

RHODES UNIVERSITY
DEPARTMENT OF EDUCATION

RESEARCH PROJECTS

Presented in partial fulfilment of the requirements for a Master in Science Education (M.Ed)

TITLES:

RESEARCH PROJECT ONE: Constructivism: An Alternate Approach to Teaching and Learning

RESEARCH PROJECT TWO: Being Constructive: College Students' Learning of work and heat as aspects of the energy concept based on a constructivist approach

RESEARCH PROJECT THREE: A College in Transition: A Case Study of the Readiness of a College in the Eastern Cape province to implement Outcomes-Based Education in an Education Development Centre

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ABSTRACTS

RESEARCH PROJECTS:

1 RESEARCH PROJECT ONE: A literature review: Constructivism: An alternate approach to teaching and learning.

Abstract

The constructivist perspectives on learning have helped enhance science educators' understanding of how students make sense of their lived experiences. Constructivism purports to be a transformation of the traditional curriculum. As such this article starts with a brief overview of behaviorism: the scientific approach to education. The main tenets underlying constructivism, how constructivism guides educators to change their classroom practice, and the implications to science teaching have been reviewed.

2 RESEARCH PROJECT TWO (Empirical study): Being Constructive: College students' learning of work and heat as aspects of the energy concept based a constructivist approach.

Abstract

This study is an extension of a literature review on constructivism as an alternate teaching and learning approach discussed in research project one. It is an empirical study concerning the use of a learning module based on a constructivist approach to develop pre-service student teachers' understanding of work and heat as aspects of the energy concept. The data consisted mainly of transcripts of students' interviews, written responses to questionnaires designed in the form of a worksheet, and comments from non-participant observers and students. The results seem to suggest that a carefully designed learning module based on a constructivist teaching and learning approach may be a valuable tool in developing pre-service student teachers' understanding of work and heat.

3 RESEARCH PROJECT THREE (Empirical study): A College in transition: A case study of the readiness of a college in the Eastern Cape province to implement Outcomes-Based Education in an Education Development centre.

Abstract

Curriculum 2005 premised on Outcomes-Based Education is the new curriculum framework for South Africa. It signifies a paradigm shift in education from the traditional 'telling-listening' relationship between the teacher and the learner to one that emphasises learner-centred approach to the teaching process. Teachers, though recognized as crucial to the educational transformation process in the country have also being identified as ill-equipped to meet the challenges posed by Outcomes-Based Education. This study starts with a brief overview of the South African curriculum and the main tenets underlying Outcomes-Based Education. The institutional conditions and whether the lecturers at a college in the Eastern Cape province perceive the need for a change in their classroom practice were also investigated. Bearing in mind the need for further research to validate the findings of this study, positive indicators that emerged from the study suggest the readiness of the college to implement Outcomes-Based Education at the proposed Education Development Centre.

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RHODES UNIVERSITY
DEPARTMENT OF EDUCATION

RESEARCH PROJECT ONE

TITLE: Constructivism: An alternate approach to teaching and learning

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Constructivism: An Alternate Approach to Teaching and Learning

1 Introduction

Teachers' views of teaching and learning influence their classroom practice (Prawat, 1992). According to van Harmelen (1999) teaching as a prescribed activity is influenced by the philosophy that underpins the curriculum. Indeed Barnard (1998) writes that teachers need to know that every philosophical perspective in education has its own underpinning epistemology: its own view of what knowledge is and its own view of truth. Arguably, the experiences and information presented in the classroom are often interpreted by students in ways that differ from those intended by curriculum planners. Wilmot (1999) writes that educational theory and practice, and research were located within the dominant scientific or positivist paradigm. According to Wilmot, behaviourism with its roots in behavioural psychology has shaped the way in which education has been and is still practiced in many schools in South Africa and throughout the western world. As Bodner (1986: 873) puts it, "until recently the accepted model of instruction was based on the hidden assumption that knowledge can be transferred intact from the mind of the teacher to that of the learner". This implies that educators transmitted pre-determined knowledge into the heads of their learners. Learners therefore became passive recipients of knowledge.

As a result, most learners are deficient in terms of the skills and competence needed at the workplace to address the needs of society. As Claassen (1998) states, across the globe there is widespread dissatisfaction with education. Many school leavers do not possess the skills and competence needed to meet the challenges posed by the real world once they leave school. This has compelled many countries to adopt curriculum reforms so that the underlying aim of education becomes not only knowledge transmission but the application of what is learnt to the problems faced as times and technology change. As Anderson (1992: 866) puts it, "if curricular reform succeeds, something will be different about the experiences of students in classrooms". Similarly changes in education reform lead to changes in the way teachers teach and students learn (Brooks and Brooks, 1993).

Accordingly, Bray (1998) writes that educational systems around the world are restructuring to place students' demonstration of skills, knowledge and values at the centre of curriculum development and teaching. This is particularly true with the constructivist view of learning. Constructivism has been described by educators as well as theorists as an alternative to the traditional approaches or toolbox of pedagogical techniques (Windschitl, 1999). Treagust and Duit (1998) write that at the heart of constructivism is the idea that the conceptions held by each individual guide understanding. In the social constructivist perspective, individuals construct their own learning through language mediated social interactions (Vygotsky, 1978 cited in Hodson and Hodson, 1998). Curriculum 2005, the South African version of Outcomes-Based Education, purports to move away from the traditional behaviorist views of teaching and learning to social constructivist and socially critical views of teaching and learning (Kuiper and Wilkinson, 1998). Similarly, Claassen (1998) writes that social constructivism is a radical transformation of the traditional curriculum. The roots of social constructivism should be understood within its historical context: a departure from the traditional curriculum (*ibid*).

However, constructivism should not be taken as a recipe for instruction. As an educational philosophy, constructivism runs the risk of providing limited indications as to what learners or teachers might do to facilitate learning (Appleton, 1997). Nonetheless, the counter claim is that it provides useful guidelines or clarifications to learning situations in order to assist educators put their visions into classroom practice.

Bearing in mind the above, the writer intends to give a brief overview of the two views of knowledge, and the principles underlying behaviorism: where we have come from. This will be followed by a discussion of the main subject of the article: the main tenets of social constructivism. Finally the educational implications of the constructivist model for teaching will be given. The literature reviewed on constructivist teaching and learning approaches will be used in a later study (named research project two) to develop a learning module on heat and work as aspects of the energy concept.

2 Two Views of Knowledge

Knowledge is made up of knowledge *what* (facts), knowledge *that* and *why* (conceptual understanding) and knowledge *how* (skills) needed to reach understanding (Ryle, 1998 cited in Gultig, 1999). There are two different conceptions or definitions of knowledge embodied in a variety of contemporary classroom methodologies (Hinchey, 1998). Hinchey maintains that a particular definition of knowledge reflects one dominant philosophical position in the classroom setting of which there is an alternative. In the classroom situation, behaviorism informed by the positivist epistemology depends on facts and rote memorization. In contrast, constructivism looks at individual construction of knowledge based on experiences. The section that follows describes the two views of knowledge.

2.1 Positivism: The traditional view of knowledge

Positivism or the scientific approach to inquiry was the dominant educational theory and practice, and research for the greater part of the 20th century (Wilmot, 1999). In the view of Cantrell (1993), knowledge within the positivist paradigm was based on the explanation of events based on knowable facts, real causes or simultaneous effects and the existence of law-like regularities. As Jaworski (1994) puts it, knowledge in the positivist paradigm is something that exists outside of ourselves. Similarly, Von Glasersfeld (1987) looks at the “iconic” conception of knowledge that requires a “match” or correspondence between the cognitive structures and what these structures are supposed to represent. Indeed, Bodner (1986: 874) asserts that ‘the traditional view of knowledge views the *mind* as a “black box”; we can accurately judge what goes in (stimulus) and what comes out (response), but we can only guess about what is happening inside the box’. The constructivist view of knowledge views the *environment* as a ‘black box’; each of us knows what is going on in our minds; what we can guess about is the relationship between our mental structures and the real world (*ibid*).

The common thread in positivism was the view of knowledge as something that existed outside of human experience. On the other hand, the constructivist views knowledge as an individual construction based on experiences. In this way, when applied to education, positivism or the scientific approach to inquiry was based on experiments and observation as the acceptable form of knowledge. Thus observation and acquisition of facts were emphasized at the expense of

conceptual understanding and skill development. The alternative to the positivist paradigm rejects correspondence as the mark of truth but looks at the view of knowledge that leads to conceptual understanding. This will be found in a later discussion.

2.1.1 Behaviorism as a philosophy of education

(a) The theoretical perspective

Behaviorism as a scientific approach to education originated largely from the work of Pavlov, Watson and Skinner. The behaviorist approach to education had increasingly been used in education years ago and many educators are zealous supporters of behaviorist techniques that they are using in their classrooms (Ozmon and Craver, 1986). As Rothstein (1990) writes, the behavioral theory describes, explains and predicts behavior as a result of observable behaviors only. It stresses how persons and objects in the environment influence behavior, and when applied to the learning environment, it produces teacher-centred approaches to education (*ibid*). van Harmelen (1999) describes learning as a human behavior. According to this author, behavior is learnt and the behaviorists developed a theory about how people learn. Learning was seen to be the result of experience by both modern scientists and behaviorists. In support of this view, Wheldall and Merrett (1984) claim that all behavior is learnt, maintained by environmental consequences and learning takes place by observing changes in learners' behavior. In the context of teaching, if environmental consequences especially in the reactions of other people are changed then learners' behavior can either be changed or controlled (*ibid*).

It is implied from the above that, the traditional curriculum was informed by the theory of behaviorism. As Bray (1998) points out, traditional education formats are very similar and exist in many schools around the world. These include:

- (i) instructional objectives based on existing curriculum;
- (ii) the purpose of teaching and learning is the mastery of subject-based content and specific course level skills;
- (iii) teaching and learning occur within individual classroom;
- (iv) students take a finite amount of time to demonstrate their achievement;
- (v) the demonstration of students' learning focuses on evidence of memorization and analysis.

Further, Johnson (1998) writes that the traditional curriculum relied on imparting 'facts'. True knowledge was learnt by the acquisition of facts. The traditional curriculum was didactic, formalistic and a structured exposition of knowledge through textbooks (*ibid*). In the South African context though with some exceptions, the classrooms show strict adherence to prescribed syllabuses and heavy reliance on textbooks and other forms of 'received knowledge' and emphasis on factual information and rote learning (NEPI, 1992).

In sum, the behaviorist principles rooted in positivist beliefs provided a method which suggested that:

- (i) Educational outcomes could be planned, predicted and measured through the application of the correct objectives;
- (ii) Education practice could be refined and ordered so that generalisations could be made which would provide proven "recipes" or formulas to apply in teaching.

(b) Effects of Behaviorism

Behaviorism has impacted on many walks of life e.g. education, business and military (Ozmon and Craver, 1986). Also behaviorism is situated in the dominant worldview of modernity and relates to the view which was most shared and understood (van Harmelen, 1999). Indeed the most outstanding feature of this theory was that it was "scientific" and based on a great deal of research and researchers can point to a measurable success using this method (Ozmon and Craver, 1986).

However, many critics maintain that behaviorism was based on a wrong and faulty view of science. Education was reduced to a product rather than a process. According to Johnson (1998), teaching, learning and assessment were linked to each other in a linear way. The teacher identified the things learners should know, translated them into a topic and imparted information (*ibid*). Thus, assessment took place after the learning experience, and was concerned with the reproduction of facts instead of how much learners understood and what they could do. Further, learners are not born with ready-made behavioral repertoires. They have to learn them based on experiences and provision of realistic guidelines for their behaviors in social institutions. In contrast to the scientific approach to education, the constructivist

model depends on individual construction of knowledge based on experiences. Indeed, this approach challenges the usual 'transport' metaphor which sees knowledge as a package to be conveyed from teachers to learners.

2.2. Constructivist view of knowledge

The constructivist movement has its roots in a long standing philosophical tradition (Von Glasersfeld, 1991 cited in Terwel, 1999). Matthews (1992: 299) echoes this statement that, "despite the anti-empiricism of much constructivist writing, in most forms its epistemology is firmly empiricist". In particular it is subject-centred and experienced-based (*ibid*). Simply put, it can be argued from the above that, like behaviorism constructivism is also subject-centred, and based on experiments and observation. The only difference perhaps lies in the roles of the teacher and the learner in the teaching and learning process. For example, constructivism stresses understanding in science instruction over the reproduction of facts that characterise most traditional classrooms. As Matthews (1992) puts it, constructivism in science and mathematics education is not just a theory of the way science develops and is validated. It is a view about how teaching should proceed, how children should be treated, how classrooms should be organized, how curricula should be implemented and sometimes even a view about the purpose of education (*ibid*). In the view of Yager (1991) much cognitive research has been used to support this new model of learning. Indeed, Von Glasersfeld (1987) asserts that the central premise in constructivism is that knowledge whether private or public is a human construction. The constructivist perspective does not depend on dogma and faith but "fits" observation. It is the knowledge that human reason derives from experience and enables us to solve experiential problems (*ibid*). According to Bodner (1986) the constructivist view of knowledge is assumed to "fit" reality the way a key "fits" a lock. In support of the above views, Driver and Oldham (1986) citing Von Glasersfeld (1982), write that knowledge cannot be "checked" against an external reality as found in the positivist view. The only check is the extent to which our constructions "fit" with our experiences in a coherent and consistent way. Thus, within this paradigm lies the notion that to understand the world means there is a need to construct explanations to fit new situations or experiences encountered. Bodner (1986) writes that the constructivist view of knowledge replaces a more or less passive recipient of

knowledge with an active learner. Thus, the constructivist view of knowledge purports to be viable, works and stands up to the constraints of our experiences.

Put together, the main tenets of constructivism are that knowledge is a human construction and the existing ideas held by individuals are used to make sense of new experiences or information. However, constructivism is purported to have been familiar to educators. As Solomon (1994: 6) puts it, 'what it described had been seen'. Solomon argues that learners had often brought their own ideas to lessons but were not thought remarkable because teachers used a particular kind of language to comment on them. Thus, the recognition of the ideas of learners that was not considered significant in one learning theory is now central in constructivism. Indeed, most studies show that the initial ideas of learners often persist and are difficult to change despite science instruction. In the view of Gunstone (1988), attempts to change students' ideas have not always been as successful as researchers had hoped since they hold subjective meaning to the learner.

Most importantly, learners should constantly be made aware through learning experiences the limitations in their ideas and that in certain contexts scientifically acceptable concepts are more meaningful than their pre-concepts. Accordingly, Fetherston (1999) writes that, there are different types of constructivism but the most commonly discussed are **Radical and Social** constructivism. Fetherston maintains that no matter the type of constructivism, the central feature is that people actively construct knowledge and that social interaction assists the process. The section that follows looks at radical constructivism.

2.2.1 Radical Constructivism

Radical constructivism focuses on cognition and the individual. The work of Piaget has been foundational to theories associated with cognitive constructivism: the system of explanations of how learners as individuals impose intellectual structures on their worlds (Windschitl, 1999). According to Jaworski (1994), there are two main principles underlying radical constructivism:

- (i) Knowledge is not passively received but actively built up by the cognizing subject;
- (ii) The function of cognition is adaptive and serves the organization of the experiential, not the discovery of ontological reality;

These two points suggest that knowledge is constructed by the individual. Individuals learn by adapting to the learning situation and the accumulation of all experiences. Any new encounter either adds to that experience or challenges it. As Appleton (1997) puts it, the existing ideas which learners may hold are used to make sense of new experiences.

However, Driver and Oldham (1986) assert that these constructions are seen as tentative models which are continually tested against experience and if necessary modified. Further, Yager (1991) argues that human beings' experience always includes and is strongly influenced by our social interactions with other humans. Thus, fundamental to teaching and learning is the consideration of communication and how meanings are shared. Language is used to accomplish our thinking, identification of issues and to propose responses (*ibid*). It can be argued from the above assertions that cognitive science which tends to focus on knowledge systems of individuals runs the risk of seriously misrepresenting human learning if it fails to take account of the social dimensions of knowledge construction.

In this way, Jaworski (1994) notes the move from a purely individual view of knowledge construction to one in which the social processes of discussion and negotiation have significant roles to play. This is what social constructivism stands for and it will be discussed in the section that follows.

2.2.2 Social Constructivism

Social constructivism emerged out of radical constructivism. Hodson and Hodson (1998) write that knowledge is not merely handed on, nor discovered or constructed by the individual but learning is rather co-constructed through social interaction. As Fetherston (1997) puts it, individuals actively construct their own knowledge and that social interaction assists the process. In the social constructivist perspective, the mental representations of students and the teacher are regarded as socially occasioned: one of the basic tenets of social constructivism (*ibid*).

Further, Treagust and Duit (1998) write that knowledge is something possessed by an individual and stored in the human brain but has significant social aspects. These authors claim that knowledge is something that is between the individual and the social and can be shared by members in a certain community (*ibid*). In support of this view, Driver (1988a) states that social factors are important in understanding the processes of conceptual change. Simply put learning is not being seen so much as an individual but as a social activity.

Moreover, Windschitl (1999) asserts that people construct knowledge in the presence of others who collectively constrain the environment with tools such as language, with conventions such as pre-determined concepts, and through accepted practices for creating and judging knowledge. In the view of Yager (1991), all learning is dependent on language and communication. As such, the tools of thought are acquired by individuals through language mediated social interactions. Thus language is used as a tool for problem solving and functions as the means by which participants co-construct meaning as they plan, act, interpret and reflect together (Vygotsky, 1978 cited in Hodson and Hodson, 1998).

From the above, it can be deduced that learning depends on language and communication. Meanings are shared and shaped through discussions and negotiations between learners, and between teachers and learners. On the other hand, it should be noted that in practice, it is often difficult to communicate with, or teach learners from diverse cultures to whom language has quite other meaning constructions. Atwater (1996) writes that the interactions among students from different ethnic groups play important part in the classroom environment. In lending

support to this, Kuiper and Wilkinson (1998) write that, to meet the multiple learning requirements of students from diverse cultures and languages in a social constructivist classroom, instruction should take account of the societal/cultural set-up in which learning takes place. This suggests that learners in small groups should be given frequent opportunities to interact and engage in problem solving or inquiry-based tasks as opposed to exercises, with little or no teacher interference. In addition learners should be encouraged to clarify their thoughts, present ideas, share views and reflect. As Sprod (1998: 463) in citing Vygotsky (1962) puts it, “what the child can do in cooperation today, he can do alone tomorrow”. This implies that students learn more by giving elaborated help to others and less from receiving low level elaboration by others experiences (Terwel, 1999).

Further, with regards to social interaction, Terwel (1999) writes that, constructivism is an inspiring theory but does not offer any practical guidelines for the creation of communities of inquiry and the avoidance of ineffective interaction patterns. In addition, Solomon (1994) argues that classroom interactions will not of themselves bring about conceptual change because of the ideational nature of prior constructions. According to Solomon, neither procedures nor structures can cause what people do or think. Of course they can and do affect how ideas are implemented (*ibid*). Terwel (1999) suggests *quality* interactions involving the active participation of all learners. In this way, passive and destructive interactions of learners in the classroom should be avoided in the teaching and learning process by long-term engagement of learners in problem-solving and task-oriented activities.

2.3 Constructivist Approach to Learning

The overarching issue in the constructivist view of learning is that individuals generate their own understanding (Gunstone, 1988). Learning involves the active construction of meaning on the part of the learner (Driver and Oldham, 1986). The key feature is that human beings construct mental models of their environment and new experiences are interpreted and understood in relation to existing mental models or schemes. The views and ideas that children hold have been given a number of names including alternative frameworks, children’s science,

alternative conceptions or mini theories (*ibid*). Kuiper (1994) describes students' prior ideas as follows:

- (i) misconceptions: the incorrect understanding in student ideas with mistakes to be corrected;
- (ii) preconceptions: the premature and incomplete ideas which have to be modified;
- (iii) alternative frameworks or conceptions: students' ideas considered to be serious and coherent alternatives to the scientific meaning of a concept and have to be challenged accordingly.

The above implies that, the learner even if young has ideas about things and these ideas play a role in the learning environment. Driver and Oldham (1986) in citing Rumelhart and Norman (1981) write that learning involves the development and change in cognitive structures:

- (i) accretion: the addition of parts to an existing structure;
- (ii) tuning: involves small modifications to an existing structure;
- (iii) restructuring: major changes in the restructuring of knowledge.

As such Posner *et al.* (1982) point out that if learners are to change their ideas, the need must be felt and certain conditions have to be fulfilled:

- (i) learners must recognise the inadequacy of their existing conceptions (dissatisfaction);
- (ii) learners must understand the new conceptions being taught (intelligible); and
- (iii) learners must recognise it to be both plausible (appear reasonable) and fruitful (ways of conceptualising the phenomena or issue).

According to Hodson and Hodson (1998) these points suggest that conceptual change is made possible when learners understand the limitations of their current views and recognise the need to replace them. Dissatisfaction with the existing idea occurs if it fails to predict correctly or control events beyond the previous restricted context. In addition, it may also be recognized that the new view meets the conditions of intelligibility and plausibility more satisfactorily than the existing idea (*ibid*). Also Appleton (1997) in referring to Mayer (1983) mentions that for learning to take place, the learner must (i) receive presented material; (ii) must have relevant prior knowledge or schema; and (iii) must activate that prior knowledge. Further, group

discussions focusing on the interpretation of phenomena may serve to foster conceptual change (Tobin *et al.*, 1994 cited in Van Driel *et al.*, 1998). These imply that the existing initial ideas of the learner, organization of classroom activities or investigations play significant roles in learning.

However, it is argued that the processing capacity of the human mind and external constraints such as physical environment, language and other forms of communication limit learning. As Driver *et al.* (1985) put it, 'what the child is capable of learning depends at least in part on what they have in their 'heads' as well as the learning context in which they find themselves. Further, any strategy for conceptual change will have to relate to a particular domain of knowledge (Van Driel *et al.*, 1998). Thus it is important through research to determine students' conceptions within a particular domain in order to develop teaching strategies to promote conceptual change in this domain (Driver, 1988b).

Consequently, Driver and Oldham (1986) cite the suggestion of Pope and Gilbert (1983) that the following possible outcomes may occur as a result of a learning programme: individuals may retain their own perspectives and reject all others though their understanding of those alternatives would have improved; hold onto the original idea but adopt another temporarily i.e. hold the two simultaneously; view their personal models as invalid and discard them; or may reject both their original perspectives and the ideas put forward by others suggesting instead an alternative which goes beyond any of them.

The above is consistent with the view of Treagust and Duit (1998) that no student's conception can completely be extinguished and replaced by science views. The reason is that despite science teaching some of the ideas used by learners are firmly held and often persist. Indeed, most studies show that "old" ideas stay alive in particular contexts and at best merge with the new ideas to form some sort of hybrid idea.

Put together, the impression is that science instruction is not necessarily to replace the existing ideas of learners. As such learners should constantly be made aware that both the scientific and

world-life domains of knowledge exist but in certain contexts science conceptions are much more meaningful and acceptable than their own. As Watt *et al* (1997) note, knowledge is not learnt mechanically but actively built by the learner. In this way learners should be assisted and guided through problem-solving and task-oriented activities to enable them to take responsibility of their own learning and accept ownership of knowledge.

2.4 Constructivist Teaching Approach

A result of constructivist theories of learning has been a corresponding emphasis on constructivist teaching (Appleton, 1997). As Bodner (1986: 877) puts it, “the constructivist model requires a subtle shift in perspective for the individual who stands in front of the classroom. A shift from someone who “teaches” to someone who tries to facilitate learning; a shift from teaching by imposition to teaching by negotiation”. Similarly, Ritchie (1994) writes that the constructivist model requires a change in teaching that involves much more than the application of a new strategy or recipe, it involves a change in beliefs (and professional practice) about knowledge, learning and teachers’ role in the teaching and learning process. Prawat (1992) describes constructivism as a dramatic change in the focus of teaching that puts students’ own efforts to understand at the centre of the educational enterprise. Indeed, Anderson (1992) writes that a constructivist perspective requires major changes in the role of teachers: a clear vision of how to change from current school practice to something better. This requires teaching and learning approaches that may create different and practically useful classroom experiences.

