportunities for internalising the new knowledge. This is

because Mr M's lessons were epitomised by instructional questions intertwined with the lecture method. For example, when students asked where they would get formulas and gave the incorrect formula, they were told that they would find the formula in the formula sheet. When they further indicated that the formula did not appear on the formula sheet, the teacher replied that he meant those taught in the Mathematics class. Thereafter, he dismissed the incorrect input by the student without further engagement. This was an interacting-authoritative communicative approach (Chin, 2006). This approach is teacher centred and provides no opportunities for students to interact meaningfully with the subject matter (Chin, 2006 and Biggs, 2001).

Furthermore, Mr M's lessons were dominated by the conveying of information to the students and this discourse, intertwined with the type of questions he asked to develop the lesson, was authoritative. For example, when he was solving problems using equations of motion he would intermittently ask students for input in terms of values for substitution in an equation. This kind of discourse does not foster student thinking (Chin, 2006) which is necessary for the development of problem solving and inquiry skills. Hence, the internalisation and application processes were seriously compromised.

6. Conclusion

The interactions and discourse in Mr M's classroom promoted rote learning. Table 2 summarises the Mr M's classroom interactions and discourse.

Interactions and discourse of Mr M

Classroom interactions and discourse	**Type and pattern of discourse**	IRF, Authoritative discourse
	Teacher questioning	Lesson development
		Evaluation
	Communicative approach	Interactive-Authoritative

Taking into consideration that the DBE (2010, 2011a) asks questions to test for inquiry and problem solving skills, Mr M's students were at a disadvantage. The kind of interaction and discourse he had with his students may not advance opportunities for students to perform in the topic and may be the subject at large during examinations. However the posits in this study are limited to the teacher who was part of this study and there is need to extend the study to more teachers to have a holistically broad view of the teaching difficulties emanating from classroom interactions and discourse in the teaching of physics.

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