Arguably, some studies show that the strategies involved in a constructivist teaching approach in the classroom situation are not yet clear. Maskill and Pedrosa de Jesus (1997) maintain that most teaching scenarios involve hurried circumstances and taking time to investigate every individual learner or group of learners is not usually an option. Also, a number of teachers have been found to be insecure about changing any significant part of their classroom practice towards a constructivist perspective for fear of losing classroom control. For example, Watts and Jofili (1998) point out that, some teachers appreciate the contribution they can give to the

personal development of learners but cannot shake off their own conscious '*gestalts*' created through their past experiences as passive learners.

Nonetheless, teachers may have to reposition themselves from their roles as transmitters of pre-determined knowledge to something better: facilitators in the teaching and learning process. For example, learners should be provided with learning opportunities that will make them aware of the limitations in their initial ideas and encourage their responses through discussions to drive lessons. According to Maskill and Pedrosa de Jesus (1997), the first task of the constructivist teacher is:

- (i) to ascertain the ideas and expectations about a topic which learners are likely to bring with them in class; and
- (ii) to take the literature findings about each topic and teach accordingly.

These suggestions are reinforced by the view of Ausubel (1968) as cited by Freyberg and Osborne (1985: 83) that 'the most single factor influencing learning is what the learner already knows; ascertain this and teach him accordingly'.

Accordingly, the way in which teachers develop their classroom practice is intrinsically tied to their understanding of how pupils learn, and on their own experiences of schools and schooling though this may not always be clearly articulated (Watts *et al*, 1997).

In view of the above, Hodson and Hodson (1998) suggest that the constructivist views of learning provide some pointers toward teaching strategies that might assist students in the task of conceptual reconstruction:

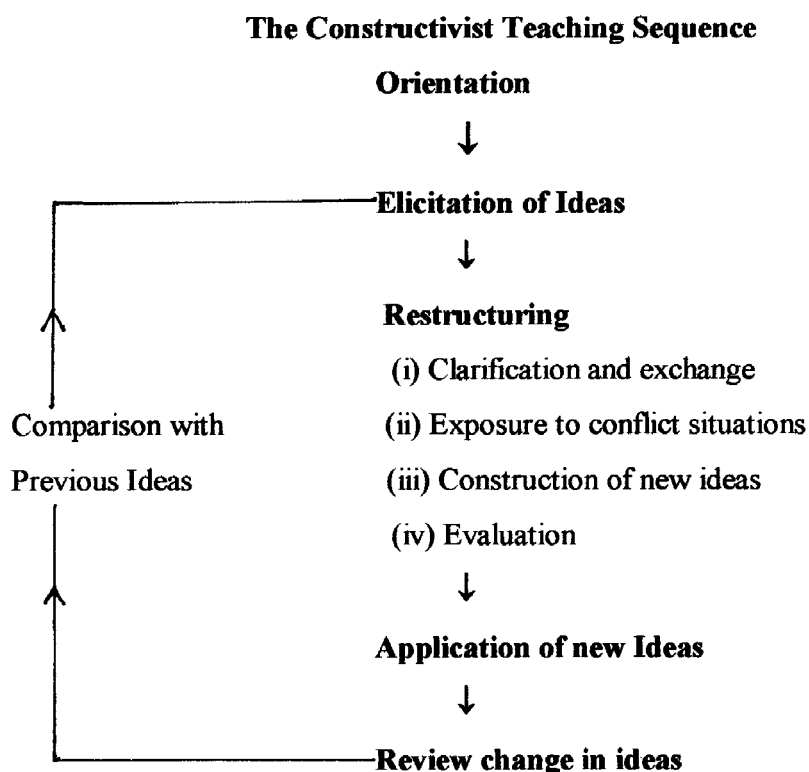
- (i) Identify students' ideas and views;
- (ii) Create opportunities for students to explore their phenomena, accounting for events and making predictions;
- (iii) Provide stimuli for students to develop, modify and where necessary change their own ideas and views;
- (iv) Support their attempts to rethink and reconstruct their ideas and views.

Similarly, Fetherston (1997) suggests that the constructivist teaching approach should include:

- (i) the ability to address students' own ideas;
- (ii) the ability to bring meaningful change in students' often incorrect science ideas;
- (iii) the increased potential for students to construct a rich understanding of science concepts.

Driver and Oldham (1986) outline the constructivist teaching scheme into five phases (see figure 2.3):

- (i) Orientation (focusing learners' interest on a particular scientific issue);
- (ii) Elicitation (helping learners to become aware of their prior knowledge and helping teachers gain access to the range of learners' ideas);
- (iii) Restructuring ideas (helping learners to become aware of alternative views, critically examine these, test, modify, extend or replace their prior concepts);
- (iv) Application of new ideas (reinforcing the newly constructed ideas); and
- (v) Review (reflection on how much their ideas have changed).



(Figure 2.3: Adapted from Driver and Oldham, 1986)

From the above, there might be differences in instructional approaches adopted by the various authors but the common features in constructivist teaching approach raised by the authors include firstly, the need to elicit students' prior ideas as the starting point for a new topic. This could be achieved from techniques such as probing discussions, interviews, and concept mapping or other representations of knowledge structures as rituals of revelation (Windschitl, 1999).

Secondly, the learners' ideas are challenged. Learners are put in small groups in direct contact with the phenomena being studied. This involves active engagement of learners in problem-solving or inquiry-based tasks, and investigations or experiences that are likely to engender contradictions to their initial hypotheses.

Thirdly, the students' ideas are restructured through discussions. Discussions are done in small groups followed by a whole class discussion until a consensus is reached. Students' responses should be valued even if they differ from the teachers' perspective but they should be made aware that in certain contexts scientifically acceptable concepts are more meaningful and appropriate than their own. Thus in the science classroom, teachers have to encourage learners to test their own ideas, compare them with accepted scientific knowledge and look for some conceptual movement in the thinking of learners. As Watts *et al.* (1997: 311) put it, "new knowledge is not learnt mechanically but actively built up by the pupil.

The strategies cited above are certainly helpful, however an important part is that efforts should be directed at understanding more fully the ways in which the constructivist teaching/learning approach can be fostered in the classroom setting. This is because these strategies give clarifications to learning situations and provide limited indications as to what learners and teachers should do to facilitate learning (Appleton, 1997). Also, as an educational philosophy, the constructivist principles should not be taken as "ready-made" repertoires for instruction but as guidelines. Challenging students' ideas is not by itself enough to promote conceptual changes, students have to be guided and assisted, and alternative ideas seen by them not only as reasonable but plausible. Again, knowing where students are starting from is not

enough to plan curricula activities but there is a need to know where to go: involving decisions about content and guiding principles. Teachers have to limit their classroom intervention in the teaching and learning process and be cautious not to leave learners in a position of engaging in their own activities simply to verify pre-determined knowledge.

Further, Watts and Jofili (1998: 175) assert that, the constructivist teacher should work at the interface between the learner and the curriculum, to merge agenda and bring the two together in a way that is meaningful to them without diminishing the curriculum. These authors suggest examples of such mediations:

- (i) theatrical director who *directs* and orchestrates learners' thinking;
- (ii) the tour guide who *guides* and chaperones learners;
- (iii) the scaffolder who *provides* structures and supports;
- (iv) the provocateur who *challenges* and *struggles* with learners;
- (v) the negotiator who acts as a broker between the learner and curriculum science;
- (vi) the committee chair who *reconciles*, *organises* and *manages* goals and agenda; and the modeller who shapes and *models* learners' knowledge.

Moreover, Brooks and Brooks (1993) suggest the following ways for teachers to become constructivists:

- (i) encourage and accept student autonomy and initiative;
- (ii) allow students' responses to drive lessons, shift instructional strategies and alter content;
- (iii) inquire about students' understanding of concepts before sharing their own understandings of those concepts;
- (iv) encourage students to engage in dialogues, both with the teacher and with one another;
- (v) engage students in experiences that might engender contradictions to their initial hypotheses and then encourage discussion;
- (vi) nurture students' natural curiosity through frequent use of learning cycle model (discovery, concept introduction, and concept application).

Put together, the role of the teacher in the constructivist perspective changes from transmitters of pre-determined knowledge to facilitators in the teaching and learning process. Teachers may have to reduce difficulties in learning tasks by helping and guiding learners. They may act out how some problem-solving tasks are approached but at the same time give more responsibility to the learner. The constructivist teacher has to value quality learning over quantity. Given the evidence of students' lack of understanding in so many basic areas, the guiding principle as regards curriculum content in the constructivist perspective must surely be in line with the suggestion of Millar (1996) that "do less but do it better".

Further, teachers would have to overcome the mindset that time is not a factor in students' learning (Brooks and Brooks, 1993). These authors suggest that if teachers would become constructivists, students will broaden their abilities to make and create individual knowledge that is meaningful to them. There are times in the teaching and learning process when teachers are compelled to present some lessons in a didactic way and say what learners should do to achieve certain aims, however, constructivist teachers must vary their teaching strategies and techniques across a wide spectrum. Indeed, the overall picture in the constructivist approach to teaching should be towards teaching-as-managing but not teaching-as-telling.

3 Educational Implications of Constructivist Model for Teaching

The focus on teaching in the constructivist perspective is shifted from the traditional "telling-listening" relationship between the teacher and the learner to one that emphasizes learner-centred approach to the teaching process. Indeed, teaching becomes learner-centred, individuals construct their own knowledge which is embedded within the social context. Teachers therefore become facilitators in the teaching and learning process.

Given the above paradigm shift, adopting a constructivist view of learning has implications for our view of the curriculum (Posner, 1982, cited in Driver and Oldham, 1986). The model sees the curriculum not as a body of knowledge or skills but as a programme of activities from which such knowledge or skills can possibly be acquired or constructed, though there is a need to acknowledge that possible learning experiences are guided by the knowledge of experts

(Driver and Oldham, 1986). Simply put, the curriculum in the constructivist perspective should not be based on pre-determined knowledge. At least it should include the development of new materials based on the learning environment of the learners as well as new instructional approaches, if teachers are to use them as intended.

However, concerns with both pre-service and practising teachers' understanding of science and the ability to teach science have been documented in recent years (Hand and Peterson, 1995). Indeed, knowing the constructivist theoretical considerations is different from implementing them in the classroom. Thus there are often difficulties found in the mismatch between actual science instruction and the stated aims: what is taught, how it is taught and assessment practices. For example, the exploration of learners' initial ideas on selected topics and restructuring of these ideas for the planning of a teaching unit require the understanding of the subject matter by the educator. According to Krugly-Smolka (1990), the problem of equating science with progress but not understanding *why* is most acute in developing countries. In particular, the majority of educators in the schools in South Africa have been identified as either unqualified, inadequately trained or do not possess the subject discipline knowledge especially the natural sciences to be effective in the classroom. Mboyane (2000) in citing Beckmann (2000) echoes this view that 40% of the South African teaching force is not qualified.

Further, any effective constructivist classroom environment requires educators to work with as small a number as possible. The urban schools are more likely to have resources. On the contrary, most classrooms especially in the rural areas in South Africa are faced with large class sizes. In the majority of contexts, teachers do not have the time, resources or skill to develop their own learning materials (Review committee of curriculum 2005), which forms an important component of the constructivist model of teaching and learning.

To overcome the problems identified above, more appropriate actions and changes need to occur for creating constructivist teachers with a sound knowledge of the subject matter. This would include a restructuring of pre-service and in-service teacher education around

constructivist principles and practices, and a focus of resources on teachers' professional development.

Moreover, bearing in mind the evidence of students' lack of understanding in so many basic areas, the guiding principle as regards curriculum content must surely be: do less but do it better (Millar, 1986). This contrasts with the traditional view in which much content is covered at the expense of conceptual development. In this way, the constructivist model of teaching has implications for instructions. As mentioned earlier, there is a shift in perspective for the individual who stands in front of a classroom: a shift from someone who "teaches" to someone who tries to facilitate learning, a shift from teaching by imposition to teaching by negotiation (Bodner, 1986)

Further, teachers are no longer transmitters of predetermined knowledge but have to be re-named and reposition themselves as facilitators. The initial understandings of learners are valued as the premise of instruction. Acquiring predetermined answers or completing teacher-directed tasks are not priorities. Value should be placed on the quality of thinking demonstrated by the learners.

Moreover, the constructivist model emphasizes the importance of two-directional flow of information between teachers and their students. There is a dialogue between the teacher and students. In this way, the constructivist should encourage learners' responses to drive lessons, encourage learners to explain their answers through discussions in small groups, and in class, and reflect on their knowledge which forms essential part of the learning process.

The constructivist perspective requires teachers to note features of students' learning processes for the purposes of providing feedback but not necessarily for assigning grades or symbols. Teachers need to pay attention to how students regulate their own learning, how they collaborate with peers through extensive discussions and how well they extract ideas from available resources. For the constructivist teacher however, there should be a range of teaching

strategies across a wide spectrum that are likely to lead learners to take responsibility of their own learning.

4 Conclusion

The discussion has shown that for any educational philosophy, there is an alternative. Thus the constructivist teaching/learning approach is an alternative to the traditional behaviorist approach to teaching and learning. Both behaviorism and constructivism are said to be empiricist: they are based on experience and observation. The object of study in both cases includes the view of the curriculum, decisions about the content of the curriculum and how learners learn in the teaching and learning enterprise. However, behaviorism sees the curriculum as a body of pre-determined knowledge and does not consider remarkable the existence of internal mental processes, and places much emphasis on teaching and acquisition of facts. In contrast, constructivism views learning as an active mental construction of the learner, and that the existing ideas of learners are valued as the starting point for instruction. Indeed, the constructivist classroom determines the strength of school reform in merging learning and understanding beyond facts and rote memorization (Brooks and Brooks, 1993).

However, it should be noted that constructivism as an educational philosophy provides useful clarifications to learning situations. It has been found to provide limited indications as to what teachers and learners should do to facilitate learning (Appleton, 1997). In this way, it cannot by itself provide adequate foundation for classroom practice (Schwab, 1970 cited in Terwel, 1999). There is a need for multiple research findings and practical deliberations in education to turn classrooms into communities of practice (Terwel, 1999). As such constructivism should not be seen to proffer recipes for instruction. Rather the implications of constructivism in terms of teaching and learning should be understood by educators for their classroom practice, and more importantly to help educators put their visions into practice. As an extension to this article, the author intends to adopt the constructivist teaching and learning sequence used by the various authors in the literature review to design and implement a learning module on some aspects of the energy concept with a group of pre-service student teachers in a later study (**Research project two**).

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RHODES UNIVERSITY
DEPARTMENT OF EDUCATION

RESEARCH PROJECT TWO

**TITLE: BEING CONSTRUCTIVE: COLLEGE STUDENTS'
LEARNING OF WORK AND HEAT AS ASPECTS OF THE
ENERGY CONCEPT BASED ON A CONSTRUCTIVIST APPROACH**

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CHAPTER ONE

1 Introduction

Teaching and learning of science are plagued by problems. Hand and Peterson (1995) have indicated the concerns raised by recent studies about the inability of both pre-service and practising teachers to understand science. In this way, a large majority of students have been found to enter teaching courses in science education with limited science backgrounds and pre-conceived ideas. My own experience both as a learner and a science educator involved in teaching pre-service science educators endorses the above assertion.

The above problem is widespread in many parts of the world. In particular, South Africa is among the countries that rank poorly in international comparisons. This was evident in the report of the Third International Mathematics and Science Survey (TIMSS) on science literacy assessment for grade 12 learners of the same age group. South Africa obtained a significantly low average score compared to other countries (HSRC, 1998).

One major concern is the teaching of physics in schools particularly the teaching and learning of the energy concept. Boyes and Stanisstreet (1990) write that energy is one of the most important theories in science education and also one of the most difficult. Prideaux (1995) echoes this view that energy is a central concept in science in general.

Indeed, Taber (1989) states that energy forms a major theme in the life sciences and also in other non-science curriculum subjects as diverse as technology and economics. There is also much concern about the need to conserve finite energy resources.

However, in spite of the centrality of the topic, the intrinsic difficulty is that the ideas about energy are encountered in everyday life and these ideas are frequently different from the formal scientific concepts. As Solomon (1983) puts it, learners view the world in two modes: the 'life world' outside school, and the 'symbolic' of formal science teaching. Learners lack the ability to distinguish between the meanings of energy in these two contexts (*ibid*).

Further, courses that introduce physics education do not seem to prevent learners from mixing scientific ideas about energy with pre-scientific ones (Viglietta, 1990).

The difficulties raised above seem to suggest that among most learners, there is a lack of understanding of the concept of energy. The sources of these difficulties may range from poor standards of teaching to lack of resources. As Bodner (1986: 873) puts it, “teaching and learning are not synonymous, we can teach and teach well without having the students learn”. Arguably teachers’ views of teaching and learning influence their classroom practice and they teach according to the way they were trained. Teaching methodologies in science have been traditional and relied heavily on textbooks, teacher directed instructions with little use of inquiry and fieldwork (Connelly *et al.* 1989, cited in Krugly-Smolska, 1990). This situation is worst in the rural areas with lack of quality teaching and resources.

Johnson (1998) writes that the traditional curriculum is didactic and formalistic and a structured exposition of ‘knowledge’ through textbooks. The old education system in South Africa was indeed pre-occupied with knowledge that was taken to be the content of the syllabus, which had to be taught to learners in each subject (*ibid*). Gultig (1999) mentions that rote learning and memorization as the logical learning strategy characterized teacher development in the South African situation.

Consequently, learners gained little or no understanding of the subjects taught because the teachers themselves lack that understanding. This has produced learners who are deficient in the skills and competence needed in the world of work.

To remediate the problems of teaching and learning of this nature, some researchers have called for a constructivist learning environment. This approach emphasizes learner-centredness in the teaching process rather than the traditional teacher-telling approach. As Brooks and Brooks (1993) assert, changes in educational reform lead to changes in the way teachers teach and students learn.

The constructivist classroom determines the strength of school reform in merging learning and understanding beyond facts and rote memorization (*ibid*). According to Treagust and Duit (1998), at the heart of constructivism is the notion that the conceptions held by each individual guide understanding. In support of this, Jaworski (1992) notes that the focus on teaching is by putting students' own efforts to understand at the centre of the educational enterprise.

Bearing in mind the importance as well as the difficulties attached to science education in general, and the teaching and learning of energy concept in particular, the researcher intends to adopt a constructivist teaching and learning approach to develop and implement a learning module on some aspects of the energy concept specifically heat and work. The choice of heat and work depends at least in part on the importance of the two concepts in the physics curriculum especially their mutual relationship formulated by the first law of thermodynamics (Van Roon *et al*, 1994), and the practical applications of the two concepts in our everyday experiences.

For the purpose of this study, first the literature on curriculum materials on the patterns in understanding the concept of energy and specifically work and heat shall briefly be reviewed. This will be followed by an overview of a constructivist teaching approach of the concept energy and the evaluation of the learning module. Finally, in the conclusion the implications of the study to teaching and learning will be given.

CHAPTER TWO

RESEARCH CONTEXT

2.1 Patterns in Understanding the Energy Concept

The concept energy is a difficult concept but its importance and universality beg an early introduction in the school curriculum. In his article, 'a more efficient approach to energy teaching', Viglietta (1990) writes that every school curriculum includes energy as a major topic, and the teaching of energy and its laws provide a fundamental key to an understanding of the physical world. In referring to the importance of energy, Viglietta points out that, energy education has been a fundamental vehicle that helps students to respond to the present and future energy related concerns and has political, social and environmental dimensions. As Taber (1989) points out, the flow of energy forms a major theme in the life sciences and that the topic of energy is found in other non-science curriculum subjects as diverse as technology and economics. Indeed Prideaux (1995) asserts that energy is a central concept in science.

Further, Boyes and Stannistreet (1990) maintain that energy as a topic is of increasing significance in socio-economic terms: the need to conserve finite energy resources has become a subject of public concern. There is much debate concerning the possible contribution to the energy dependent economies by renewable energy sources (*ibid*). In the view of Lijnse (1990), energy originated as a physical notion and has developed into one of the most fundamental concepts of the natural sciences and that energy as a concept applies both to the life-world and to the structure of physics.

Put together, the common thread is that energy is used theoretically in the physics curriculum and when applied to the life-world domain, it is concerned with energy use and consumption.

Moreover, in addition to the centrality of the topic, there are a number of difficulties associated with the teaching and learning of energy:

(i) Ogborn (1986) writes that energy is a complex concept that confused the scientific community itself up to a hundred years ago;

(ii) Taber (1989) mentions that the concept of energy itself, its forms, transformations, degradation provide difficulties to many secondary school learners. Yet because of its fundamental importance in the natural sciences, the study of energy will remain a major topic in school science;

(iii) Viglietta (1990) states that courses which introduce physics do not seem to prevent learners from mixing scientific ideas about energy with pre-scientific ones. The same vocabulary: energy, work, force, power, and conservation is used in both the life-world and scientific domains and this often causes conceptual difficulties (Duit, 1984; Driver and Warrington, 1985 cited in Boyes, 1990);

(iv) Trumper (1993) cites the studies of Clement (1978); Viennot (1979); Gilbert (1983) and Duit (1984) with regard to students' lack of differentiation between energy and other physical terms e.g. the concept of force.

The above statements suggest that the teaching and learning of energy are dogged with a variety of problems. Many of these problems are difficult to overcome because of their general nature. For example learners find it difficult to move freely their ideas about energy between the life-world and the scientific domains (Solomon, 1983). The source of this difficulty may be the general lack of public understanding of science. The poor standards of teaching, and inadequate resource status may also have roles to play. Also there has been the promotion of mythic and textbook science rather than the presentation of science as it 'really is'.

2.1.1 Why the teaching of Work and Heat as aspects of the Energy Concept?

Work and heat are important scientific concepts particularly in considering their mutual relationship formulated by the first law of thermodynamics (Van Roon *et al.* 1994). Work and heat are major topics of the energy concept in the physics curriculum. In particular, in South Africa, the two aspects form an important component of the natural science learning area of curriculum 2005 at both the primary and secondary school levels. Though taught in abstraction, work and heat are also major topics in tertiary institutions.

Both processes involve the transfer of energy: work is done when energy is transferred from one body to another by mechanical means, whereas heat is the transfer of energy due to a temperature difference (Giancoli, 1991). Indeed, much of our everyday experiences entail the transfer of energy between objects at different temperatures, and the application of forces on objects in diverse ways.

However, the concepts work and heat are often used with ill-defined meanings because of the misconceptions associated with their use. The articles of Summers (1983), and Se-Yuen Mak (1987) mention the problems in the teaching and learning of the concepts heat and work in both secondary and tertiary institutions. Prideaux (1995) points out that like energy itself, the use of the word 'work' is problematic. In physics it is a precise and abstract concept that clashes with the common use of the word e.g. it is hard to hold a brick at arm's length yet no work is done on it (*ibid*).

Also heat is one of the most difficult topics conceptually in the whole secondary school science curriculum because nearly all textbooks deal with it in a manner that is likely to confuse students (Summers, 1983). The everyday usage of the word heat has a less specialised meaning and this leads to the confusion between the energy in a system (internal energy), and a form of transfer of energy between systems (heat).

Moreover, the concepts work and heat are among the possible ways to introduce the energy concept as outlined by Becu-Robinault and Tiberghien (1998): via work, heat, transformation, conservation or degradation.

Viewed in this way, the teaching and learning of the concepts work and heat in the physicist's perspective play important roles in interpreting the misconceptions associated with their use. It is therefore important for teachers who teach them to have a better understanding of the concepts.

2.2 A Constructivist Approach to teaching Energy

Energy is a complex concept. As mentioned earlier, the concept energy was even confusing to the scientific community itself a hundred years ago. Indeed the ideas about energy encountered in everyday life are often different from the formal scientific concepts (Boyes and Stannisstreet, 1990). Thus learners are confronted with implicit assumptions about energy in daily conversations through the mass media which are directly at odds with scientific explanations learnt at school. As such, there are a number of difficulties associated with the teaching of energy in spite of the centrality of the topic.

From the above, Watts (1983) describes the most popular and persistent students' alternative frameworks on energy as follows.

- Anthropocentric: energy is associated with human beings;
- Depository: some objects have energy and expend it;
- Ingredient: energy is a dominant ingredient within objects and released by a trigger;
- Activity: energy is an obvious activity;
- Product: energy is a by-product of a situation;
- Functional: energy is seen as a very general kind of fuel associated with making life comfortable;
- Flow transfer: energy is seen as a kind of fluid transferred in some processes.

Viewed in this way, Trumper (1990) asserts that the first approach to teaching energy concept is to take students' most pervasive alternative frameworks into account. Similarly Boyes and Stanisstreet (1990) point out the attempts to define the frameworks within which children think and the need to organize teaching schemes accordingly. Indeed, as Van Driel *et al.* (1998) put it, in order to teach a topic successfully, one must know the relevant preconceptions the students have regarding the topic and what revisions or developments in these conceptions are necessary. Thus, the common feature from the suggestions of these authors is to put learners' own ideas and understanding at the centre of the teaching process: the adoption of a constructivist teaching and learning approach.

In this way, the interview-about-instances technique is used to delineate the conceptual schemes within which learners view energy (Osborne and Gilbert, 1980 cited in Boyes and Stanisstreet, 1990). Fetherston (1999) echoes the interview-about-instances approach, and in addition mentions the questions-about-events technique. Trumper (1993) in citing Shadmi (1984) suggests that the instructional approach should be based on a step by step definition of energy. These authors claim that learning begins by analysing chains of causes and results of processes, and drawing of relations between energy and each phenomenon. Then the process is described by means of energy transformation whenever an interaction between the two processes occurs (*ibid*).

Dealing with the anthropocentric framework, Trumper (1993) suggests that learners should be exposed to 'comparative events' (analogies) to lead them from their alternative framework (energy related with human beings) to create a new and more generalized framework which sees human beings as agents in the process of energy transformation. Trumper maintains that restructuring occurs as a result of the interactions between students' existing framework and the new experience.

In summing up, the above approaches require the need to elicit learners' prior ideas as the starting point for instruction, challenged through a variety of learning experiences, and restructured. Accordingly, in applying the conceptual change strategies mentioned in **(Project one pages 11 & 12)**, certain conditions including students' dissatisfaction with their present conceptions (Posner *et al*, 1982), and active engagement through small group discussions have to be considered (Tobin *et al.*, 1994 cited in Van Driel *et al.*, 1998).

CHAPTER THREE

THE RESEARCH DESIGN

3.1 Methodology

A pilot study was conducted within the interpretivist paradigm. This paradigm forms the basis of the present study. As Cohen and Manion (1994) point out, interpretivism is characterised by the concern for the individual and how he/she constructs meaning from experiences. These authors maintain that to retain the integrity of the phenomenon being investigated, efforts should be made to get inside the persons' head and to understand from within.

The choice of the interpretive approach was to enable the researcher to understand the subjective perceptions of individuals, and how they construct knowledge from their experiences.

The investigation was conducted within the confines of a tertiary institution with unique characteristics that differ from others. In keeping with the suggestion of Patton (1987), a qualitative case study was chosen because it involves an innovative process which is described 'in depth', 'in detail', in context and holistically. As Abagi (1995) writes, the qualitative approach describes processes instead of simply the outcome or end results.

3.2 Goal of Research

The central aim of the research was to develop and implement a learning module (see **appendix B**) based on a constructivist teaching/learning approach, and investigate whether the learning module will change students' initial ideas and enhance their understanding of work and heat as aspects of the energy concept. The researcher was therefore interested in answering the following research question:

Would constructivist teaching and learning approaches promote students' better understanding of work and heat as aspects of the energy concept?

3.3 Procedure

In an attempt to answer the research question, a learning module (see appendix B) based on constructivist teaching/learning approaches on some aspects of work and heat: conception, conversion, transfer and conservation was developed and implemented with a group of students. Students' constructs before and after the lesson implementation were compared to determine conceptual changes in the students. The research was conducted by means of a qualitative case study of a group of third year pre-service student teachers who followed the Secondary Teachers' Diploma course and offered physical science as one of their major subjects. The group involved were taught physical science as a subject by the researcher as part of the normal teaching periods at a College of Education located in the Eastern Cape province.

3.4 Data collection Techniques

The data collection instruments were semi-structured interviews, questionnaires, and direct classroom observations. The use of the multi-technique approach for data collection was to obtain a holistic or total view of the research (Karugu and Wamahui, 1995). Triangulation is an important and necessary method for qualitative research particularly with small samples (Knafi and Breitmayer, 1989, cited in Hand and Peterson, 1995). In the views of McKernan (1991) and Patton (1987), the use of a number of methods is to gain an understanding of a situation. As such the use of questionnaires, interviews, and observations was to limit the distortions and weaknesses found in single methods of data collection.

3.4.1 Interviews

The purpose of interviews (**see appendix A**) is to gather descriptive data in the subjects' own words (Cantrell, 1993). Interviews enable the inquirer to develop insights into how participants interpret and make meaning of the world (*ibid*). In the view of Guba and Lincoln (1985), the purpose for doing interviews is to obtain a here-and-now construction of persons. For the purpose of this study, the interview-about-instances approach (Osborne and Gilbert 1980, cited in Boyes and Stanisstreet, 1990) was used. As such the interviews included students' responses to probing questions on examples and descriptions of energy, and explanations to energy related situations like the conversion and transfer of energy by human beings and machines.

The interviews were semi-structured and open ended. The aim was to give the students the opportunity to freely express themselves orally to enable the researcher to get some insights into the thinking of the students on the concept of energy. All interviews were conducted individually, tape-recorded and transcribed.

3.4.2 Questionnaire

The function of a questionnaire lies in measurement (Oppenheim, 1992). Though the focus of the data collection was qualitative, some quantitative data associated with questionnaires were quite useful in interpreting the data. Seven questionnaires designed in the form of worksheets were used as diagnostic instruments. The first and second questionnaires were implemented after the interviews. They were used together with the interviews to elicit the students' initial ideas on energy concept in general. In this case, the questions asked in the two questionnaires were extensions and analogies of the activities found in the interview: questions on students' conceptions and associations with energy, and explanations to energy related situations particularly on aspects involving work and heat. The main purpose was to corroborate the information on students' initial ideas on some aspects of energy obtained from the interviews.

The subsequent questionnaires consisted of a sequence of lesson units: lessons three, four, five, six and seven. The lessons included activities aimed at giving the students opportunities to try out and apply their concepts in a range of ways. An additional questionnaire was also used as an evaluative instrument for the lessons. This was to give the students the opportunity to comment on the extent and ways in which their thinking has changed after the implementation of the learning module.

3.4.3 Non-participant observation

As a data gathering device direct observation makes an important contribution to descriptive research (Best and Kahn, 1986). As Guba and Lincoln (1985) point out, a major advantage of direct observation is that it provides here-and-now experiences in depth. Two colleagues were asked to observe some of the lesson presentations.

The researcher also played the role of a participant observer and kept a record of events in a journal throughout the lesson implementation.

This approach is consistent with the view of Cohen and Manion (1994) that the careful use of two or more observers and participants independently can lead to more valid and reliable results.

3.4.4 Sample

The study involved a group of five third year pre-service student teachers who offered physical science as a major subject at a college of education. It was a convenience sample because at the time of the investigation the students and researcher were members of the college community where the research took place.

3.4.5 Data Analysis

The data that emerged from the study was analysed by qualitative methods. The aim was in keeping with the view of Wamahui and Karugu (1995) that qualitative analysis tends to be inductive, moving from the particular to the general. As such the researcher adopted the suggestion of Cantrell (1993) for the analysis of the results from the investigation: content analysis involving the identification of categories or themes based on ideas that emerged from the data. This was followed by sorting, comparing and contrasting, and classification. In this way, the students' written responses were categorised by comparing the similarities and differences in the responses.

3.4.6 Validation

As the subject lecturer and researcher, the author assured the students that their responses would not be taken into account in the evaluation of their performance in physical science. As such they were told that the study formed part of the normal teaching schedule aimed at developing their understanding on energy concept. Since the research was conducted at the workplace of the researcher, possible limitations like the close involvement of the researcher with the group and bias in judgement were inevitable. In this way draft copies of the study were submitted to colleagues for validation by 'member checking' (Miles and Huberman, 1984). The results were also triangulated: student interviews, questionnaires, and direct observations to limit distortions in the methods of approach.

3.5 The Design and Implementation of the Learning Module

The learning module (see **appendix B**) consisted of seven lesson units on work and heat developed and based on constructivist teaching and learning approach. As mentioned earlier, the choice of work and heat was in line with the relationship between the two concepts as established by the first law of thermodynamics and the ill-defined meaning attached to the use of the two terms in everyday life. Boyes and Stannistreet (1990) refer to Duit (1984) that to give structure to the perception of energy, the work could focus on five basic aspects: the conception, conversion, transfer and conservation or degradation. In this way, the main focus of the learning module included activities on the conception, transfer, conversion and conservation of work and heat. The intention was to use these concepts to develop the students' understanding of the links between the different types of energy especially work and heat.

For the purpose of this study, the researcher adopted the conceptual change strategies outlined by Posner *et al.* (1982) as cited in (**Project one, p.11 & 12**): the literature review on constructivism as an alternate approach to teaching and learning. Probing and diagnostic questions, and practical investigations constituted the main activities of the learning module. Thus the lesson units in the learning module were purposely used to explore, restructure and consolidate the students' ideas on work and heat:

3.5.1 Exploration of Students' Initial Ideas

Driver *et al.* (1985) write that taking account of students' prior ideas is one of the strategies though not the only one which enables teaching to be adapted to students. Student interviews (see **appendix A**) as discussed earlier under data collection tools were based on the interview-about-instances approach (Osborne and Gilbert, 1980). Among the questions asked were what the students know about energy (**A: Q.1**), a description of the energy changes that take place along an incline plane (**A: Q.3**), the explanation to the melting process of a bucketful of ice (**A: Q.4**). The responses that follow were among those expected from the students (**Note: Rn, shows the expected responses to sample questions (Q); n is the question number; Appendix A: interview**).

R.1

Q.1 Energy is the ability to do work; there are different types of energy; energy changes from one form to another; it is a conserved quantity;

Q.3 On the top of an incline plane, an object has potential energy, it changes to kinetic energy as the object moves, and heat energy because of the friction between the surfaces of the plane and the object.

Q.4 The melting of ice takes place from the transfer of energy (heat) as a result of the temperature difference between the high temperature of the sun rays and the low temperature of the ice.

Lessons one and two (**see appendix B**) formed the introductory or initiation phase of the energy concept in general. The introduction to lessons three and five were used specifically to further explore the students' initial ideas on work and heat respectively:

Lesson one included questions on students' definitions of energy (**Q.1**), associations with and examples of energy (**Q.2 & Q.3**), sources of energy (**Q.6**), and explanations to situations involving energy transfer. The definitions they were expected to respond to were among the following:

R.2

Q.1 Energy is the ability to do work;

Q.2 Give among the responses everyday examples especially aspects connected with work and heat e.g. the use of electrical appliances, daily activities involving energy as a process.

Q.3 Any examples of the different types of energy;

Q.6 The main sources of energy available to South Africa include the sun, coal, crude oil, nuclear power, electricity, light etc

Lesson two was used to further explore the students' initial ideas. The questions included students' explanations to 'comparative events' (analogies) on energy concept covered in the interviews and lesson one e.g. explanation of energy conversions in a coal fired steam engine (**Demonstration 3**), energy changes that take place in a simple pendulum (**Demonstration 7**).

The aim was to get the students' understanding of energy concept within a more generalized framework that relates energy to both human beings and machines. The students were expected to respond in the following ways:

R.3

Demonstration 3: *The coal in the steam engine possesses chemical energy. When coal is burnt, there is a temperature difference which results in heat flow. This is used to boil water. Water changes to steam (vapour). The vapour is pressurized which leads to the kinetic energy of the engine.*

Demonstration 7: *The energy of the simple pendulum changes from potential energy to kinetic energy and back every half cycle. At the far side (A and C), the simple pendulum has maximum potential energy. When released, P.E falls and the K.E rises. As it swings through the centre (B), the speed is greatest and K.E is a maximum. But at any stage the sum of the P.E and the K.E is equal to the initial P.E.*

Lesson three included probing questions that were aimed specifically to determine the students' initial ideas on the concept of work done by a maximum force and when the displacement and the force are at an angle of zero or perpendicular e.g. (Q.1 & Q.2). The students were expected to respond to Q.1 and Q.2 in the following way:

R.4

Q.1 *The work done by a force is maximum when the angle between the force and displacement is zero i.e. the force acts in the direction of the displacement.*

Q.2 *The work done by the upward force on books carried at a rest position is zero because there is no displacement.*

Lesson five consisted of some focus questions. It was particularly used to explore the students' initial ideas on the concept of heat.

The questions included in the lesson were students' understanding of the concept heat (Q.1), the distinction between temperature and heat (Q.2), and the heat capacities of objects (Q.5). Among the responses expected from the students were the following:

R.5

Q.1 Heat is the energy transferred as a result of a temperature difference between objects. Heat does not reside in objects.

Q.2 Temperature is the measurement of the degree of coldness or hotness of a body.

Q.5 Heat capacity depends on the nature of the substance and the quantity and arrangement of matter. The more massive a substance, the greater the quantity of particles and the greater the heat capacity. The 50g mass will have a higher heat absorbing capacity than the 25g mass of the same object.

3.5.2 Restructuring and Consolidation of Students' Ideas

This section formed the heart of the learning module. It was covered in lessons three, four, six and seven. The lessons were designed and implemented particularly to include activities aimed at restructuring the existing ideas of the students on the selected topic. The aim was to give the students the opportunity to be aware of the limitations in their existing ideas by being in contact with the phenomena under study. As such, the students were actively engaged in problem solving and task-oriented activities. They were also encouraged to express and share their ideas through small group discussions followed by a whole class discussion:

The greater part of lesson three consisted of a variety of practical activities including work done by a constant force (**activity 3**), work done by variable forces (**activities 4 & 5**), the work-energy theorem, and a class exercise.

Lesson four consisted of an exercise on the concept of work. This included focus questions that required the students to apply what was learnt to explain some concepts and solve numerical calculations on work done (**Qs 1-7**).

The purpose was to give the students the opportunity to review the extent and ways in which their thinking on the concept of work has changed.

Lesson six was a continuation of lesson five to reinforce the students' understanding of heat. The lesson unit was mainly involved with practical activities aimed at developing the students' understanding of their conception of heat (**activities 1, 2, 3 & 4**), and heat exchanges (**calorimetry: activities 5, 6 & 7**).

Lesson seven was mainly developed and implemented to extend the students' understanding of the three methods of heat transfer: conduction, convection and radiation. The lesson included practical investigations (**activities 1, 2 & 3**), and the relationship between internal energy, work done and heat inflow (the first law of thermodynamics).

3.5.3 The role of group work

Though some task-oriented activities were assigned to the students individually in view of the small class size, group activity dominated a greater part of the lesson implementation. The students were put into two small groups of two and three learners.

The purpose of the group work was to give the students the opportunity to share their ideas and views, solve anomalies in their thinking, and to discuss their findings collaboratively. Group discussions focusing on the interpretation of phenomena may serve to foster conceptual change (Tobin *et al.*, 1994 cited in Van Driel *et al.*, 1998).

3.5.4 The role of the researcher

The teaching and learning approach used for the implementation of the learning module put learners at the centre of the teaching process. The students were faced with initial problems in understanding the teaching and learning approach. As such, the main role of the researcher/teacher was to intervene at certain times to help the students to address their preconceptions and guide them to develop their conceptions on energy that were scientifically invalid.

For the purpose of this study, the researcher adopted the constructivist teaching sequence outlined by Driver and Oldham (1986) and cited in **(Project one, p.15)**: orientation, elicitation of students' ideas, restructuring, and review of ideas. In this way, the students were provided with a number of task-oriented and problem solving activities involving work and heat. Each time a lesson unit was completed, there was a session for small group and whole-class discussions. The aim was to formalise the learners' conceptual understandings.

3.6 Evaluation of the learning module

Students' responses to a questionnaire, comments from non-participant observers, and a class test **(see appendix C)** constituted the main evaluation tools used for the design and implementation of the learning module. The students were asked to remark on some aspects of the learning module and the presentation of the lessons e.g. content and organization, readability of the learning module, and the level of understanding of the teaching and learning approach. As mentioned earlier, two colleagues were asked to observe and comment on the presentation of some lessons. Also apart from the routine class revision that followed each lesson unit, a class test on some aspects of work done and heat was organized after the implementation of all the lessons.

CHAPTER FOUR

4.1 Research Findings

In order to acknowledge the conceptions and reasoning of the students on the selected topic (work and heat), a qualitative analysis was used. The inclusion of some quantitative data was to make the qualitative interpretation of some aspects of the study easier. For the sake of brevity the analysis was limited to the conception, conversion, transfer and conservation of work and heat as aspects of the energy concept. Students' responses that emerged from the interviews, questionnaires, and comments from non-participant observers have been classified according to the following themes:

4.1.1 Students' constructs before the implementation of the learning module;

4.1.2 Students' constructs after the implementation of the learning module;

4.1.3 Evaluation of the learning module;

For illustrative purposes, excerpts of students' responses have been quoted **verbatim**.

(Students' names are abbreviated for the purpose of anonymity in the investigation: **D.S, K.S. N.M, T.M, and Z.N**). The following codes were also used in the analysis: **A** – responses to interviews; **Qs** – questions; **Appendices: A** – interview schedule, **B** – lesson units, **C** – lesson evaluation.

4.1.1 Students' constructs before the implementation of the learning module

4.1.1.1 Students' description of the term energy

When the students were asked in the interview: *What do you know about energy* (see **appendix A, Q.1**), the following students' responses were identified:

D.S: Energy is the ability to do work.

K.S: There are different kinds of energy, potential energy and kinetic energy.

Energy cannot be destroyed but changes to other forms.

N.M: Energy is the ability to do work.

T.M: Energy is the ability to do work. There are different types, K.E and P.E.

N.Z: Energy is the ability to do work.

Almost all the students associated energy with the ability to do work. From the responses to **A.Q.1**, four students defined energy as the ability to do work. Kinetic and potential energy were common in the descriptions given by two students. Only one student defined energy in terms of the conservation principle.

(b) In another question (**B. Q.3**), the students were asked: **Write down three examples of the word energy**. The following were the excerpts of the students' responses:

D.S: Heat, light, potential energy;

K.S: Potential energy, kinetic energy, heat;

N.M: Kinetic energy, electric energy, potential energy, chemical energy;

T.M: Kinetic energy, potential energy, electrical energy;

N.Z: Kinetic energy, potential energy, electrical energy.

The responses to **B. Q.3** show that many students were familiar with the common types of energy. For example almost all the students included kinetic energy and potential energy among the examples. Electrical energy was among the examples of energy mentioned by three students. Two students wrote heat, and one indicated chemical energy.

(c) To probe the students' understanding of the importance of energy, they were asked to answer the following question in a questionnaire:

Q.2 Write down your first three associations with the word energy.

Table 4.1 shows the distribution of the students' association with energy according to the categories described. The results given in table 4.1 show that all the students indicated their associations with energy similar to the expected response (**R.2, Q.2**): with things. Four students indicated their associations with physical concepts. All students included descriptions in their association with energy. Only one student mentioned an association with a phenomenon and no student indicated an association as a process.

Table 4.1. Distribution of Students' responses to associations with energy (N = 5)

Category	Number of Informants
Things (human beings, appliances)	5
Process (physical and mental)	0
Phenomenon (light, heat, electricity)	1
Physical concept (work, power, force)	4
Descriptions (other than the above)	5

(d) Table 4.2 shows that all the students have some level of understanding of the sources of energy available to a country as well as some misconceptions about the source of energy. Their responses were similar to the expected responses (R.2, Q.3). All students mentioned coal as a source of energy. Three students indicated the sun, water (one), nuclear power (one). Though Eskom and Sasol are corporations that generate energy, one student felt that Eskom is a source of energy. Another student also indicated Sasol as a source of energy.

Table 4.2 Distribution of students' responses to sources of energy to South Africa (N = 5)

Source	Number of informants
Coal	5
Eskom	2
Sun	3
Crude oil	1
Sasol	1
Water	1

4.1.1.2 Students' conception of work done

The students were asked to explain the questions below (see appendix B, lesson 3: Qs.1 & 2) in order to know the extent of their understanding of the concept work done. The responses that follow were identified:

Q.1: Given $W = Fd \cdot \cos \theta$, when is work done by a force maximum? (W: work done; F: Force, d: displacement; θ : angle between force and displacement).

D.S: When $\theta = 0$, when a force is applied to counter-act the gravitational force and distance must be upwards.

K.S: When the angle is less than 90° .

N.M: The force will be a maximum at an angle of zero. The cos of zero is greater than cos 90.

T.M: When the angle is small. Because the greater the angle, the smaller the work done.

N.Z: If you compare angle 90° , 60° and 45° , the work done if $90^\circ = 0$ J. $60^\circ > 0$ and $45^\circ > 60^\circ$ therefore $90^\circ < 60^\circ < 45^\circ$ therefore 45° is the maximum work done.

Q.2: A girl carries a box of books on the head. If the girl remains at rest, why is it that the work done by the upward force is zero? If the girl carries the books and walks horizontally across the surface of the floor at a constant velocity, give in terms of $W = Fd \cdot \cos \theta$ with reasons the magnitude of the work done.

D.S: Because there is no displacement. The angle is 90° then the force is perpendicular to the displacement. Work done is zero because the force is perpendicular to the displacement of the girl.

K.S: There is no distance walked by the books or the girl. There is no work done because the force is perpendicular to the distance or displacement.

N.M: The force is acted on the object without magnitude. The force is acting to the perpendicular to the horizontal surface of the floor which the girl walks across it.

T.M: There is no distance travelled and the books are perpendicular to the girl and $\cos 90^\circ = 0$. The books are perpendicular to the girl. When it is perpendicular there is 90° so $\cos 90^\circ$ is equal zero.

In the responses to **4.1.1.2, Q.1 and Q.2**, two students could mention that maximum work is done when the angle is zero but failed to give explanations to their answers. The responses revealed the students' incorrect interpretation of angles. For example two students felt that the maximum work is done at small angles and angles less than 90° . All students could indicate that the work done is zero when the force and displacement are perpendicular. Three students wrote that no work is done when there is no displacement, however there were some mistakes in their explanations. For example some students wrongly used the term distance instead of a displacement by the applied force.

4.1.1.3 Students' conception of heat

When the students were asked: *what do you understand by the term heat (lesson 5: Q.1)*, the following responses emerged:

D.S: Heat is the hotness of matter. Type of energy that can be caused by friction and collisions;

K.S: Is the energy released to make substance of liquid hot.

T.M: Heat travelled from the cold part to the hot part. Heat transfer.

N.Z: Heat is the change in temperature through gaining energy an object gains some hotness.

In another question (**lesson 5: Q.2**), the students were asked to distinguish between the concepts heat and temperature:

Q.2 Heat and temperature are two different concepts. Describe the main differences between the two concepts. Excerpts of students' responses follow:

D.S: Temperature is the measurement of hotness or coldness of matter therefore temperature is different from heat because heat is energy but temperature can be hot therefore heat is an example of temperature.

K.S: Temperature is the hotness or coldness of a substance and heat is the energy to get things hot.

T.M: Temperature is the hotness or coldness of the object. Heat is only the hotness.

N.Z: Temperature is the measure of degree of hotness or/and coldness of an object. Heat is the gaining of heat energy and the differences between original temperature and after gaining heat.

To further explore the students' understanding of the concept of heat, they were asked to explain the differences in heat capacities of different masses of the same object (**lesson 5: Q.5**).

Q.5. If 25g of copper is heated and the temperature rises. Is more heat, less or the same amount of heat needed to heat a 50g mass of the same metal? Explain your choice of answer to the question.

The responses identified were the following:

D.S: Less, the heat energy used to 25g will be different from the 50g because there is more substance in 50g metal.

K.S: Same amount of heat because of the same texture so the temperature rise up.

T.M: More heat because the mass is doubled now. Heat might be the same and the mass of copper is not the same but the time is fixed.

N.Z: More heat is needed to heat the 50g mass of the same metal. The quantity and volume is the controlling factor. In this case therefore the greater the quantity the greater should heat be.

The results from **lesson 5: Qs.1, 2 & 5** revealed some correct responses as well as errors in the students' understanding of the concepts heat, temperature, and heat capacity.

The responses show that all students associate heat with objects and the degree of hotness of an object. Majority of the students could not clearly distinguish between heat and temperature. Though all the students could define temperature as a measure of the coldness or hotness of a body, two students argued that heat is the hotness of a body. One student also felt that heat is an example of temperature. Three students could mention that the 50g mass has a higher heat capacity than the 25g mass. Two students gave some reasons that were almost similar to the expected responses but their explanations were not clear.

4.1.1.4 Students' understanding of energy conversion

(a) The students were asked to explain in their own ways the energy changes involved in sliding along an incline plane (see appendix A: Q.3):

Q.3: A boy slides down an inclined plane from the top of a hill. What type of energy changes take place? The responses below emerged:

D.S: At the top of the hill, the boy has energy which is potential energy. As started moving, sliding down energy is converted to kinetic energy.

K.S: The boy has potential energy at the top of the hill. When sliding he gets kinetic energy. Friction also causes heat.

N.M: That is from potential energy to kinetic energy when there is sliding. When there is sliding down it has got energy of motion which is kinetic energy. When the boy hits the ground, there is work done because the force is applied through a distance.

T.M: Energy changes from potential energy to kinetic energy.

N.Z: On top was potential energy. As the boy slides he gains kinetic energy and there is work done as the boy moves down.

The majority of the students' responses related the movement of objects with energy conversion but most of the explanations were not clear. All students indicated a change from potential energy at the top of the incline plane to kinetic energy as the boy slides down the plane. Two students mentioned that work is done if the boy moves down the incline plane but only one student could relate the applied force and the distance moved by the boy to the work done. One student also mentioned that the kinetic energy of the boy causes friction and heat.

(b) The students were asked: *look carefully at the diagram below. It shows a model coal-fired steam engine. Describe the energy changes that take place (lesson 2: demonstration 3)*. The following responses were identified:

D.S: First there is the coal, a coal has chemical energy. The heat is used to cook water. The boiling water makes steam. The steam drives a shaft in a steam engine. That steam engine is moving and kinetic energy is the result.

K.S: They burn coal which releases heat and it heats the container with water, the water becomes hot and water molecules collide and kinetic energy is released which makes the train to move.

N.M: It starts with heat from coal. Chemical energy from coal to heat energy and then to kinetic energy of the locomotive train.

T.M: There is the coal and water. Coal is converted to another type of energy to give mechanical.

N.Z: The train heats some coal. The coal is used to boil water which makes the steam. Coal has chemical energy which is converted to heat. Heating the water, the steam is converted to kinetic energy.

The students' responses revealed that energy resides in objects. For example three students mentioned that coal has chemical energy. All students indicated that the burnt coal is the source of heat for the production of steam but could not explain that heat is the energy transferred from the temperature difference caused by the burnt coal.

Four students wrote that steam causes the kinetic energy of the engine but none could explain how the steam gives rise to kinetic energy. No student was able to relate the heat change to the work done by the engine.

4.1. 1.5 Students' understanding of energy transfer

The students were asked to demonstrate their perception of energy transfer by answering the question below (see appendix A: Q.4).

Q.4: In your own way of understanding, describe in terms of energy what happens to a bucketful of ice kept in an open space for a long time. The responses that follow were identified:

D.S: The ice will melt because of heat energy from the sun. The water acquires kinetic energy because it will move.

K.S: The ice will melt into water and evaporate because of heat energy from the sun.

N.M: The ice will melt. Heat energy from the sun melts the ice to form water.

T.M: The ice melts. Heat energy from the sun melts the ice to form water.

N.Z: The ice will melt because the sun releases hot rays. The ice is at a low temperature. It gains hotness from the sun because there is a change in temperature.

All students responded to Q.4 above that heat energy resides in the sun. For example all students mentioned that the ice melts to form water because of the heat from the sun but majority of the students could not explain the melting of ice in terms of energy transfer from the sun as a result of a temperature difference. Only one student mentioned that ice at a low temperature gains energy from the sun but failed to give any explanation. Another student indicated that the water formed from the melting ice moves because of a gain in kinetic energy but failed to explain the process of energy change.

4.1.1.6 Students' understanding of energy conservation

The students were asked to explain the energy changes if a simple pendulum swings from a point A through B to another point C (see lesson 2: demonstration 5). Excerpts of students' responses follow:

D.S: A: Potential energy is maximum; B: Kinetic energy is maximum; C: Potential energy is maximum; at A, B and C, mechanical energy is maximum.

K.S: A is potential energy; B is kinetic energy; C is potential energy.

N.M: At point A is stored energy; at point B is kinetic energy; C is potential energy.

T.M: A: Potential energy – stationary; B: kinetic energy- motion; C: kinetic energy- motion.

All the four students indicated changes in kinetic energy and potential energy with the oscillation of the pendulum but in different ways. No student could clearly explain how kinetic or potential energy changes from zero to maximum at different points during the oscillation of the pendulum. None of the students was able to mention that at any point of the oscillation the sum of K.E and P.E is equal to the initial potential energy: no student mentioned the law of conservation of energy in their explanation. (Note: N.Z was absent during this lesson).

4.1.2 Students' Constructs after the implementation of the learning module

Group discussions and individual responses to focus questions specifically on some aspects of work and heat in a routine class exercise, and an organized class test (see **appendix C.2**) were used to determine whether there was any improvement in the students' understanding of the selected concepts (**work and heat**) after the implementation of the learning module. The students remained in the same groups throughout the discussions.

4.1.2.1 The Concept of work done

The students were asked to explain the questions below on work done (**lesson 4: Q.1 & Q.2**). The responses that emerged follow:

Q.1: A net force acts on a moving object. Explain in each case the following:

(a) In what situation is work done?

(b) In what situation is no work done?

Group A: (a) Work is done when the force act on a moving object at a certain distance in the direction of a force. (b) When there is no displacement and at a perpendicular angle.

Group B: (a) Work is done when a force is applied on a moving object and where there is displacement. (b) When there is no displacement when the angle is perpendicular.

Q.4: A hammer with a 1kg head is used to drive a nail into a wooden board. If the hammer is moving at 15 m/s when it strikes the nail and the nail moves 1 cm into the board.

(a) Is work done or not? Explain.

(b) Determine the average force exerted by the hammer on the nail.

(c) Describe the energy changes involved in the process.

Group A (a) No work done because the hammer is perpendicular to the head of the nail.

(b) $V = 15 \text{ m/s}$ $= \frac{1}{2} \times 1 \text{ kg} (15)^2$

$$\begin{aligned}
 M &= 1 \text{ kg} & & = 112,5 \\
 S &= 0,001 \text{ m} & \therefore W &= F \cdot S \\
 & & F &= W/S \\
 W &= \frac{1}{2} mv^2 & F &= \frac{112,5}{0,001 \text{ m}} \\
 & & F &= \underline{112500 \text{ N}}
 \end{aligned}$$

(c) Potential energy changes to kinetic energy.

Group B (a) Whenever a force is applied and causes displacement in the direction of the force, there is work done.

$$\begin{aligned}
 (b) \quad V^2 &= 2gS & F &= mg \\
 15^2 &= 2 \times 0,01g & &= 1 \text{ kg} \times 1125 \text{ m/s}^2 \\
 &= \underline{225 \text{ m}^2/\text{s}^2} & & \\
 &0,02 \text{ m} & &= 11250 \text{ N} \\
 g &= 11250 \text{ m/s}^2
 \end{aligned}$$

(c) Potential energy to kinetic energy whilst is moving then strikes to sound energy.

The students' responses to **lesson 4: Q.1 & Q.2** show a progression in their thinking as well as errors in some explanations. Both groups were able to relate the quantities, applied force and displacement to work done appropriately. For example it was evident from the responses of the two groups that work is done when the applied force and displacement act in the same direction and no work is done when the force and displacement are perpendicular. Also except some mistakes in calculation, the two groups were able to use different but appropriate methods to determine the applied force from either kinetic or potential energy. However, the students in **Group A** could not use a similar approach to explain the work done by a hammer as it drives a nail into a wooden board.

4.1.2.2 The concept of heat

The improvement in students' understanding of heat transfer was determined by the following questions (see **appendix C.2: Q.2.2**). The responses that emerged follow.

Q.2.2: A metal and a plastic cup have been standing on a table in the laboratory for a long time. The cups are both empty. When the two cups are touched in turn, the metal cup feels colder than the plastic cup.

2.2.1: Are temperatures of the two objects the same or different? Explain your answer.

2.2.2: Why do the cups feel different to the touch?

D.S: The temperatures are the same, both at room temperature. The only difference lies in metals are good conductors of heat. They absorb and give away heat easily than non-metals (plastic). The metal draws the heat on the hand and that is why it feels colder than the plastic. Plastic draws heat slower than metal.

K.S: They are the same because they have a tendency of assuming the room temperature. It is because they differ in conductivity of heat because they are not of the same material.

N.M: The heat energy is transferred from the body to the cups and the metal is a good conductor of heat . Plastic are poor bad conductor of heat.

T.M: They have the same temperature. They are taking the temperature of the laboratory room which is the room temperature.

N.Z: The same because the temperature inside and inside the laboratory are the same Because you are releasing energy to the metal cup or transfer energy to the cup. So the cup gains energy and you are losing energy.

Q.2.3: Two aluminium beakers of equal size contain equal volumes of water. The beakers are placed at equal distances from an electric heater. One of the beakers is painted matt black and the other is given a shiny silver surface. If a thermometer is placed into each:

2.3.1: Discuss the methods of heat transfer present in the experiment.

2.3.2: Which of the two surfaces cools faster if the source of heat is removed. Briefly explain.

D.S: 2.3.1 Radiation – takes place when heat travels through air media from heater to the beakers. Conduction – the heat is conducted through the glass to the water inside the glass.

Convection – the water inside the glass heat is convected throughout the water molecule.

2.3.2 The beaker which is painted in matt black cools faster. The black colour is a good absorber and gives away heat easily because of dull colour heat is lost easily.

K.S: 2.3.1 The heat will be radiated from both the heater to both of the beakers and when the heat reaches the beakers will conduct the heat and after some time the content of the beakers that is the water in the beakers will undergo conversion in order to transfer the heat therefore there will be three processes namely; radiation, conduction and convection.

2.3.2 The one which is covered by black or painted black due to the fact that it is the one that is a good conductor of heat it means that it can easily cool also.

N.M: 2.3.1 The heat is supplied direct to the two beakers. Heat is transferred to the beakers .

The beakers conduct the heat and the molecules of the beaker start to collide each other. The conduction is taken place through the beakers and heat supplied to them. The hot water molecules move up to the top and cold water molecules sink down. The water molecules collide with the walls of the beaker contain. The convection process takes place. At very high temperature the water molecules gain the radiant energy at high temperature objects radiate. The radiation takes place.

2.3.2: The painted black beaker will cool faster than the shiny silver. The black colour absorbs heat easily and loses heat easily. The shiny silver colour reflects and prevents leaving what is inside and what is to enter. Shiny silver beaker protects the net loss very easily.

T.M: 2.3.1 The heat will come from the heater to the beakers. They will be transferred equal heat because they are on the same distance. The beakers will be different to absorb heat and transfer it to water. The bottom will expand and become less dense and goes to the top. That will happen to both beakers.

The shiny one will be the first to catch up because that shiny surface will easy to conduct heat. The black one will absorb more because it black has the highest frequency.

2.3.2 The shiny one will be the first one to radiate all the energy but the black beaker will cool first. Though it absorbed a lot but it is the first one to cool down.

N.Z: 2.3.1 The beaker which is painted black gains energy quicker than the one given a shiny surface. Because black colour absorb heat and shiny silver emit or reflect heat. But it take time to get hot. The first to get hot is the black one but it cools faster than the other one. Because it emitted the energy inside or the hotness inside now.

2.3.2 The one which is painted black, because it only absorb the quickly and it cannot keep it longer when the source is removed. The shiny silver keep the hotness longer than the one because of that silver.

There was an extension in the students' understanding of the concept heat (**see appendix C.2: Q.2.2 & 2.3**). The terms heat and temperature took a new and slightly better meaning in explanations given by all the students. Majority of the students indicated that metal cups conduct heat better than plastic cup. Two students could explain that metal and plastic objects may have the room temperature, however metals feel colder than plastic objects because the former draws energy from the hand. Though there were errors in the explanations, three students could include in their descriptions of the methods of energy transfer the terms: conduction, convection and radiation. All students also indicated that black objects absorb and emit energy faster than shiny objects but only one was able to relate this to the dull surface of objects painted black.

4.1.2.2 Students' understanding of the concept of energy conversion

To determine the students' understanding of energy conversion, the following questions were asked (**lesson 3: Q. 6; appendix C.2: Q.2.1**):

Q.6 If the net work done on an object is equal to a change in kinetic energy, what happens to the kinetic energy if: (a) the work done is doubled (b) the speed of the object is doubled?

Group A: (a) The kinetic energy will be doubled (b) also be doubled.

Group B: (a) When work done is doubled the kinetic energy is also doubled (b) the speed is doubled therefore the kinetic energy is multiplied by four times.

Q. 2.1: An electric drill can be used to make holes in a piece of wood. Describe all the energy changes that take place.

D.S: Electrical energy supplying the drill is converted into kinetic energy and the drill spins. The change in motion causes heat energy because of friction between parts of drill and contact with wood. Therefore some of kinetic energy is converted into heat energy.

K.S: When the switch is off there is only potential energy but when the switch is on potential energy is converted to electric energy and when the drill works electric energy is converted to kinetic energy.

N.M: Electrical energy is to change to heat energy. The heat energy is change to the kinetic energy.

T.M: The electric drill has potential energy. When it is started it is converted to kinetic energy. When it is also converted to electrical energy when moving most mechanical energy is used.

N.Z: The electric drill is in motion, there is kinetic energy. By the time it enters the wood it makes some friction between the drill and wood. Kinetic energy now changes into sound energy and it changes into heat energy.

The results from **lesson 3, Q.6; C.2. 2.1** show an extension in the thinking of the students on some aspects of energy conversion. There were also mistakes in the explanations of the students. For example, the students were able to draw links between the different types of energy. Both groups could relate the changes in work done to the change in kinetic energy of an object (**Q.6**) but one group was not able to appropriately relate the change in speed of an object to a change in kinetic energy.

Also four students were able to draw a link between electrical energy and kinetic energy of the drill (**see appendix C.2: Q.2.1**).

Three students indicated the link between kinetic energy and heat but some of their explanations were not clear. Two students mentioned that the friction between the parts of the drill and contact of the drill with the wooden board caused heat but failed to explain this in terms of energy transferred from a temperature difference. No student was able to relate electrical energy and heat change to the work done by the drill.

4.1.3 Evaluation of the learning module

4.1.3.1 Students' impressions and expectations

(a) As can be seen from table 4.1.3a, majority of the students found the learning module to be well-structured. The contents of the learning module were found to be legible and illustrations readable by many students. Many students indicated that the learning module contained a variety of activities. Though all the five students experienced the same classroom activities, three of them indicated that, the learning module's support for active learning and critical thinking was quite well, while two felt that it was moderate. This was an inconsistency noticed in the student's responses. (see appendix C.1, questions 1, 3, 4, 5).

Table 4.1.3a: Distribution of students' responses to impressions about the learning module

Criteria	Very well	Quite well	Moderately/to some extent	Not particularly	Not at all
Structure and organization	4	0	1	0	0
Legibility of content and readability of illustrations	5	0	0	0	0
Variety of activities in the content	4	1	0	0	0
Encouragement of active learning and support for critical thinking	0	3	2	0	0

(b) In responding to a question on students' impressions about the instructional strategies used for the implementation of the lessons, all students indicated that they were followed but one student felt that some aspects were difficult. Three students found the lessons to be interesting and understandable. (see appendix C.1: Q. 11): **What is your impression about the instructional strategies?**

Students' responses to Q.11

D.S: They were planned in such a way that every learner can express himself therefore instructions were easy to follow.

K.S: The instructions were easily followed and understandable.

N.M: They were clear and interesting.

T.M: They were followed, some were difficult.

N.Z: They were articulate enough and comprehensible.

(c) In comparing the teaching approach used for the implementation of the learning module with the traditional approach (see appendix C.1: Q.18): **How would you compare the teaching and learning approach used for the lessons with the previous traditional method of approach?** Many students found the current approach to give a better understanding and more interesting than the traditional method. Two students mentioned that the approach encourages learner involvement. Also all students suggested that the teaching approach should be repeated but modified in future lessons (see appendix C.1: Q.19): **Based on your experience gained from the lessons, what suggestions would you make for future lessons?**

Students' responses to Q.18

D.S: The lessons are constructive and helps constructiveness at learners. Learner cannot be passive in doing these lessons.

K.S: It gives me better understanding and interest in learning.

N.M: It helps with more understand and very interesting to learner.

T.M: It encourages more understanding,

N.Z: It promote more learner involvement or learner centred.

Students' responses to Q.19

D.S: The lessons were planned so that the learner had to be active therefore the lessons sometimes be done like those.

K.S: It must be repeated.

N.M: It must be repeated and modified.

T.M: Modified and repeated.

N.Z: In future this should be modified with more examples that are connected to the learners' social context.

Table 4.1.3b: Distribution of percentage marks obtained by students in a class test

Name of student	Marks obtained
D.S	80
K.S	56
N.M	56
T.M	67
N.Z	63

(d) Table 4.1.3b documents success in the learning of students' on the selected topic. The results show that one student scored 80%, two students had above 60% and two students had above 50%. This is partly an indication of the students' understanding of the lessons though there was a big difference between the highest and the lowest marks scored by the students in the test.

4.1.3.2 Remarks of non-participant observers about the learning module

Though one observer found the student-student discussion to be a bit limited during the discussion phase of the lesson, group work and the active participation of students during the lesson presentation were common in the comments given by the two observers. Also, the encouragement given to the students to express their ideas through questions were evident in the comments given by both observers. The following comments were noted by the non-participant observers:

Observer A: Students appeared comfortable with their investigations. Lecturer provided guidance such as correct ways of setting apparatus for the investigations. Students were confident to provide reasons/suggestions for the apparatus that was not working. Discussion was freely done. Students contributed confidently and asked questions. All students took part in the discussion. Lecturer posed questions which seemed to lower the status of the students' ideas of explaining the concept of heat transfer. Students' gestures showed that they had better understanding of the concept of heat transfer after the discussion. Students were attentive and seemed to be enthusiastic with the discussion. The lecturer used relevant/everyday examples to explain concepts to students. The students seemed to understand why some of their explanations were not appropriate to explain their observed phenomena (i.e. experimental results). Discussion was smoothly between lecturer and students. Student-student discussion was a bit limited.

Observer B: Learners participated fully in the lesson as each contributed in drawing up the summary on the chalkboard. They took turns to answer questions. The facilitator posed questions to the learners to get information from them. The learners took active part in group and class discussions. The overhead projector was effectively used.

CHAPTER FIVE

5.1 Discussion

The research question in this study concerned the use of a constructivist teaching and learning approach to develop students' better understanding of work and heat as aspects of the energy concept. The results were mainly based on students' responses to interviews, questionnaires and comments from non-participant observers. The use of a learning module on the selected topic and the adoption of a constructivist teaching and learning approach gave the students the opportunity to be aware of their own ideas and the limitations in them. To apply the constructivist ideas in the classroom, the learner must receive presented material, have relevant prior knowledge or schema and activate that prior knowledge (Mayer 1983 cited in Appleton, 1997). It should be noted that, this approach might have some inherent difficulties as students grapple with their own efforts in understanding during the instructional process.

Nonetheless, first the study revealed that the students hold intuitive ideas on the concept of energy in general and specifically the concepts work and heat. As can be seen from table 4.1, before formal instruction the majority of the student associated themselves with energy in descriptions, physical concepts and things. No student mentioned an association with a process. The students seemed to be familiar with some types of energy e.g. the concepts potential and kinetic energy were common in the examples of energy given by the students. Another indicator was that many students described work done in terms of an applied force and displacement but experienced problems in the interpretation of angles between the force and displacement.

Many students related the movement of objects with energy conversion and established a link between the changes in kinetic and potential energy. Few students could mention the link between kinetic or potential energy and work done. Majority of the students described heat as a form of energy that resides in objects. They associated heat with objects and the degree of hotness of an object. For example many students indicated that coal has chemical energy and gives heat when burnt instead of heat as a transfer of energy from a temperature difference.

These findings are consistent with some of the most popular and persistent students' frameworks on energy outlined by Watts (1983) e.g. the view of energy to be associated with human beings (anthropocentric framework), energy causes things to happen ('cause' framework), and energy as a product of some process or processes (product framework). This gives an endorsement to the view of Trumper (1990) that, the energy concept cannot be effectively taught without taking students' alternative frameworks into account.

The study still revealed some ambiguities and errors in the constructs and explanations of the students after the implementation of the learning module. This is quite understandable because as Treagust and Duit (1998) put it, despite science teaching, no students' conception can completely be extinguished and replaced with science views. Research shows that children's ideas are usually firmly held, difficult to change but unfortunately scientifically incorrect (Fetherston, 1997). The implication of this to teaching is that challenging students' present ideas is not enough to promote conceptual change. Alternative ideas have to be offered and these need to be seen not only as necessary but reasonable and plausible (Driver *et al.* 1985).

However, there were some improvements and a progression in the answering patterns of many students. For example, majority of the students were able to recognise some connections between the key concepts used in the study: the conception, conversion, transfer and conservation of work and heat took a new and better meaning after the students had gone through the learning module. Though some students still had difficulties in the correct interpretation of angles, all the students were better able to relate work done to the quantities force and displacement acting in the same direction. Also many students were able to mention that no work is done when the displacement is perpendicular to the applied force.

Further, none of the students could clearly describe heat as a transfer of energy from a temperature difference, and to relate it to work done. However, many students were more able to use the terms heat and temperature correctly than before formal instruction, and related heat to other forms of energy such as electrical energy, kinetic energy.

Also, in spite of the mistakes in the explanations given by many students, majority of them could mention the terms conduction, convection and radiation as the main methods of heat transfer. Though there were inconsistencies and mistakes in the explanations, many students responded that black objects absorb and emit heat faster than shiny objects.

In addition to explanations as a measure of understanding, the study revealed the students' ability to apply what was learnt in one context to another. For example, in spite of the errors found in the calculations and some explanations, the students were able to establish links between different types of energy and used them to solve numerical calculations involving the energy concept: to relate a change in work done with a change in kinetic energy, and to determine the applied force from the change in kinetic energy and potential energy.

Worth mentioning is that, the investigation revealed that almost all the students lacked the vocabulary and language comprehension to express themselves adequately in terms of the questions asked in the investigation. In some cases the explanations were not comprehensible and clear. This was evident in the students' oral and written responses to questions raised in the interview and questionnaires. This problem may be explained by the difficulty most learners have in understanding scientific concepts since the teaching and learning of science in most classroom environments take place in a second language. The problem is exacerbated by the lack of the necessary conceptual, logical and linguistic backgrounds of most learners as mentioned earlier.

The investigation revealed the students' recognition of interest and understanding gained after the implementation of the learning module. Though test scores do not give a true reflection of students' performance in a particular topic, the marks obtained by the students in the class test partly give some indication of an improvement in the students' understanding of the selected topic (**see table 4.1.3b**).

In addition, the non-participant observers acknowledged the group and active participation of students in discussions, and the encouragement given to the students to express their own ideas through questions during the presentation of the lessons.

Conclusion

From the findings and deductions raised above, this study suggests that, the use of a constructivist teaching and learning approach to design and implement a learning module on work and heat can be a valuable tool in developing students' better understanding of work and heat as aspects of the energy concept. This was indicative of the progression in the answering patterns and the increase in the number of concepts used by the students after the implementation of the learning module. Learning occurs when there is a change in the learners' existing ideas, either by adding some new information or reorganizing what is already known (Appleton, 1997). This is reinforced by the personal construct psychology that learning is the increase in the number of constructs (Kelly, 1955). In addition the learners acknowledged in a questionnaire the interest and understanding, and the acceptance of the constructivist teaching and learning approach used for the implementation of the lessons. As an extension to this study, future research should look into the assessment of students' practical work on energy.

Implications for teaching

It should be noted that attempts to change students' ideas have not always been as successful as educators had hoped. However having students to understand and control their own learning is a major step in accommodating the ways of thinking of learning, and new teaching and learning strategies. Students need to have real experiences of different phenomena in order to arrive at meaningful and scientifically acceptable conclusions. They should be encouraged to speculate and argue but not just to give correct or incorrect answers. Further, educators should perform task analysis and diagnose students' knowledge to help them build upon their prior knowledge and construct new knowledge.

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APPENDICES: A; B; C.1 & C.2

APPENDIX A: STUDENTS' INTERVIEW SCHEDULE ON ENERGY CONCEPT

INTRODUCTION

You have got your own ideas and understanding of the energy concept. The purpose of this interview is to get some information about these ideas. Please this interview does not form part of your physical science assessment. It forms part of the normal teaching periods aimed at developing your understanding of work and heat as aspects of the energy concept. Be relaxed and express yourself as freely as possible.

Q.1 What do you know about energy?

Q.2 Describe any three examples of energy?

Q.3 A boy slides down an incline plane from the top of a hill. What type of energy changes take place?

Q.4 In your own understanding, describe in terms of energy what happens to a bucketful of ice kept in an open space for a long time?

Q.5 An immersion heater is dipped into a bucketful of water. Describe the boiling process in terms of energy transfer.

Q.6 An electric motor is used to lift a heavy load into a truck. What type of energy changes take place?

APPENDIX B: A SAMPLE OF A LEARNING MODULE ON WORK AND HEAT

LESSON ONE

INTRODUCTION:

You have got your own understanding of the concept Energy. Please answer the questions provided below. The aim of the questions is to get some information on your understanding of the Energy Concept.

1. Describe the meaning of the word energy.

2. Write down your first three associations with the word Energy.

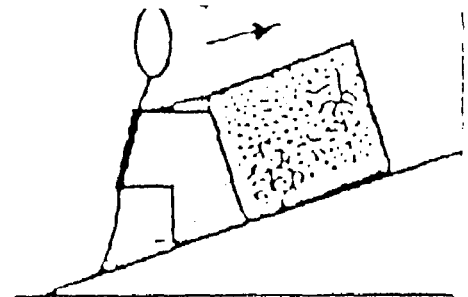
3. Write down three examples of the word Energy.

4. How do plants get their energy?

5. How do animals get their energy?

6. What are the main sources of energy available to South Africa?

7. In the diagram a boy pushes a box up a hill.

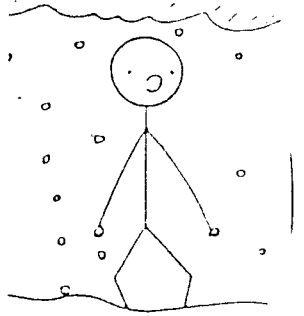


7.1. Is there any energy change? -----

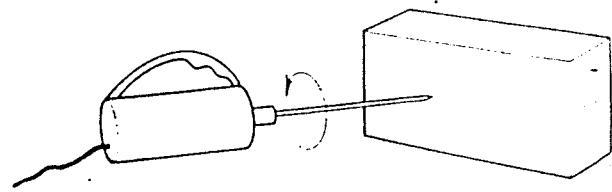
7.2. Describe the energy changes if any.

8. Look at the drawing below. It demonstrates a man trapped in a melting snow.

8.1. Describe the energy changes if any.



9. The diagram below shows an electric drill used by a mechanic to drill holes in a piece of wood. Describe the energy changes that take place.



10. A transistor radio will not work because the dry cells(battery) are 'flat'.

10.1. Is energy lost, gained or transferred?

10.2. Describe the energy changes.

11. What forms of energy are found in the following examples?

Item	Form of energy
(a). Coal	-----
(b). A rotating flywheel	-----
(c). Burnt petrol	-----
(d). A piece of bread	-----

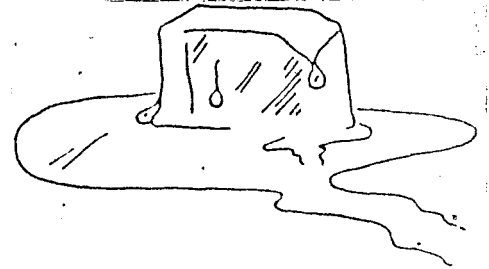
LESSON TWO

FURTHER EXPLORATION ON ENERGY CONCEPT

The lesson contains some graphical demonstrations on some aspects of the Energy concept. Study each activity carefully and provide answers according to your understanding. The aim of this activity is to further explore your understanding of the energy concept.

Demonstration 1

The diagram shows a melting ice:



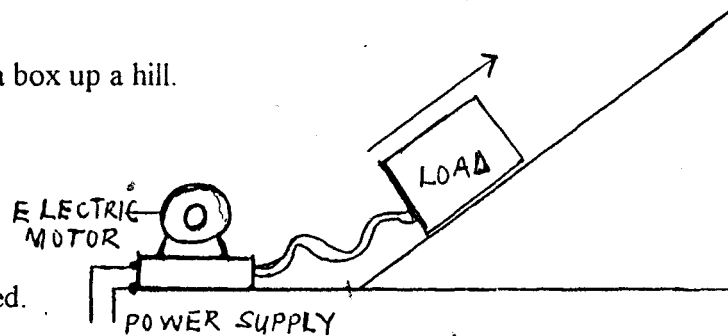
(a). Is there any energy change here? -----

(b). Describe the energy changes if any?

Demonstration 2

The diagram shows an electric motor pushing a box up a hill.

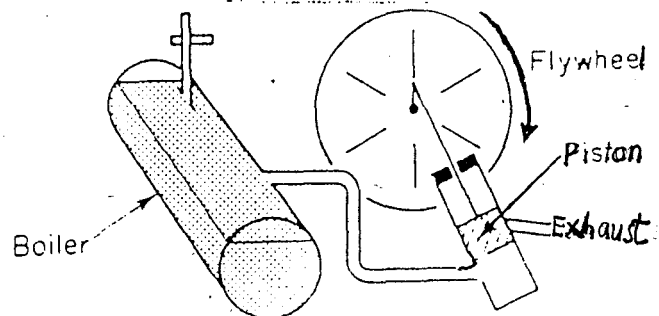
(a). Is there any energy change here?



(b). Briefly explain the energy changes involved.

Demonstration 3

Look carefully at the diagram below. It shows a model coal-fired steam engine.



(a). Describe the energy changes that take place.

Demonstration 4

The car shown below is filled with petrol. If it begins to move and covers a distance of 50 kilometres.

(a). Are there any energy changes?

(b). Describe the energy changes if any.



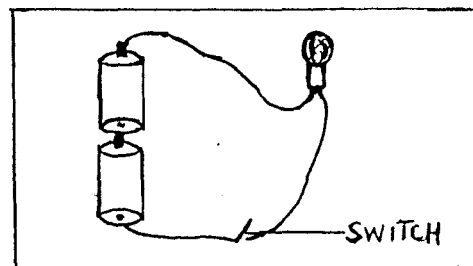
Demonstration 5

Look at the drawing. If the switch is closed.

(a). What happens to the bulb?

(b). What is the main source of energy for the bulb?

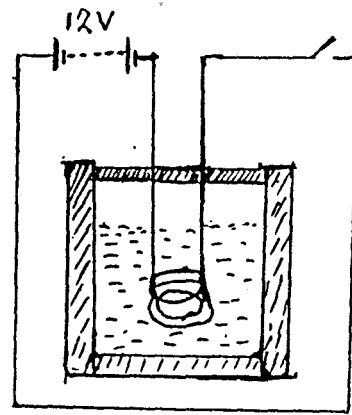
(c). Give a brief description of the energy changes that take place in the circuit.



Demonstration 6

The diagram below shows a heating coil immersed into a calorimeter filled with water.

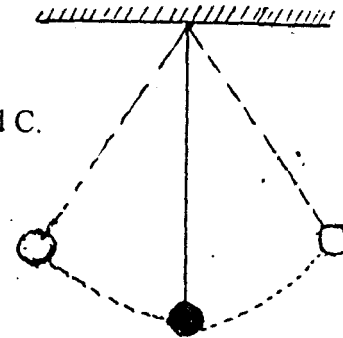
(a). What is the source of energy supply?



 (b). Briefly explain the energy changes that are involved in this process.

Demonstration 7

The simple pendulum shown, swings from point A through point B to C.



(a). Describe the types of energy possessed by the bob at the points A, B and C.

Focus Question 1

Describe the properties concerning energy that are common to man, the electric motor and steam engine.

LESSON THREE
LEARNING ABOUT WORK ENERGY

Introduction: The activities in this lesson unit will help you to develop your understanding of work as a form of energy. Give your own explanations to the questions asked in the different activities. Your responses will be compared with the explanations during the class discussion.

Work done by a constant force: The work done on an object by a constant force is the energy transferred by the application of a force along the line of action. It is defined as the product of the magnitude of the displacement times the component of the force parallel to the displacement. The unit of work is the **Joule**: if a force of 1 Newton moves its point of application by 1 metre along the line of action of the force.

$$W = F_{\parallel}d$$

In general $W = Fd\cos\theta$

W = work done

F_{\parallel} = constant force parallel to the displacement

d = net displacement

θ = angle between the direction of force and displacement.

Activity 1

Give your explanation to the following questions in the spaces provided:

Question 1

Given that $W = Fd\cos\theta$.

- (a) When is the work done by an applied force a maximum? Explain.

Question 2

A girl carries a box of tools on the head.

- (a) If the girl remains at rest, why is it that the work done by the upward force on the books is zero?

- (b) If the girl carries the books and walks horizontally across the surface of the floor at a constant velocity, give in terms of $W = Fd\cos\theta$ with reasons the magnitude of the work done.

Question 3

A boy pulls a heavy box along a plane inclined to the horizontal surface. Is the work done against the force of gravity to lift the box vertically upwards equal to, less than or greater than the work done to move the object along the inclined plane? Explain.

Question 4

The earth exerts a gravitational force on the moon. If the moon travels a certain distance each time it orbits the earth. What is the magnitude of the work done by the earth on the moon?

Activity 2

Look at the set up and weigh the dynamic trolleys provided. Push the trolley through a displacement of 10m.

(a). Draw a diagram indicating the forces that act on the trolley.

(b). What happens to the trolley after some time? Explain your observation.

(c). Put the second trolley on top of the first one and push the unit with the same displacement of 10m. What can you say about the work done on the trolleys if the force applied in both cases were the same.

Activity 3

Look at the set up and incline the wooden board at some angle to the surface of the laboratory floor. By means of the rope attached to the box, pull the box to the top of the table.

(a). Draw the incline plane and indicate the direction of the frictional force, the force of gravity and the pulling force.

(b). Why is the work done by the frictional force negative in magnitude?

(c). If the wooden box is inclined to the surface of the laboratory at an angle of θ . Write expressions to represent the vertical and horizontal components of the force of gravity if the acceleration due to gravity is g .

(d). Why is the magnitude of the vertical component of the force of gravity equal to zero?

Question 5

A piano of mass 3kg slides 4m down a rough plane inclined at 30° to the horizontal. If the coefficient of friction is 0.25.

(i). Determine the work done by the normal force on the piano.

(b). What is the work done on the piano by the force of gravity?

Work done by a variable Force

When a Force varies in magnitude or direction, the work done by the force is determined by the path over which the point of application of the force moves as a series of small displacements eg. the movement of a rocket against the force of gravity, the stretch of an elastic spring and a chest expander.

If a particle moves through a displacement from a point x_1 to x_2 .

$$\text{Work done} = \int |F| dx$$

F = the variable force
dx = the small change in displacement.

Example one

A particle is moved through a displacement of 5m along a smooth horizontal surface by a force of magnitude $F = (8 - X/2)$ N. If X m is the displacement of the particle from the initial position. Determine the work done by the force.

Solution

If the force acts along the direction of motion:

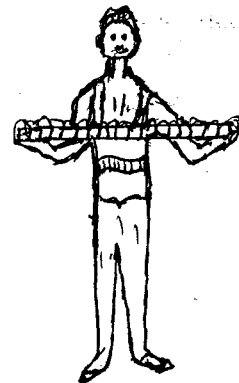
$$W = \int |F| dx$$

$$\begin{aligned} W &= \int_0^5 (8 - x/2) dx \\ &= (8x - x^2/4) \Big|_0^5 = (8 \times 5) - 1/4 \\ &= 33, 75 \text{ Joules.} \end{aligned}$$

Activity 4

Stretch the chest expander as shown by the picture.

(a). What happens?



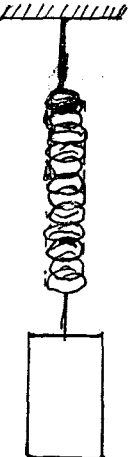
(b). Why did this happen?

(c) What makes the spring to return to its original position after the stretch?

Activity 5

The diagram below shows a spiral spring with a load attached to the end. Set up the apparatus provided as shown in this picture.

(a). Draw a diagram of the set up and indicate all the forces available when the load is attached to the end of the spiral spring



(b). What happens to the spring when the load is attached?

(c). How would you estimate the work done by the force of the load on the spring?

Work-Energy Theorem

Consider a particle of mass m moving uniformly along a straight line.

If the mass of particle = m
initial velocity = v_1
final velocity = v_2
acceleration = a

From Newtons second law of motion,

$$F = ma$$

$$\text{Work done} = Fd = mad$$
$$= mad$$

$$= m \frac{(V^2 - v^2)d}{2d}$$

$$= \frac{1}{2} mv^2 - mv^2$$

$$= \frac{1}{2} mv^2$$

The net work done by the force on the dynamic trolley is converted to translational Kinetic Energy

Question 6

If the net work done on an object is equal to a change in kinetic energy.

6.1. What happens to the kinetic energy if:

(a). the work done is doubled?

(b). the speed of the object is doubled?

Question 7

How much work is required to accelerate a 1000kg mass from a speed of 20m/s to 30m/s?

Question 8

A body of mass 15g slides from rest down a smooth slide of length 4m inclined at 30° to the horizontal.

(a). Determine the loss of potential energy and gain in kinetic energy of the body.

(b). Estimate the work done by the object at the foot of the slide.

Power

The concept of Power is applied to any machine which does work in converting energy from one form to another. The unit of Power is J/S (Watt).

1 kW = 1 kilowatt = 1000 watts

Note: the former unit of power is Horsepower

1 Horsepower = 746W.

Activity 6

Find the typical values for the power ratings of the following items found in the laboratory:

Item	Power rating	Work done per second
(a). an electric kettle	-----	-----
(b). electric iron	-----	-----
(c). microwave oven	-----	-----
(d). television set	-----	-----

Activity 7

Use the bathroom scale to measure your mass. Ask one member in your group to record the time while you run the stairs that lead to the administration block of the college. Count the number of steps and measure the height.

(a). What is the power developed?

(b). Why is the power developed an approximate value?

(c). What factors have been overlooked in determining the power developed?

Question 9

A car engine is rated at 7460W. If the car of mass 1200kg climbs a hill inclined at 30° to the horizontal at a steady speed. The car travels 600m and the resistance to the motion of the car is 800N.

(a). What is the resultant force on the car?

(b). Determine the net work done by the force of the car's engine.

(c). Determine the time used by the car to travel the distance of 600m with the same engine power.

LESSON FOUR

EXERCISE ON WORK

Introduction: This lesson is made up of questions set to develop and extend your ideas on the concept of work through calculations and some explanations. Use your knowledge acquired from the class discussions on the concept of work to answer the following questions:

1. A net force acts on a moving object. Explain in each case the following:

(a) In what situation is work done?

(b) In what situation is no work done?

2. A hammer with a 1kg head is used to drive a nail into a wooden board. If the hammer is moving at 15ms^{-1} when it strikes the nail and the nail moves 1cm into the board.

(a) Is work done or not? Explain.

(b) Find the average force the hammer exerts on the nail.

(c) Describe the energy changes involved in the process.

3. If the population of South Africa in 1998 was estimated at 38 million and about 2×10^{20} Joules of work was performed under human control.

(a) Determine the average power consumption per person in Watts ($1 \text{ year} = 3,15 \times 10^7 \text{ s}$).

4. Coal is transported by a horizontal conveyor belt at a rate of 30 kg s^{-1} when the belt moves at a steady speed of $1,8 \text{ ms}^{-1}$.

Calculate:

(a) The force needed to keep the belt moving.

(b) The kinetic energy per second gained by the the coal falling onto the the belt.

(c) The power required to keep the belt moving at $1,8 \text{ ms}^{-1}$.

(d) Explain why the answer in (b) differs from that of (c).

(5) A boy uses a rope and the pulley system to raise a 20kg box to a height of 5m. If he exerts a force of 700N on the rope and pulls a total of 20m of the rope through the pulley.
(a) make a drawing to demonstrate the task undertaken by the boy.

(c) How much work does the boy perform.

(d) What is the magnitude of the potential energy exerted on the box?

(e) If the answers in (b) and (c) differ . What do you think is the problem?

(6). A nuclear power plant operates at a level of 100 megawatts per day. How much mass is converted into energy per day?

7. A boy pulls a box of mass 75kg along a wooden plank inclined at an angle of 25° to the horizontal. If the boy covers a distance of 15m along the plane:

(a) Does the work done by the boy on the box depend on the angle of the hill or change in elevation? Explain your choice of answer.

(b) Make a drawing to illustrate the the process above and indicate all the forces acting on the box by using arrows to indicate the direction of each force.

(a) Calculate the pulling force and frictional force acting on the box.

LESSON FIVE

LEARNING ABOUT HEAT

Introduction: You have already expressed your ideas on the concept of energy in the previous discussions. This lesson is meant to get some information about your understanding of some aspect of energy: the concept of **Heat**.

Activity 1:

Answer the following questions according to your understanding:

Question 1

What do you understand by the term heat?

Question 2

Heat and temperature are two different concepts. Describe the main differences between the two concepts.

Question 3

A mixture of ice and water is heated on a bunsen burner.

- (a) Does the temperature of the mixture before the ice starts to melt remain at 0°C , less than zero or greater than zero?

- (b) Why does this happen?

Question 4

The same amount of energy (heat) is supplied to different quantities of water in separate containers of the same size.

(a) Are the changes in temperature the same or different for both?

(b) Why does this happen?

Question 5

A 25g mass of copper rod is heated and the temperature rises.

(a) Is more heat, less or the same amount needed to heat a 50g mass of the same metal?

(c) Explain your choice of answer to question (a).

Question 6

If a wooden light post and a metal rail are touched in a cold day, the rail seems considerably colder than the wooden post though both may be at the same temperature.

(a) Why does this happen?

Question 7

Air is a poorer conductor of heat than wood.

(a) Why is saw dust used for insulation purposes in some houses?

Question 8

Glass is a poor conductor of heat. It cracks when hot water is poured into it.

(a) Why does this happen?

Question 9

When a piece of iron is bent, the temperature of the rod increases.

(a) Why does this happen?

Question 10

The average kinetic energy of gas molecules tends to increase more than a given mass of a metal with an increase in temperature.

(a) How do you explain the difference in kinetic energy of the two substances?

Question 11

Aluminium is a good conductor of heat but aluminium foils are often used for the insulation of houses.

(a) Explain why the aluminium foil is used for the insulation of houses.

LESSON 6

REINFORCING UNDERSTANDING OF HEAT

Introduction: You are given some task-based activities in this lesson unit. Perform the various tasks assigned to you. The purpose of the activities is to reinforce your understanding of heat as a process of energy transfer.

Activity 1

Hold the ice cube in your hand.

(a). What do you notice?

(b). Why?

Activity 2

Heat the mixture of ice cubes and water in the beaker with the bunsen flame until the ice begins to melt. Measure the temperature of the mixture.

(i)

(a) Is there an increase, decrease or no change in temperature?

(b) Explain your observation.

(ii) Heat the mixture until it starts to boil.

(a) Measure and record the temperature of the boiling water with the thermometer.

(iii) Continue to heat the boiling water for another 2 minutes.

(a) Measure and record the temperature.

(b) Are the temperatures in (ii) and (iii) the same or different?

Activity 3

You are provided with the following items on the laboratory bench: copper rod, wooden ladle and cotton wool. Touch the different items in turn.

(a). Which substance is the coldest?

(b). Are the temperatures of the different items the same or different? Explain.

Activity 4

Rub your hands on the laboratory bench.

(a). How do you feel?

(b). Why does this happen?

Discussion:

1. Distinction between Temperature, Heat and Internal Energy.

Temperature is the measure of the degree of coldness or hotness of a body. Temperature measures the average kinetic energy of molecules in a system. The unit of measurement is degree Celsius ($^{\circ}\text{C}$) or Kelvin (K).

Internal energy refers to the total energy of all particles in an object: the sum of the random kinetic energy and electrical potential of the particles.

Heat refers to a transfer of energy from one object to another as a result of a temperature difference. The direction of heat flow from an object depends on the temperature but not on the internal energy. The converse is not always true e.g. a body at melting or boiling point. There is the flow of heat energy but temperature does not rise. Heat transfer alone does not determine a change in temperature as some amount of the energy transferred may cause a change of state of the substance.

Example 1

If a beaker of cold water is placed on a hot stove, the fast moving molecules of the hot object collide with the slow moving molecules of the cold object (water molecules). The speed of the fast moving molecules is slowed down and there is increase in the speed of the slow moving molecules. Heat energy is transferred to the cold object in the process.

Change of state

A substance changes in physical state or phase when energy is transferred to or transferred from it. The energy involved in the process is known as **Latent Heat** ('hidden heat'):

- (a) Solid to liquid (melting): latent heat of fusion;
- (b) Liquid to vapour: latent heat of vaporization;

In other situations, solids change directly to the vapour state without passing through the intermediate liquid state e.g. heating of iodine crystals. This process is known as sublimation)

Question 1

If a wooden post and a railway track are touched outdoors separately in a cold day, the rail seems colder than the wooden post though the two may have the same temperature.

- (a). How would you explain this observation.

Question 2

A known quantity of water was changed to vapour. If the same quantity of vapour is changed to the liquid state, will the latent heat be the same or different from that involved in changing water to the vapour state? Explain.

Question 3

A boy puts some potatoes into boiling water.

- (a) If the flame of the gas stove is turned up. Would the potatoes cook faster or slower? Explain.

- (b) If the boy had used a pressure cooker. Would the potatoes cook faster or slower? Explain.

Example 3

5 Kg of water at 40°C is poured on a large block of ice at 0°C. How much ice melts?

Solution 3

Heat lost by water = Heat gained by ice.

$$M_w C_w \Delta T = M_{ice} L_{ice}$$

$$5 \text{ Kg} \times 4200 \text{ J. Kg}^{-1} \cdot \text{C}^{-1} \times (40 - 0)^\circ\text{C} = M \times 3,33 \times 10^5 \text{ J.Kg}^{-1}.$$

$$\begin{aligned} \text{Mass} &= \frac{840000 \times 10^{-5} \text{ kg.}}{3,33} \\ &= 2, 52 \text{ kg} \end{aligned}$$

Activity 5

Measure about 200 cm³ and 400 cm³ cold water into separate beakers of the same size. Heat the contents of the two beakers with the same source of energy from the bunsen burner.

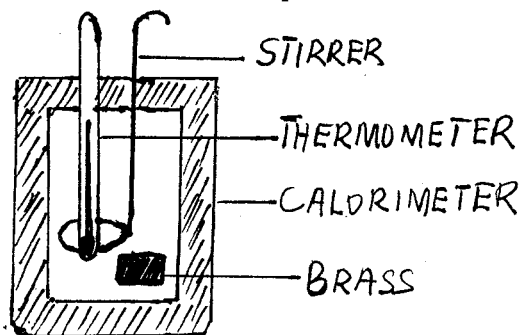
(a). Use the thermometer to measure the temperature of water in the two vessels in turn after 5 minutes and record your answer.

(b). Is there any difference in temperature?

(c). If yes explain why the difference in temperature happens?

Activity 6

Weigh the brass rod provided and measure the temperature T₁ of about 200cm³ of cold water. By means of a thread put the brass rod into boiling water for about 10 minutes and record the temperature T₂. Take out the brass rod by means of the thread and put it into the cold water in the calorimeter as shown. Stir the mixture and record the equilibrium temperature T₃.



Calorimetry

It is the process that leads to the quantitative measurement of heat exchange. A calorimeter is the insulated vessel for the heat exchange.

Heat capacity: The energy required to produce a unit temperature rise in a unit mass of a substance or the heat energy required to increase the temperature of a substance by 1 K.

Units: $J.K^{-1}$

Specific Heat Capacity

The energy required to increase the temperature of 1 kg of a material by 1 K.

Units: $J.Kg^{-1}.K^{-1}$.

Heat transferred Q: (mass)(specific heat capacity)(temperature change).

$$Q = MC\Delta T$$

M = mass

C = specific heat capacity

ΔT = temperature change

Example 1

How much heat should be transferred to 3 kg of water to raise the temperature from 20°C to 80°C?

Solution 1

Heat transferred, $Q = M_w C_w \Delta T$

$$= 3 \text{ Kg} \times 4200 \text{ J.Kg}^{-1}.\text{C}^{-1} \times (80 - 60)^\circ\text{C}$$

$$= 2,52 \times 10^5 \text{ J}$$

Example 2

In order to raise the temperature of 5 kg of water from 20°C to 30°C, 2 kg of iron is heated and dropped into water.

(a) What should the temperature of the iron bar be?

Solution 2

From the law of conservation of energy:

Heat loss by iron = Heat gained by water

$$MC_w\Delta T_w = M_{Fe} C_{Fe} \Delta T_{Fe}$$

$$5 \text{ kg} \times 4200 \text{ J.Kg}^{-1}.\text{C}^{-1} \times (30 - 20)^\circ\text{C} = 2 \text{ kg} \times 460 \text{ J/kg.} (T - 30)^\circ\text{C}$$

$$= 311^\circ\text{C}$$

(a) What substance was the source of heat transfer?

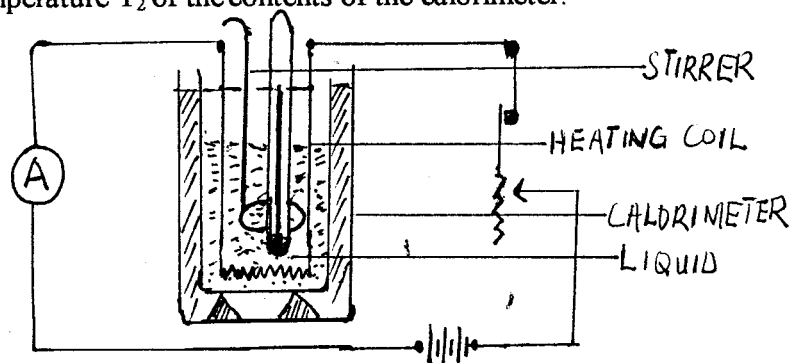
(b) What were the main sources of heat loss?

(c) Suggest some possible methods to control the heat loss?

(d) If the specific heat capacities of water and the calorimeter are $4200 \text{ J.Kg}^{-1}.\text{C}^{-1}$ and $400 \text{ J.Kg}^{-1}.\text{C}^{-1}$ respectively. Determine the specific heat capacity of brass.

Activity 7

Measure the temperature T_1 and mass M_w of about 150cm^3 of cold water. Measure the mass of the empty calorimeter M_c with a known specific heat capacity C_c . Set up the apparatus as shown by connecting the voltmeter, ammeter and the rheostat. Set the rheostat to measure a constant current. Switch on the current for about 10 minutes. Switch off the current and measure the temperature T_2 of the contents of the calorimeter.



(a) Determine the electrical energy transferred to the water and the calorimeter if :

$$E = IVt$$

I = current

V = voltage

t = time

(b) Will the electrical energy supplied be equal to, lesser than or greater than the heat energy transferred to the calorimeter and water? Explain.

(c) If the electrical energy supplied is equal to the heat energy transferred to the contents of the calorimeter, use the relation below to determine the specific heat capacity of the liquid (take the specific heat capacity of the calorimeter to be $390 \text{ J.Kg}^{-1}\text{K}^{-1}$).

$$IVt = M_w C_w(T_2 - T_1) + M_c C_c(T_2 - T_1).$$

Questions

1. A 30g ice cube at 0°C dropped into 200g of water at 30°C . What is the final temperature?

2. A 20 kg mass of water has a higher heat capacity than the same mass of iron.
(a) Why does this happen? Explain.

3. When 220g of a substance is heated to 330°C and dropped into a 100g Aluminium calorimeter cup containing 150g of water at $12,5^\circ\text{C}$, the final temperature registered by the by a 17g glass thermometer is $33,8^\circ\text{C}$. Calculate the specific heat capacity of the substance.

4. When a match is struck, the temperature of the head of the matchstick increases. It is explained that the high temperature causes a chemical reaction to start. A student responded: ' the temperature of the head of the matchstick goes up when you strike due to the flow of heat from the matchbox to the head'.

(a) Is this statement correct or incorrect? Explain carefully.

LESSON SEVEN

METHODS OF HEAT TRANSFER

Introduction: You have learnt some aspects of measuring heat exchange in the previous lesson. There are some experimental activities in this unit. Perform the tasks involved in the various activities and answer the questions according to your own understanding. The aim of this unit is to extend your ideas on the methods of heat transfer.

There are three methods by which heat is transferred: **conduction, convection and radiation.**

Conduction: Heat energy is transferred by means of collisions between rapidly moving particles e.g. atoms and molecules at the hot end of a body of matter and the slow moving particles at the cold end. Some kinetic energy gained from the temperature increase of the fast moving particles is transferred to the slow moving particles. The successive collisions result in a flow of heat energy through an object. Conduction takes place in solids, liquids and gases.

Convection: A volume of hot fluid rises to displace cold fluid. The hot fluid at the bottom expands slightly. The density of the expanded molecules decreases and the buoyancy of the molecules cause them to rise to the surface. Colder and denser molecules descend to take the place at the bottom. The process continues until the volume of fluid e.g. water acquires a uniform distribution of heat energy.

Radiation: All objects emit thermal radiation. Radiation consists of electromagnetic waves with wide range of wavelengths e.g. infra-red, x-rays, radio waves. This process does not require any material medium for the passage of heat energy. The higher the temperature of an object, the greater the rate at which energy is radiated.

Question 1

A given quantity of a solid conducts more heat than equivalent quantities of liquids and gases.

(a) Why does this happen? Explain.

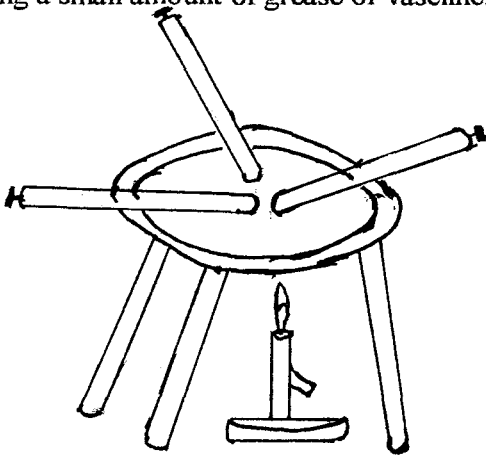
Question 2

If all objects radiate electromagnetic radiation, why do objects around us in everyday life not become colder and colder?

Activity 1

Use the metals (iron, copper, aluminium) rods of equal lengths and diameter provided.

- (i) Place the rods in the tripod stand as shown by means of the strings.
- (ii) Stick a tack at the end of each rod by using a small amount of grease or vaseline.
- (iii) Light the burner to heat the rods.



(a) Why do the tacks fall off the rods?

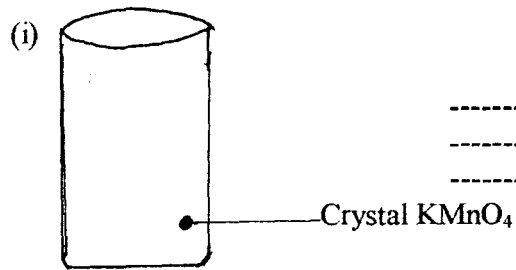
(b) Which of the metal rods is the best conductor of heat? Explain.

(c) Suggest with explanations any methods of heat transfer that are available in activity one.

Activity 2

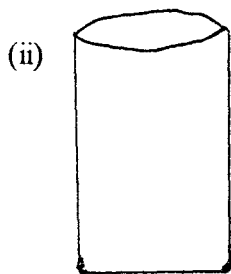
Fill a beaker with some quantity of tap water and place it on the tripod stand. By means of a glass rod, drop a crystal of potassium permanganate ($KMnO_4$) to the bottom of the beaker. Put on the bunsen burner to heat the contents of the beaker.

(a) Make drawings to illustrate your observation and draw your own conclusions:

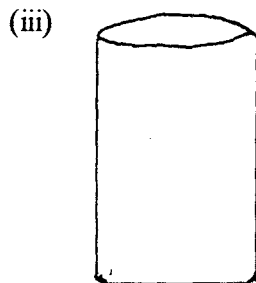


Initial

Conclusions



After 2 minutes

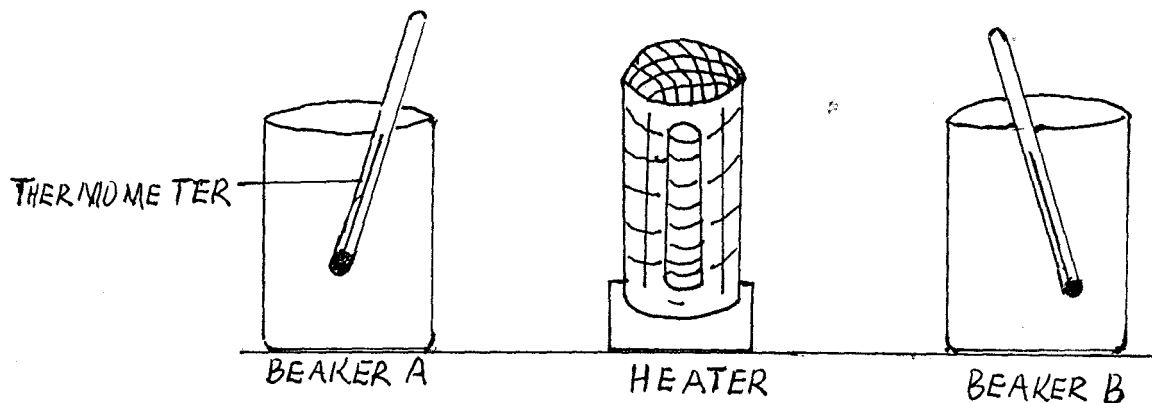


Later

(b) Describe with reasons the method of heat transfer demonstrated by activity two.

Activity 3

You are provided with two beakers of equal size. Cover one of them with the aluminium foil (Beaker A) and darken the other with the black paint (Beaker B). Fill the two beakers with equal volumes of water and place them at equal distance from the heater as shown.



(a) Complete the table below:

TEMPERATURE	BEAKER A	BEAKER B
Initial temperature (T_1)		
Temperature after 2 minutes (T_2)		
Temperature after 5 minutes (T_3)		
Change in temperature ($T_3 - T_1$)		

(b) How would you compare the heat absorbing and emitting powers of the two beakers?

(c) If the heater is switched off, which beaker will cool down faster initially? Explain.

Relation between Heat transferred, Work done and Change in Internal Energy

Heat transferred (Q) and Work done on a system (W) are processes of energy transfer that take place on a system e.g. a pump, reaction vessel or calorimeter to produce changes in properties. Heat energy transferred is equal to the difference between the change in internal energy (ΔE) and the work done (W) on the system. From the law of conservation of energy, both processes are related to the change in internal energy by the First law of thermodynamics:

$$\Delta E = Q + W$$

ΔE = Change in internal energy

Q = Heat transferred

W = Work done

Example 1

Consider an electric heater immersed in a bath of boiling water at 100°C . The temperature of the heater will remain constant with respect to time and so does the internal energy. (if the heater is taken as the system).

Energy change:

Work done (W) by electric charge on heater (IVt) = Heat released (Q) by the heater

$$W = IVt$$

$$Q = - IVt$$

$$\Delta E = Q + W$$

$$= 0$$

Conclusion: Energy goes into the system as work done and goes out as heat. There is no internal energy: $\Delta E = 0$, there is heat flow $Q \neq 0$.

QUESTIONS

1. You are to share your experience gained from the methods of heat transfer with a local builder who intends to erect a structure for accommodation. Describe how you would advise him on house insulation.
2. Air is a poorer conductor of heat than wood. Explain why sawdust is used as insulation for ice houses?
3. Lengths of aluminium foil are used for house insulation yet aluminium is a good conductor of heat. Explain.
4. Snow melts more rapidly after it has become dirty than when clean. Explain.
5. Water is heated in a kettle over an electric heating coil. Describe all the processes of heat transfer involved.
6. For a maximum efficiency of an electric tea kettle:
 - (a) Should the sides of the kettle be shiny or darkened? Explain.
 - (b) Should the bottom of the kettle be shiny or darkened? Explain.

APPENDIX C.1

STUDENTS' QUESTIONNAIRE FOR THE EVALUATION OF LEARNING MODULE

You have gone through the lessons found in the learning module. The purpose of this questionnaire is to get your impression about the implementation of the learning module.

Please indicate by a tick (✓) or express your opinion where appropriate for each question.

1. Was the learning module well structured, organised and contained up-to-date information?

- Very well ()
- To some extent ()
- Not particularly ()

2. Did the language level of the learning module encourage your understanding?

- Certainly ()
- Almost ()
- Not at all ()

3. Was the content of the learning module legible and illustrations readable?

- Very well ()
- To some extent ()
- Not particularly ()

4. Did the content of the learning module contain a variety of activities?

- Very well ()
- Moderately ()
- A little ()
- Not at all ()

5. Did the learning module contain information that encourage active learning and support critical thinking?

- Quite well ()
- To some extent ()
- Not particularly ()

6. Did the learning module afford the opportunity for self-activity and independent thinking?

- Very well ()
- A little ()

Not at all ()

7. Did the learning module acknowledge your prior learning experience?

Yes () No ()

8. Which of the following classroom activities were available in the lessons?
(You may tick more than one activity)

Teacher's demonstration ()

Individual activity ()

Group activity ()

Cooperative learning ()

Others(specify) -----

9. How did you find the laboratory tasks assigned to you?

Very easy to follow ()

Moderately ()

Difficult ()

10. How did you find the teaching and learning approaches?

Very appropriate ()

A little appropriate ()

Not appropriate ()

11. What is your impression about the instructional strategies?

12. Which of the lessons did you understand the most?

13. Which of the lesson(s) was least understood?

14. What skills have you learnt from the learning module?

15. What is your impression about your involvement and the role played by you during the lessons?

16. How did you find the contributions made by your colleagues during the lessons?

- Quite supportive ()
- A little motivating ()
- Discouraging ()

17. To what extent did you notice lecturer intrusion in the presentation of the lessons?

- Too much ()
- Just a little ()
- Not particularly ()

18. How would you compare the teaching and learning approach used for the lessons with the previous traditional method of approach?

19. Based on your experience gained from the lessons, what suggestions would you make for future lessons?

APPENDIX C.2: STUDENTS' ASSESSMENT: A CLASS TEST ON WORK AND HEAT

Instructions: Answer all questions:

Time: 45 minutes

Marks: 40

2.1 An electric drill can be used to make holes in a piece of wood. Describe all the energy changes that take place. (6)

2.2 A metal and a plastic cup have been standing on a table in the laboratory for a long time. The two cups are both empty. When the cups are touched in turn, the metal cup feels colder than the plastic cup.

2.2.1 Are the temperatures of the two objects the same or different? Explain your answer. (4)

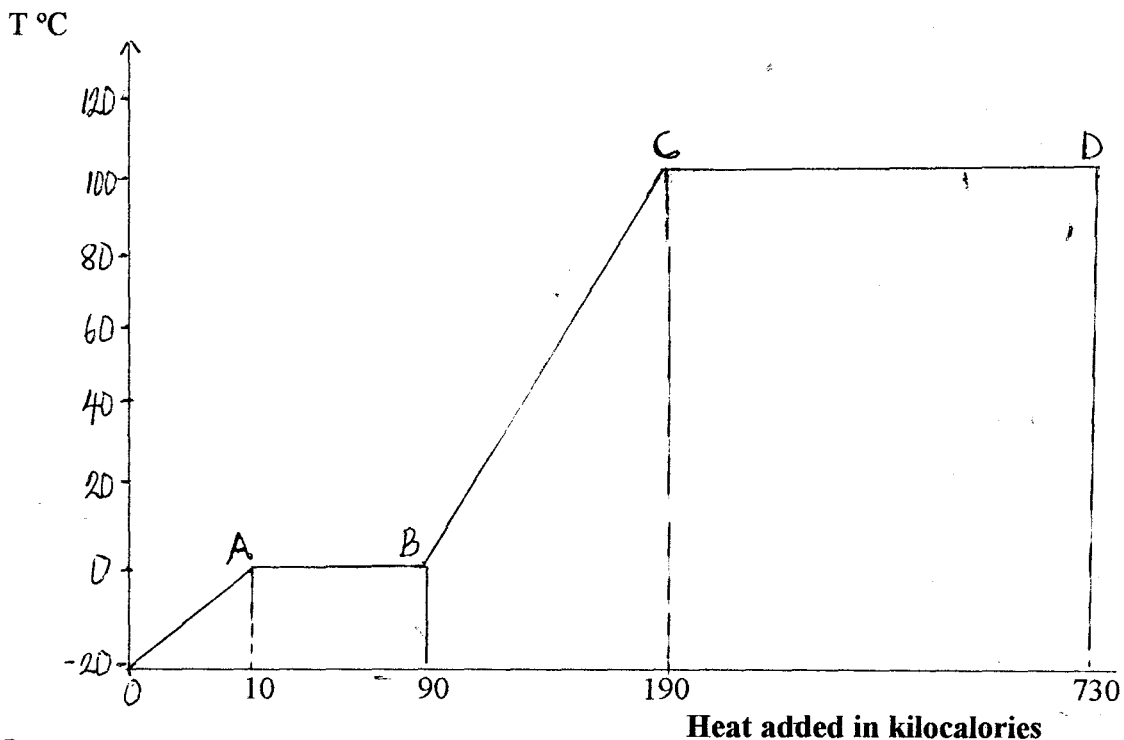
2.2.2 Why do the cups feel different to the touch? (4)

2.3 Two aluminium beakers of equal size contain equal volumes of water. The beakers are placed at equal distances from an electric heater. One of the beakers is painted matt black and the other is given a shiny silver surface. If a thermometer is placed into each:

2.3.1 Discuss the methods of heat transfer present in the experiment. (9)

2.3.2 Which of the two beakers cools faster if the source of heat is removed? Briefly explained. (5)

2.4 A mass of 1 kg ice is heated from a temperature of -20°C to $+120^{\circ}\text{C}$ at standard atmospheric pressure. Below is the graphical representation of the process:



2.4.1 Describe the processes that take place at the portions labelled OA, BC, CD (9).

2.4.2 Suggest a name for the temperature corresponding to the portion labelled CD (3)

RHODES UNIVERSITY

DEPARTMENT OF EDUCATION

RESEARCH PROJECT THREE

TITLE: A College in transition: A case study of the readiness of a college in the Eastern Cape province to implement Outcomes-Based Education in an Education Development Centre

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CHAPTER ONE

1 Introduction

Across the globe, education systems are undergoing reforms in order to be relevant to the lives of people. As Hartshorne (1985) writes, education does not exist in vacuum but in a particular social, economic, political, and (now in South Africa) constitutional contexts. A curriculum is perceived to be at the heart of the educational enterprise. In this way, curriculum reflects the views, interests and values of the stakeholders that are involved in the planning. In addition, any educational policy reflects a country's political options, its traditions and conceptions of the future (Haure, 1972 as cited in Hartshorne, 1985).

Further, Taylor (1999) mentions that a curriculum framework sets out the intentions of policy makers. Indeed, Vermeulen (1997) notes that a curriculum should take account of all the realities of the situation for which it is intended. As such the previous South African curricula perpetuated race, class, gender and ethnic divisions and ...emphasised separateness rather than common citizenship and nationhood (Department of Education, 1997). A curriculum is drawn up by a particular group of people and reflects particular points of view (NEPI, 1992). According to van Harmelen (1999a), the traditional behaviourist teaching and learning approach was and is still the dominant theory of education in most South African schools. Bellis (1997) refers to the traditional practice as a pedagogic approach characterised by both subject-centredness in curriculum and syllabus, and content-centredness in the delivery of the syllabus.

Consequently, the education system created a situation where educators and educator trainers were told what, how and when to teach through the medium of the syllabus in a bureaucratic education department that excluded them from decision-making (NEPI, 1992). Educators were receivers but not creators of the curriculum (*ibid*). Thus the teacher-centred classroom activities predominated the classrooms that emphasized factual recall and rote learning at the expense of skill and conceptual development. Gultig (1999) refers to a similar situation in teacher education as content overload: the focus on the provision of bits of discrete information without a set of conceptual rules needed to organise information coherently. Given these difficulties, rote learning

became a logical learning strategy (*ibid*). This is reflected in the view of Yager (1991) that the traditional epistemological paradigm is now being turned upside down, yet in most colleges of education, teacher preparation continues as though nothing has happened.

The effect of the above is that there is a widespread dissatisfaction with education in many countries. Many school leavers are found not to possess the skills and competence needed in the workplace to meet the challenges posed by the real world. The relationship between work and learning, between learning and capability, between learning and employability, between qualification and employment are problematic (Bellis, 1997). In South Africa it is not only problematic but demands urgent, sensible discussion, attention, policy making and implementation (*ibid*). This was evident in the De Lange report on education: “ the concept of relevant education is dealt with in terms of the ‘disharmony’ between school products and what the work situation demands and the imbalance between the so-called ‘academic’ and career education in the light of those terms of reference which had to do with economic growth and manpower requirements”(HSRC, 1981: 138).

In support of the above, Mackrory (2000) mentions that the changing world of work has given rise to unpredictable career paths, unemployment and the need for multi-skills. The world needs people who can change, adapt fast and are life-long learners likely to improve their performance (*ibid*).

Consequently, intense demands have been placed on schools to provide the vehicle for achieving quality living (Krugly-Smolska, 1990). As a result many countries have reformed their educational curricula in order to be relevant and Outcomes-Based Education is one example of the innovations adopted by many countries to reform their education for example, Canada and the USA. Thus Curriculum 2005 was the particular version of Outcomes-Based Education adopted by South Africa (Claassen, 1998).

However any attempts at educational reforms can become targets for public criticisms. As Taylor (1999) writes, there is a need for a systematic research programme to investigate the factors required to improve teaching and learning

conditions: teacher training, systemic and institutional context of teaching and learning particularly at the school level, the provision, deployment and use of classroom resources and a change in the curriculum itself. In this way, teacher education which is crucial to the transformation process needs to include measures to increase teacher participation and empowerment through in-service training (INSET). The INSET should not only 'tell' teachers about OBE but should provide the development of skills with regards to classroom management, resource development, new assessment strategies and methodologies (Department of Education and Training, 1997). This poses a challenge to the existing colleges of education in South Africa and calls for the need for a re-direction in the development of teachers possibly the kind of re-education that will address some of the inadequacies of the previous education system.

It is in the light of the above discussion that the researcher decided to investigate the readiness of a college of education in the Eastern Cape province to implement outcomes-based education in a proposed Education Development Centre (INSET). In the literature review, a brief overview of the history of South Africa curriculum, the socio-political and institutional conditions of the college that are likely to influence the implementation of Outcomes-Based Education in INSET has been explored. Finally factors that determine educational reforms followed by the main components and limitations of outcomes-based education will be given.

CHAPTER TWO

THE RESEARCH CONTEXT

2.1 An Overview of the history of South African Curriculum

Buckland (1982: 68) claims:

... the notion of the curriculum as a process rather than a product means that a curriculum cannot be picked and examined but must rather be viewed in a historical perspective in its socio-political context. The relationship of the curriculum to the social structure of which it is a co-producer and product must be seen in terms of an ongoing dialectic.

In short it is clear from the above statement that the roots of a new curriculum should be understood within its historical context. A curriculum is not a 'thing' but embodies social relationships. It is drawn up by a particular group of people and reflects particular points of view (NEPI, 1992). The assumptions about what constitutes valuable knowledge, basic skills and essential learning experiences are socially influenced and contested. Viewed in this way a curriculum cannot be neutral or removed from the patterns of power (*ibid*).

As van Harmelen (1999b: 4) writes, what we teach:

- (i) reflects particular interpretations of what constitutes knowledge,
- (ii) is considered worthwhile and necessary according to the prevailing political, economic, and social conditions of a society at a particular time of that society's history. All of which is dependent on the value system of the philosophy dominant in that society.

Further, Morris (1986) maintains that the primary feature that distinguishes the education systems of many developing countries from that of the west is the extent of centralized control of the system in general and the curriculum in particular. The above views are evident in the education systems of South Africa. The education system that has evolved in South Africa for the past years owes its existence partly to the western traditions and the ruling group ideology of the past government. Historically, apartheid curriculum policies stressed diversity above commonality: a system of different schools for different races, ethnic groups and languages (NEPI, 1992). One of the basic tasks of the education system was to protect and perpetuate

these differences. In spite of the different education departments, the state had a high level of indirect control through financing and a common examination for the blacks that was administered by the former Department of Education and Training (*ibid*).

Moreover, the apartheid education system had its roots in the philosophical underpinnings of the Christian National Education and Fundamental pedagogics. According to van Harmelen (1999a), the behaviourist theory was and is still the dominant theory of education in our schools. As such, the syllabus made no distinction between knowledge and skills, and skills were thought to require no knowledge or understanding (Department of Education and Training, 1997). As Tunmer (1981) asserts, teaching methods were not more than a textbook built painfully and hastily revised when changes were made in the syllabus by the central authority. The textbook writer and the syllabus planner were rarely the same person and there was a mismatch between the two sets of intentions (*ibid*). Indeed the plethora of textbooks, curriculum packages and syllabi conveyed an impression of lack of consensus about priorities, structure, what was central, and what really matters (Millar, 1996). Johnson (1998) writes that assessment was something done to learners at the end of a period of teaching. In support of this view, Wilmot (1999), mentions that assessment in South Africa is still largely influenced by behaviorism and psychometrics and that intelligence is innate, fixed and can be measured and expressed numerically.

In effect teacher education which forms part of the transformation was characterised by curricula with outdated concepts, philosophies and methodologies that did not develop teachers' ability to think critically, problem-solve and to draw a hard divide between theory and practice (COTEP, 1998). Little focus was placed on developing teachers' subject knowledge and understanding of appropriate use of a variety of modes of assessment (*ibid*). Gultig (1999) citing Ryle (1998) writes that the theoretical education of teachers focused on "knowing *that*" or (*about*) rather than "knowing *how*" (and *why*). Teachers, though considered as crucial to the transformation have been recognised as ill-equipped to meet its challenges (Gultig, 1999). Their training was characterised by rote learning and memorisation as logical learning strategies. Morris (1986) indicates that teachers lecture while learners answer narrow questions and transcribe information into exercise books in the majority of

lessons taught. Hinchey (1998) refers to such teachers as somewhat experts in what is known and pass information along to the learners. Further, Claassen (1998) notes that the teacher and the curriculum are the main sources of knowledge while the learner is 'an empty vessel', a passive recipient of predetermined content.

Consequently, learners gain little or no understanding of the subjects taught because the teachers themselves lack that understanding. Most teachers trained in the apartheid Colleges of Education in South Africa did not get adequate training and need to be retrained (Beckmann, 2000 cited in Mboyane, 2000). In this way many countries have reformed their education curricula to be relevant to the needs of society in order to produce learners with applied and integrated competence capable of leading more fulfilled lives and to work productively.

However, Atkin (1998) writes that though there are some common stimuli for change in education curriculum in many countries such as the desire to develop problem-solving skills among students, reforms are driven by somewhat different concerns in different countries. As such different countries resort to somewhat different sets of conditions and perceptions in the reforms and particularly the impetus for the innovations. Each country develops its own strategies for the reforms in education. In this way the reforms in education were part of the transformation process that followed the new political dispensation in South Africa.

Accordingly, the Curriculum Research Group initiated by the National Education Co-ordinating Committee (NECC) laid the foundation document upon which much of the existing 1998 curriculum policy is based (NEPI, 1992). Indeed the first national curriculum initiative was limited to a political intervention in the form of a highly superficial sanitation of apartheid syllabuses as a response to a serious legitimacy crisis in the aftermath of the elections (Jansen, 1998). This was followed by the introduction of the policy of continuous assessment in schools, and a series of White Papers on Education, the most important being the White Paper on Education and Training of 1995 (*ibid*). This served as the most significant document that reflected the ideas of integration and competency as elements of education restructuring ambition in South Africa. Thus curriculum 2005, premised on Outcomes-Based Education emerged out of the 1995 White Paper on Education and Training.

2.2 Brief history of the College

2.2.1 Background

The college, originally a teacher training school was founded in 1978. It has an interesting history since the establishment was linked to the 'creation' of the former Ciskei homeland. The excision of some areas in the province at that time compelled the residents to migrate and settle in a new environment. The parents demanded the establishment of a teacher training college in the locality because they could not afford the cost involved in sending their wards to distant places for teacher education.

The approval for the establishment of a teacher training school came as a relief to the inhabitants of the community. Up to this time, these people had been neglected in terms of socio-economic development. The name given to the college was quite significant and meaningful as it implies literally '**we are thankful**': a sign of gratitude to God and the previous Ciskei homeland government (Head of department, 2000 pers. comm.)

The college was first located in a temporary building now occupied by a high school in the district. It was later relocated to a prefabricated structure at the old site and in 1989 was moved to the permanent building funded by the Anglo-American Company through the Development Bank of South Africa (Rector, 2000 pers. comm.).

2.2.2 Courses Offered

Initially, the college offered a two-year primary teachers' certificate (PTC) course. The entry qualification was a standard eight certificate. The low admission requirement was reflected in the increasing number of students admitted between 1978 and 1982. In 1983, the college was upgraded to offer a 3-year Primary Teachers' Diploma (PTD) and the entry requirement was raised to matric certificate. As a result the student population dropped to one hundred and seven in 1983 as few first year students qualified for admission (see table 4.5a). In 1989 a 3-year Secondary Teachers' Diploma (STD) course for the training of Secondary School Science educators was introduced. In 1998, a two-year part-time course to upgrade teachers previously holding the Primary Teachers' Diploma (PTC) qualifications to PTD level was also introduced. A similar programme used to be offered on full-time basis to upgrade teachers with low qualifications starting from course two.

2.2.3 Student admission and staff population

Student admission policy has changed considerably over the past two decades. In spite of the low entry qualification, student admission was solely in the hands of the college administration between 1978 and 1990 (Rector, 2000 pers. comm.). In the early nineties, the tense political atmosphere of the time resulted in forced admissions by the local civic organisations, and students. For example a record number of over six hundred first year students were admitted in 1991 irrespective of qualifying grades. There was a drastic increase of student population from 560 in 1990 to 1032 in 1991 (see table 4.5a). This has been reflected in the quality of teachers developed and the backlog of students who have written supplementary examinations for the past few years.

However, the advent of the new political dispensation in 1994 has caused a drastic change in the number of students admitted, and the nature of courses run at the college between 1995 and 2000. The change in admission criteria was in line with the government's policy for the rationalisation of colleges. In accordance with the Eastern Cape provincial Education Department policy on student admission at colleges of education, there was no intake of first year students for the year 2000. Only few students registered for courses at the second and third year levels, and the upgrading of teachers on part-time basis in the year 2000. Arrangements were made to transfer the continuing students to the University of Port Elizabeth at the beginning of the year 2001 to complete their course of study following the governments' policy for the incorporation of colleges of education into higher education institutions.

The staff population stood at an average of twenty-three between 1978 and 1988 at the old site under five departments: Languages, Professional subjects, Social sciences, Natural sciences and Practical subjects. The number rose to a record level of sixty-seven in 1994 with the creation of additional departments including English, Afrikaans and Education, the introduction of new subjects, and the increase in student population (see table 4.5a). The management team was composed of eight heads of departments, the vice rector, registrar and rector. The college has a number of lecturers with postgraduate qualifications and a few professional diplomates. The redeployment exercise implemented by the provincial education department in 1998 reduced the staff population to thirty-four including fourteen declared in excess. The

remaining twenty included the rector, one head of department, three senior lecturers and fifteen lecturers. The criteria used for the redeployment exercise that included for example 'Last In First Out' (LIFO) were quite simplistic and overlooked among other factors the experience, subject area and qualifications of the lecturers. Records show that the current rector has headed the college for more than fifteen years and a large percentage of the lecturers have ten or more years of teaching experience at the college. Moreover, the position of the college is not quite certain in view of the inconsistencies on the part of the provincial educational department in terms of policies for the rationalisation of colleges of education.

2.2.4 Governance

Prior to the new political dispensation, the college was run by a committee appointed by the former director of education in the former Ciskei homeland (Rector, 2000 pers. comm.). Until the disestablishment of colleges of education in the Eastern Cape province, the governing body of the college was a democratically elected governing council: rector and representatives from the staff, parents and students. Students played no active role in the administration of the college and this was evident in the number of students' class boycotts and demonstrations at that time.

2.2.5 Curricula trends

The college has gone through at least four different curricula in succession: 1981, 1985, 1990 structures drawn up by the former Department of Education and Training (DET) and the 1995 structure guided by the Committee on Teacher Education Policy (COTEP) document. The first three curricula were based on the traditional school philosophy and authoritarian with the exclusion of the lecturers in the planning and development of the curriculum. The syllabi and instructional practices were built around issues of time and students' custody: students were kept at the college and taught for a certain number of weeks. Lecturers had to carry out instructions from the former DET for the implementation of the syllabus.

Assessment in the old curricula structures was essentially norm-referenced and depended solely on tests and examinations. Promotion to the next class or retention depended on examinations written at the end of the year. Final year students wrote external examinations set and marked by the DET in most subjects. Few subjects were

either internally assessed by the college lecturers or internally assessed by the college lecturers and externally moderated by the Department of Education and Training. In contrast, the current 1995 structure used by the college was drawn up by the lecturers in the various subject areas and appears to be flexible. Thus it seems to emphasize the academic, occupational and professional development in teacher education as stipulated in the COTEP, 1998 document.

Further, the college was affiliated to Rhodes University for the accreditation of qualifications, moderation of syllabi and examinations from 1996 to date. The initial plan for the college to form a cluster with other colleges in the province in 1998 did not materialise. This was partly due to the failure of the cluster to meet the requirements for higher education and the lack of a common understanding among the colleges. The college is among the few colleges earmarked by the Provincial Education task team for the rationalisation of colleges to serve as an Education Development Centre.

2.2.6 Bio-physical Dimension

The college is located in a modern spacious complex building sited on carefully landscaped grounds. The complex contains a modern assembly hall almost similar to an auditorium, the administration block, lecture theatres and partly developed science laboratories. The college can boast of a well-equipped library, micro-teaching rooms, home economics block and a computer laboratory (see figures 2a and 2b), and a stretch of land originally planned for further development projects is used by the biology and geography departments for field studies. In addition, the college has no hostel facility as the actual development plan of the funders was thwarted by the local politics of the time. At present the college facilities have been used by the district education office in the area to organise courses for teachers and sport activities, and by the community for local functions.



Figure 2a: The college administration block and lecture rooms



Figure 2b: The college lecture theatre

2.3 Factors influencing National Curriculum reforms

The inefficiency of the traditional schools to provide for the needs of the learner and society together with the wider social and economic forces has necessitated the need for global reforms in curricula. Many countries including South Africa have adopted curriculum reforms in order to be competitive to meet the challenges posed by the shift from a manufacturing economy to an information technology based economy.

Consequently, the South African economy which was based on agriculture and mining started to become industrialised some years ago. There was the need for skilled labour and this called into question the traditional content-based teaching method and necessitated the need for curriculum reforms. In the South African context, Gultig (1999) argues that the curriculum reform was driven by internal socio-political imperatives that needed to address the apartheid inequalities in education, work opportunities and political power and external economic efficiency imperatives. As such, there was a need to look over our shoulders into the imbalances in education created by the previous system, and the future to provide for the needs of the people. South Africa is linked to the global world economy and it is imperative to produce skilled and productive workforce that can flexibly address the needs of the society and compete globally. This was evident in the educational transformation process initiated by the government after the advent of the new political dispensation in 1994.

In this way, Anderson (1992) writes that curriculum reform is a complex endeavour with many facets including:

- (i) the development of teaching materials;
- (ii) the identification of appropriate instructional approaches;
- (iii) implementation of the process by which these materials will be introduced into practice and sustained;
- (iv) appropriate attention to the social context in which it all occurs, and the full understanding requires that it will be viewed from a multiplicity of perspectives including psychological, socio-cultural, subject matter, philosophical, and economic perspectives. In support of this view, Morris (1986) asserts that curriculum development strategies can usefully be analysed by reference to decision making groups, linkages between superordinate and subordinate groups and the nature of

resources provided. It could be argued that curriculum reforms have social, political and economic dimensions and should take into account the realities of the situations for which they were intended.

In referring to Outcomes-Based Education, Naicker (1999) argues that to move towards a new curriculum, one has to understand the old and new assumptions, theories and practices to avoid repeating the old within the new framework. It is important therefore for any curriculum to have relevance and to enhance the quality of the lives of the learner than to seek salvation in 'more of the same'. This need was expressed in the view of Hartshorne (1985) that education systems are effective when:

- (i) they have the acceptance of the users: learners, parents and the community;
- (ii) they have the involvement and participation of the users in decision about education;
- (iii) the user agrees with the view of man and society that informs the philosophy in which the education system is based.

In support of the above, the planning of any new curriculum should not be based on intuition but should adhere to certain criteria: the results of the previous evaluation of curriculum, needs identified through research, conditions and restrictions identified through a situation analysis (Fraser *et al.*, 1997 cited in Vermeulen, 1997). Moreover in education assuming that the major 'clients' are students, the shift in emphasis amounts to putting most of the responsibility for curriculum design with teachers who know their students, and encourages creative solutions at school level (Malcolm, 1999). In other words the design of curriculum and assessment lies especially with the people on the spot: teachers to suit learners.

Consequently, the curriculum reforms within the South African context were signalled by the March 1995 White Paper on Education and Training based on an integrated education that implies a view of learning which rejects a rigid division between 'academic' and applied 'theory' and 'practice', 'knowledge' and 'skills', 'head' and 'hand' (Department of Education and Training, 1995).

Nonetheless, in spite of the innovations and rich proposals that accompany curriculum reforms, there are always problems from the time of policy making through the

processes used to translate the policy into educational programmes to implementation in the classrooms.

2.4 A Brief Trajectory of Outcomes-Based Education

As mentioned in the earlier discussion, education in many countries is changing to curricula that will address the needs of the learner. One innovation which has been implemented in countries such as Canada, the United States and New Zealand is Outcomes-Based Education (Claassen, 1998). A particular version of Outcomes-Based Education has been adopted in South Africa as the basis of the new curriculum (*ibid*). Among the outcomes approaches, there are significant variations but whether they are called 'National Curriculum' (UK and New Zealand), 'Profiles' (Australia), 'OBE' (USA, Canada, South Africa), or 'National Standards' (USA), they have common features and motivations (Malcolm, 1999: 80). Thus outcomes indicate the ultimate result that is sought from learning. The section that follows outlines the basic tenets of Outcomes-Based Education.

2.4.1 Basic Tenets Underlying Outcomes-Based Education

Outcomes-Based Education is concerned with the outcome of a curriculum from the learners' point of view (Claassen, 1998). It stresses the intended results of learning (what the learner knows and can do) instead of pre-determined experiences (inputs) from which learners learn. According to Spady (1994) OBE is a paradigm shift of educational functioning that differs strongly from the time-based industrial age approaches to schooling: a move from a time-locked system where success was measured by the number of hours spent to a more enlightened free thinking exploration of how knowledge is constructed without restraints of subject matter, grade levels or systems. In the view of Vermeulen (1997), Outcomes-Based Education is a drastic break from the current educational practices as a means of providing educational success for all learners. It is an educational approach which is results oriented (*ibid*). Indeed, as Wilmot (1999) argues, OBE does not only challenge the existing views of knowledge, teaching and learning but calls for new approaches to assessment.

Moreover, variations in models of OBE arise because of different choices of outcomes, and different management systems to achieve them (Malcolm, 1999).

Whether a particular model will 'work' depends on a complex of historical, cultural, political and resource issues (*ibid*). The choice of outcomes and the creation of an epistemology of outcomes are central issues, if not the only ones (Spady, 1994; 1997, cited in Malcolm, 1999). In this way, the method or approach used by a teacher to develop a particular concept depends on his/her professional judgement (*ibid*). Perhaps what happens in a country, a school or a particular classroom may be different from the other because teachers work in different environments and constrained in practice by their own theories and adaptations. However, judging teaching from the pre-specification of explicit outcomes may prevent teachers from taking advantage of those teaching-learning opportunities which occur unexpectedly and unplanned in the classroom (Malan, 1997), but the counter-claim is that it may be difficult to defend teaching as quality if learners are not made aware of the things considered worthwhile by nations.

2.4.2 Basic Assumptions of Outcomes-Based Education

Spady (1994) writes that Outcomes-based education is based on three key assumptions:

- All students can learn and succeed but not on the same day in the same way,
- Successful learning promotes even more successful learning,
- Schools control the conditions that directly affect successful learning.

The above statements take the differences in students' learning into account: their cognitive and psychological foundations of prior learning and the need for educators to change the conditions of learning and encourage all students to be successful learners (Lubisi *et al.*, 1998).

In this way, teachers and learners are to focus their attention on two main aspects concerning Outcomes-based education:

- (i) the desired end results of each learning process (outcomes): the emphasis on education and assessment must be what the learner knows and can do and the intended results of learning rather than the prescriptions of content. At the end of significant learning experiences, learners will need to demonstrate the tangible application of what has been learnt.

- (ii) content and processes that guide learners to the required end results: content (what) is learnt and processes (how) it is learnt.

From points (i) and (ii), teaching and learning become learner-centred and experienced-based respectively. Education should put learners first, recognising and building on their knowledge and experience, and responding to their needs (Department of Education and Training, 1996).

Put together, learners' responses and activities should drive lessons in outcomes-based education. Assessment also plays a central feature in authentic OBE. It is an ongoing process: not only are standardised tests and examinations written but learners are also assessed in their daily oral and written responses in class, on individual and group projects and on other activities such as the assembly of portfolios in different learning areas (Celliers *et al.*, 1997 as cited in Vermeulen, 1997). Similarly, Johnson (1998) emphasizes the importance of formative assessment: assessment that informs teachers planning not instead of but in addition to summative as well as the evaluation of learners performance against a set of shared and explicit criteria.

As such, outcomes-based education requires teachers to be renamed and reposition themselves as facilitators of learning with a focus on small group discussions and collaborative methodologies (Gultig, 1999).

2.4.3 Traditional, Transitional, and Transformational Outcomes-Based Education

Spady (1994) defines three approaches to OBE according to the kind of performance in the culminating outcomes:

- (i) Traditional OBE: emphasises knowledge and skills in traditional subjects;
- (ii) Transitional: emphasises broad competencies such as problem solving and the use of technology;
- (iii) Transformational: the emphasis is on 'role performances', the ability of learners to demonstrate that they are quality producers, can create products that achieve their purpose, are appropriate to their audience, reflect craftsmanship and use technology and resources.

The three approaches are hierarchical, transformational OBE being the highest and traditional the lowest. The traditional is old, transformational is new, and the

competence version is transitional – the way from traditional to transformational, not the other way (Malcolm, 1999). However it is argued that transformational OBE presupposes the greatest change in existing structures and operations in schools. As Spady and Marshall (1991: 70) put it, “this paradigm represents the highest evolution of the OBE concept, and it contrasts sharply with both the prevailing educational system and with traditional OBE”. As such OBE models in most countries in the world including Australia, Canada and South Africa, lie somewhere between **traditional** and **transitional**. The outcomes are derived jointly from learning areas on one hand, and overarching ‘national goals of schooling’ (Australia, AEC, 1994a,b, cited in Malcolm, 1999) or ‘critical outcomes’ (Canada, Ministry of Education and Training, Ontario, 1995; South Africa, DOE, 1996, cited in Malcolm, 1999). Variations in models of OBE arise from different choices of outcomes. Though official interpretation emphasises a non-technicist, transformational approach for South Africa, there is no assurance that this will be the case (Claassen, 1998). The next discussion is Curriculum 2005: the South African version of OBE.

2.5 Curriculum 2005: The South African Version of Outcomes-Based Education

The introduction, and implementation of Curriculum 2005 premised on Outcomes-Based Education were part of the transformation in Education that followed the new political dispensation in South Africa after 1994. As Jansen (1998) argues, Outcomes-Based Education has triggered the single most important curriculum controversy in the history of South African education. According to Malcolm (1999), the meaning of OBE is essentially dependent on the context within which it is used. Also historical accounts further suggest that politics remains the primary force in shaping the timing, focus and content of curriculum policy in democratic states. Indeed, the sudden introduction of Outcomes-Based Education in South Africa was a response to a long period of non-intervention (1994-1997) in the apartheid curriculum apart from the superficial attempt to cleanse the apartheid syllabuses (Jansen, 1998).

Consequently, the March 1995 White paper on education and training was a cornerstone document that describes the paramount role of post-apartheid educational task as building: ‘an integrated approach to education and training linked to the development of a new National Qualifications Framework (NQF) based on a system of credits for learning outcomes achieved that will encourage creative work in the

design of curricula and recognition of learning attainments where ever education and training are offered' (Department of Education Training, 1995: 15).

As a result, in February 1997, the then minister of Education Professor Bengu announced the implementation of curriculum 2005 as "our new national curriculum for the 21st century":

- (i) a new curriculum based on the ideal of lifelong learning for all South Africans;
- (ii) the new curriculum will affect a shift from one which has been content-based to one which is based on outcomes (Department of Education and Training, 1997).

In sum, the revised Curriculum 2005 has transformational social constructivist roots (Claassen, 1998). This author argues that a dialogue exists between the learner and the curriculum, education becomes a lifelong process rather than a product, and knowledge is negotiable and changeable. Also learners accept responsibility for their beliefs and actions and the teacher becomes a facilitator. A similar view is shared by Kuiper and Wilkinson (1998) that curriculum-2005 moves away from the traditional behaviourist views of teaching and learning to social constructivist and social critical views of teaching and learning. In the social constructivist approach, learners, their ideas, learning and learning activities are at the centre of the teaching process (Kuiper, 1998).

Further, OBE calls for the integration of subjects to allow learners the opportunity to make connections between the knowledge that is learnt in specific learning areas, across the learning areas, and in the real world in which they live. In this way, the knowledge gained in one learning area can be used to enrich learning experiences in another learning area. In particular, the South African Qualifications Authority (SAQA) serves as the body responsible for the development of the critical cross-field outcomes that apply to all learning areas to drive any curriculum design. Learners should be able to demonstrate their ability to:

- identify and solve problems by making use of critical thinking skills,
- work effectively with others as members of a team, group, organisation and community,
- organise and manage themselves and their activities responsibly and effectively,

- collect, analyse, organise and critically evaluate information,
 - communicate effectively and make responsible decisions,
- use science and technology effectively and critically showing responsibility towards the environment and health of others,
- show awareness of the importance of effective learning, citizenship, multiculturalism, career opportunities and entrepreneurial skills (Department of Education and Training, 1997).

Moreover, according to the South African version of Outcomes-based education, the curriculum was no longer to be organised around discrete subjects. The review committee on Curriculum 2005 has recommended the reduction of the original eight learning areas to six in the GET band: languages, mathematics, science and technology, social sciences, arts and culture, life-orientation and the specification of three learning programmes in the Foundation Phase and six in the Intermediate and Senior phases (Review Committee Report on Curriculum 2005, 2000).

In spite of the measures to correct the perceived inadequacies in the previous curricula as well as the novel goals attached to the adoption of outcomes-based education in South Africa, there are objections and criticisms raised against the effective implementation of outcomes-based education. Each country has its own intentions in educational transformations and adopts different measures in the implementation of the reforms.

2.5.1 Educational implications of Outcomes-based Education

The understanding of Outcomes-based education seems to vary within schools, between schools as well as amongst educators, trainers and officials tasked with the implementation. Outcomes-based education purports to be learner-centred, activity-based, inclusive and emphasises critical thinking and integration. The learner, his/her ideas and learning activities are at the centre of the teaching process. As Claassen (1998) mentions, a curriculum premised on Outcomes-based education has social constructivist roots: it is negotiated between the facilitator and learners. In this way, learners are encouraged to develop their own insights and solutions. Also OBE allows

more opportunity for self-organisation than was found with the non-negotiable, time-framed traditional curriculum (*ibid*).

Further, Outcomes-based education goes beyond vague symbols, labels and scores used as indicators for student learning and achievement by the traditional system (Lubisi *et al*, 1989). The focus is on what students have actually learnt and can do and gives educators, parents and employers a picture of student capabilities. The role of educators also changes from transmitters of predetermined knowledge to facilitators of learning. This is echoed in the view of Gultig (1999) that Outcomes-based education requires educators to be renamed and re-position themselves as facilitators of learning with a focus on small groups and collaborative methodologies. In addition Outcomes-based education presupposes the participation and empowerment of educators in decisions regarding curriculum planning and implementation.

Nonetheless, reforms in education are not without problems. The problems range from the adoption of policies to implementation in the classrooms. The limitations inherent with Outcomes-based education will be discussed in the section that follows.

2.5.2 Limitations and Suggestions for improving Outcomes-based Education

The areas of learning described in any curriculum framework are meant to serve indigenous needs as well as to be comparable in terms of credibility to both national and international standards. In spite of the benefits expected from Outcomes-based education, the following have been found to limit the use of OBE:

Outcomes-based education tends to have some behavioristic components: the pre-specifying of explicit outcomes may prevent teachers from taking advantage of those teaching and learning opportunities which occur unexpectedly and unplanned in the classroom (Claassen, 1998). This author maintains that if learning is reduced to measurable outcomes, it becomes dehumanising and teaching becomes completely assessment driven. Indeed the way OBE has been espoused in official documents in many countries, for example in the South African context presupposes a transformational approach in view of the political past of the country. In reality, the content and structure of the curriculum appear to be the same as before. As Spady (1991) puts it, exits and courses that existed are still there. The outcomes are

synonymous with the traditional content-dominated categories that do not relate to real life demands and living experiences (*ibid*).

Further, Jansen (1997) argues that the language and innovations associated with Outcomes-based education appear too complex, confusing and often contradictory. Teachers have to come to terms with different concepts and labels (*ibid*). A similar problem was found by the committee that reviewed Curriculum 2005: the use of meaningless jargon, vague and ambiguous language, the unnecessary use of unfamiliar terms to replace familiar ones and the lack of a common understanding (Report of Curriculum 2005 Review Committee, 2000).

In addition, OBE seems to be based on flawed assumptions about what happens in the classrooms, the organisation of classrooms and the kind of teachers in the system. According to Jansen (1997), the claim of a collaborative, flexible and empowerment-oriented system suggests qualified teachers with a sound knowledge of the theoretical underpinnings of OBE. On the contrary this is particularly absent. Many have endorsed the principles of learner participation, activity-based tasks and especially the use of group work in the classrooms, many teachers, trainers and officials do not appear to understand the principles underlying Outcomes-based education and become confused.

Also there is a mismatch between teacher education and Outcomes-based education. The latter appears not to take account of the essential components of the change process in teacher education: personal reflection on epistemologies, beliefs, classroom practices and commitment to change. As a result many teachers find it difficult to shed their old assumptions and philosophies regarding teaching and learning.

Moreover the notions of 'mixed authority' are likely to be experienced by some teachers as they attempt a balance of power in the classrooms. Outcomes-based education replaces teacher-centred approaches with learner-centred approaches in the teaching and learning process. As a result, a number of teachers appear insecure about changing some significant parts of their classroom practices as teaching moves away from the traditional teacher-centred approach to learner-centred approach.

Further, there are problems with availability, use and quality of teaching and learning resources. Outcomes-based education calls for more student-student, student-teacher interactions but in the majority of cases teachers are confronted with large class sizes, inadequate resources and lack of classroom space restricting the effective use of resources and OBE methodologies.

However, in spite of the difficulties raised above, no single educational philosophy can provide adequate foundation for classroom practice (Schwab, 1972 cited in Terwel, 1999). There should be multiple research findings, adequate debates and public discussions to change educational theories into useful and practical applications. As Gultig (1999) suggests, teacher education should aim at developing a sound understanding of subject knowledge, an understanding of educational theory and ability to use both in an integrated act of teaching.

Further, there should be adequate teacher participation and empowerment in decisions concerning curriculum development. Teachers must be supported through INSET and be provided with the skills in classroom management, assessment strategies and methodologies through workshops. Also learners should be encouraged to be involved actively in learning, to use variety of problem-solving skills and engaged in experiences that are likely to challenge their own ideas. As Malcolm (1999) writes, the test for OBE should be whether it enables teachers to design good curricula and the test for teachers is whether students learn. This implies that the questions of which outcomes are most worthwhile, by whose definition, and how will we know must be addressed alongside issues of teacher effectiveness.

Moreover, there should be the provision of adequate teaching and learning resources with relevance to our situation or needs. Also there is a need for a change in the mindsets of the people involved in curriculum development and implementation. It is quite imperative for South Africa to take positive and constructive measures to avoid the uncritical emulation of international education systems without practical benefits to our situation or needs. Of course South Africa can take note of the recommendations, objections, warnings as well as the successes from the countries where OBE has been implemented.

Given the main characteristics of Outcomes-based Education and components of teacher education courses from literature, the aim of the researcher is to use some data gathering tools such as interviews, questionnaires, observations and document review to investigate the nature and quality of knowledge transactions that take place at a college in transition in the Eastern Cape province: the kind of teaching, learning and assessment strategies within the institutional conditions.

CHAPTER THREE

RESEARCH DESIGN

3.1 Research Methodology

The research was located within the interpretive paradigm. As Cohen and Manion (1994) state, the central endeavour in the context of the interpretive paradigm is to understand the subjective world of human experience. Counter to the positivist the interpretivist seeks the subjective perceptions of individuals (Cantrell, 1993). Similarly, Connole (1993) writes that human actions take place within a structure of social rules within which they have meaning for both actor and observer. Again the data that emerge from the interpretivist approach is holistic, contextual, descriptive: in-depth data rich in detail (Karugu and Wamahui, 1995).

In this way, the researcher chose the qualitative case study since the investigation was carried out in an educational institution with unique characteristics different from others. This is consistent with the view of Abagi (1995) that society and its institutions comprise an enormous and complex world which may differ tremendously from one to the other.

3.2 Goal of Research

The researcher intends to answer the following research question:

How ready is a college in transition for the implementation of Outcomes-Based Education in an Education Development Centre (EDC)?

In an attempt to answer this question, the investigation was focused on the following issues:

- (i) Institutional conditions e.g. factors that either facilitate or inhibit teaching and learning;
- (ii) Lecturers Educational background, and Informants' access to Outcomes-Based Education information;
- (iii) The use of integrated curriculum and forms of classroom activities;
- (iv) Teaching and learning, and assessment practices;
- (v) Availability and use of resources.

3.3 Procedure

Though there are a lot of quantitative data, the research approach was essentially qualitative. This approach was to enable researcher to acknowledge the understanding and meanings attached to the experiences of the informants. According to Cantrell (1993), the use of a multiple approach is to limit the weaknesses inherent in single method of data collection. As such, semi-structured and open-ended interviews, questionnaires, document analysis and participant observation were the main data collection tools. This is consistent with the assertion by Denzin and Lincoln (1994) that an interpretive case study relies on interviewing, observation and document analysis. The purpose of this approach was to make the data that emerged more reliable and valid by comparing and contrasting the different sources of information.

As Cohen and Manion (1994) write, interviews serve as the principal means of gathering information which has direct bearing on research objectives. The researcher chose interviews because oral accounts seem to yield far more reliable and accurate information than relying on a superficial and quantifiable analysis of questionnaires. Also the use of interviews serves as an effective tool to probe into the opinions and perceptions of the informants. The interview schedules (**see appendix A**) were semi-structured and open-ended to afford the informants the opportunity to freely express themselves orally. The responses from the interviews were tape-recorded and later transcribed.

The inclusion of questionnaires (**see appendices B.1 and B.2**) associated with quantitative research is consistent with the suggestion by Reichardt and Cook (1979) that research instruments should be used as eclectically as possible. The use of some open-ended questions was to make the questionnaire more comprehensible for the purposes of clarification from the informants. Two different questionnaires were designed. The lecturers' questionnaire (**see appendix B.1**) was to gather some information relating to their educational background and teaching experience, access to OBE information, teaching and learning approaches, assessment practices, availability and utilisation of resources and impressions about INSET. The students' questionnaire included their access to OBE information, classroom activities and

assessment practices they experienced, and access to teaching and learning facilities. The aim was to corroborate the information gathered from the lecturers' questionnaire. The purpose of this approach was to give the researcher the opportunity to find out how OBE impacts on teaching and learning at the college and the possibility of implementing it in an Education Development Centre.

At the heart of every case study lies observation (Cohen and Manion, 1994). The researcher played the role of a participant observer and kept a record of events and informal remarks, though not extensively in a journal. The purpose of this direct on-site observation was to supplement the information obtained from the other sources of data collection.

The use of documents provides a wealth of information of which some is not accessible through observation or interviewing as well as to clarify or verify data (Cantrell, 1993). In keeping with the principles of historical research (Cohen and Manion, 1994), samples of syllabi and the college admission register were analysed. The aim was to gather information that is not easily covered orally (**see tables 4.5a, 4.5b and 4.5c for summaries of these documents**).

3.3.1 Sample

The sample was composed of a total of 42 informants. It was a convenience sample as the informants and researcher were members of the college community: students and lecturers at the time of the investigation. Three informants were interviewed: two long serving lecturers, and the rector of the college. Thirty-nine informants completed and returned the questionnaires: Twenty-one lecturers and eighteen students. The students' sample was composed of pre-service student teachers in the following areas: Foundation Phase (seven), Intermediate Phase (six) and Senior Phase (five).

3.4 Data Analysis

What is important to analyse in qualitative research emerges from the data itself out of a process of inductive reasoning (Miles and Huberman, 1984). Similarly, Patton (1990) mentions that the use of inductive analysis means that the patterns, themes and categories of analysis come from the data rather than being imposed on them prior to data collection and analysis (Patton, 1990). In practice the responses that emerged

from the investigation were analysed through the identification of patterns or themes, categorisation and interpretation.

3.4.1 Validation

The informants were duly informed about the purpose of the research. Draft copies of the research were submitted to colleagues for validation by “member checking” (Miles and Huberman, 1984) and pilot tested. As Cantrell (1993) writes, the use of a multiple approach (triangulation) is to limit the weaknesses inherent in single methods. The choice of a multiple approach: interviews, questionnaires, document analysis and participant observation were to limit the distortions found in single methods.

3.4.2 Research Constraints

The difficulties that emerged from the research were the following:

- (i) Some of the informants particularly the lecturers were quite hesitant to accept the questionnaire. They expressed uncertainties regarding the redirection of the college and the future of their posts. I further explained the motive behind the research to them and only five did not return the questionnaire. This is one of the weaknesses of using self-completed questionnaires.
- (ii) Initially, I experienced some difficulties in getting access to some documents as most are kept in the rector’s office and could not be reached easily. After some attempts I managed to get in touch with the rector and had the opportunity to get the college admission register and quarterly returns. The college librarian also assisted me with some old syllabi which were difficult to locate.
- (iii) Many student informants did not understand the language used in the questionnaire hence I had to rephrase some of the questions and explained some aspects of the questions to them.

CHAPTER FOUR

4 Research Findings

The analysis of the questions and responses that emerged from the investigations revealed the possibility of grouping the responses into five main categories to make the analysis easier. The categories identified were the following:

- Educational background of Lecturers;
- Dissemination of Outcomes-based Education information;
- Teaching, Learning and Assessment practices;
- Availability and Utilisation of Resources;
- Institutional conditions.

Though quantitative data has been used in most of the analysis to make the categorisation of responses easier, the researcher chose to interpret the data qualitatively. The purpose of this approach was to acknowledge the understanding and meanings attached to the responses of the informants. For illustrative purposes, excerpts of responses from the informants have been quoted verbatim. The responses to questionnaires and interviews of selected informants have been coded: **(AR: rectors' responses to interview; AL: lecturers' responses to interview; BL: lecturers' responses to questionnaire; BS: students' responses to questionnaire)**.

4.1 Educational background of lecturers

This category is partly concerned with the quality of knowledge transactions that take place at the college. The informants (lecturers) were asked questions to probe into their educational qualifications, teaching experience and evidence of professional development. The tables 4.1a, 4.1b, 4.1c and 4.1d show the distribution of responses. Tables 4.1a and 4.1c show that many lecturers have more than 10 years of teaching experience and postgraduate qualifications. Four out of the total of twenty-one possess only professional diploma qualifications. Majority of the lecturers attend workshops and read educational bulletins and journals. Less than 50% (9) of the lecturers attend conferences, and only a few undertake research. It was evident from the investigation that only 25% (4) of the lecturers are involved in further studies and inadequate staff development programmes are organised by the college (see table 4.1d: Qs. 6 & 9).

Table 4.1a: Distribution of responses showing qualifications of lecturers (N = 21)

Type of Qualification	Number of Informants
Professional diploma only	4
Bachelors' degree only	2
Postgraduate qualification	15

Table 4.1b: Distribution of responses showing methods used by lecturers' for professional development (N = 21)

Method	Yes	No
Conference attendance	9	12
Workshops	20	1
Reading of educational bulletins and journals	15	6
Research	4	17

4.1c: Distribution of responses showing lecturers' teaching experience at a College (N = 21)

Age category (years)	Number of informants
Less than 5	1
5 –10	8
More than 10	12

Table 4.1d: Distribution of lecturers' responses to some activities aimed at professional development (N = 21)

Question Number	Question	Responses	
		Yes	No
6	Are you presently engaged in further studies?	4	17
9	Does the college provide staff development programmes?	6	15
10	Do you attend training in curriculum 2005?	16	5
11.1	Do you integrate the teaching of content with the development of skills in your subject area?	19	2
13.1	Do you have facilities/resources available to improve your teaching at the college?	18	3

Table 4.1e: Distribution of students' responses to some learner development items (N = 18)

Question number	Question	Yes	No
6	Does your training at the college integrate content with skill development?	16	2
8	Do learning materials available to you at the college encourage active learning?	18	0
9	Are the learning support materials e.g. textbooks written in appropriate language to your level of understanding?	16	2
11	Does the college have adequate resources/facilities to support your learning?	16	2

4.2 Dissemination of Outcomes-based Education information

Both lecturers and students were asked to indicate their sources of OBE information. Many lecturers indicated that they attend training in curriculum 2005. For example most of them indicated that they integrate the teaching of content with skill

development (see table 4.1d: Qs.10 & 11.1). All students ticked the inclusion of OBE in their tuition and confirmed that OBE is not taught separately. Majority of the students responded that they read OBE documents. However, five students indicated that they do not read OBE documents (see table 4.2a).

Table 4.2a. Distribution of learners' responses to sources of OBE information (N=18)

Item	Yes	No
Inclusion of OBE in tuition	18	0
Teaches OBE separately	0	18
Reads OBE documents	13	5
Not at all	0	-

4.3 Teaching and learning approaches, and assessment practices

Within this category, the informants were asked questions about the use of the different classroom activities and assessment strategies (see appendices B.1: Qs. 11.3 & 15 and B.2: Q. 14). Table 4.1d shows that many lecturers integrate the teaching of content with the development of skills. This was confirmed by the majority of the student informants (see table 4.1e). All lecturers indicated the use of group activity. The use of cooperative and individual activities were mentioned by majority of the lecturers. About 50% (12) of the lecturers responded that they use teachers' demonstrations. Only one lecturer indicated the use of other activities. The majority of the informants indicated standardized tests, written examinations and daily oral and written responses as the main modes of assessment often used. Peer group, portfolios and journals were found to be used to a limited extent by the informants. The study revealed some inconsistencies in the responses made by both students and lecturers. Students in the same group from the sample: Foundation, Intermediate and Senior phases do not seem to respond consistently. For example all students indicated the use of standardized tests, nearly 100% (17) of the students indicated the use of written examinations, oral and written responses but one student who might belong to a particular group and probably taught by the same lecturers indicated that he had never been assessed by oral and written responses (see table 4.3c). Also it was evident from the study that three lecturers have never used standardized tests though all students indicated that they are assessed often or sometimes by standardized tests (see

tables 4.3b & 4.3c). Table 4.3d shows that many lecturers monitor the progress of their work by self- and student evaluation. Few lecturers indicated the evaluation by peers and outside experts.

Table 4.3a. Distribution of Lecturers' responses to the use of different classroom activities (N = 21)

Activity	Number of informants
Individual	17
Group activity	21
Teachers' demonstration	12
Cooperative learning	15
Others (e.g. field activity)	1

Table 4.3b. Distribution of lecturers' responses to assessment practices (N = 21)

Assessment mode	Often	Sometimes	Never
Standardised tests	12	6	3
Written examination	11	10	0
Oral and written responses	12	9	0
Peer group	8	10	3
Portfolios and Journals	5	8	8

Table 4.3c. Distribution of learners' responses to assessment practices (N = 18)

Assessment mode	Often	Sometimes	Never
Standardised tests	11	7	0
*Written examinations	11	6	0
Oral and written responses	13	4	1
Peer group	8	5	5
Portfolios and Journals	5	8	5

* One student did not answer this question.

Table 4.3d. Distribution of responses showing evaluation strategies used by lecturers to monitor the progress of work (N = 21)

Mode of Evaluation	Yes	No
Self-evaluation	18	3
Peer evaluation	9	12
Student evaluation	14	7
Evaluation by HOD	7	14
Evaluation by outside experts	6	15

4.4 Availability and utilisation of resources

The informants were asked questions about the availability and access to resources/facilities. Majority of the informants indicated that they have access to computers, audio-visual aids and library. Only few lecturers responded that they have no access to the use of audio-visual aids and computers. About 43% (9) of the lecturers noted the availability of well-equipped science laboratories. This is quite understandable because few lecturers are involved in the teaching of science at the college. Twelve students indicated that they have access to the science laboratory. The majority of both students and lecturers mentioned that the micro-teaching rooms have been under-utilised (see table 4.4a, and appendices A.1: Q.11; A.2 & A.3: Q.12;

and B.1: Q.13.3). Excerpts of unedited responses to interviews and questionnaires follow.

A.1 (Q.11): Does the college have the necessary resources/facilities to implement the INSET?

AR.11: There are a lot of facilities but unfortunately not all of them are fully utilised. The micro-teaching centre which plays a pivotal role in teacher education is virtually under-utilised.

A.2 and A.3 (Q.12): The college has been recommended by the provincial education task team to re-direct into a teacher development centre. INSET involves the development of skills in classroom management, improved assessment techniques etc. Does the college have the necessary resources/facilities to effect the implementation of INSET programmes?

AL.2: The necessary infrastructure, teaching and learning facilities are in place but under-utilised. You may think of facilities like the micro-teaching room, reading laboratories in the library and others which are virtually not utilised.

AL.3: The college has enough facilities but not all of them are accessible especially the micro-teaching rooms.

B.1 (Q.13.3): Which facilities are not well-utilised?

BL.1: Micro-teaching: a complicated system, very costly but once installed no workshops were given to explain the working itself.

Table 4.4a. Distribution of responses showing students' and Lecturers' access to resources: **Students' Responses (N = 18)** **Lecturers' Responses (N = 21)**

Resource/Facility	Yes	No	Yes	No
Audio-Visual aids	13	5	15	6
Computers	15	3	19	2
Well-equipped laboratories	10	8	9	12
Micro-teaching rooms	7	11	5	16
Well-resourced library	15	3	17	4

4.5 Institutional conditions

This category probes the system of governance and administration, curriculum structure and trends, variations in student and staff population, infrastructure, impressions about the transformation, and other factors that facilitate or inhibit teaching and learning at the college.

4.5.1 Governance and administration of the college

The analysis of responses revealed that from 1994, a democratically elected governing council that comprises the rector, and representatives from the staff, parents and students replaced a committee appointed by the 'director general' of education in the former homeland administration. It was also revealed that the students and the community played no active role in the governance of the college during the previous administration (see appendices A.1: Q. 4; A.2 & A. 3: Q.5). The following unedited responses to interviews were identified:

A.1 (Q.4): What has been the trend in the governance of the college?

AR: The college was governed by a committee appointed by the director general of Education in the previous Ciskei government. There was virtually no student involvement in the governance of the college until the advent of the new political dispensation. At the moment, the college is governed by a democratically elected governing council including the rector and representatives from the lecturing staff, parents and students.

A.2 & A.3 (Q.5) What has been the system of governance at the college to date?

AL.2 The college was run by the rector and HODs without the involvement of students during the former Ciskei government administration. There were some pockets of resistance from the students but virtually they played no role in the running of the college. At present the college is run by an elected governing council and both students and parents are represented together with the staff;

AL.3 Previously the college was run the management team: rector, heads of departments with a strict departmental control. There was no actual involvement of students and the community in the administration of the college. At the moment the college is run by an elected governing council comprising the rector, representatives from the lecturing staff, students and the community.

4.5.2 Curriculum structure and trends

The investigation revealed that the college has used two different curriculum structures: the old structure of 1981, 1985 and 1990 (see table 4.5a), and the new structure of 1995 (see table 4.5b). An analysis of the 1990 Secondary Teachers' Diploma (STD) old curriculum structure showed four groups of subjects: Professional subjects, Academic subjects, Background subjects and language skills, and Ancillary or Practical subject. Students offered two major academic subjects of the following combinations: biology and geography or biology and mathematics, or mathematics and physical science, the subject didactics related to the academic subjects, and education. These were the main subjects that were externally examined by the DET. In addition, other subjects e.g. School management, Christian and other philosophies of life, and student guidance were offered and internally examined. The responses to the interviews and questionnaire revealed that the lecturers were not involved in the planning of the old curriculum. Also, the old curriculum was found to be subject-centred, limited in skill development, and did not reflect the needs of the learner (appendices A.1: Q.6; A.2: Q.7).

The new curriculum: the 1995 Secondary Teachers' Diploma (STD) curriculum structure revealed five groups of subjects: Education, Professional studies, Communication and Religious Education, Academic subjects, and Practical or Ancillary subjects. Though few lecturers expressed some disagreement with the new

curriculum, the majority of them indicated their involvement in the development of the new curriculum and felt that it will address the needs of the learner. This emerged from the responses to the questionnaire and interviews (see appendix B.1: Q. 12.1). However, the main difference between the old and new curricula structures was found in the subject grouping. Also, practical subjects like computer literacy and keyboards were introduced in the new curriculum. Science practical is offered for three years in the 1995 curriculum instead of two years in the 1990 old curriculum structure. General mathematics is offered by all students who choose biology and geography as major subject as a way to improve on their competence in mathematics. It also emerged from the analysis of the new curriculum that the content subjects are almost similar to the subjects in the old curriculum. Some courses offered in both curricula are almost the same except that they differ in names. For example, students offer two major academic subjects and subject didactics related to the academic subjects that are similar to the old curriculum structure. School management, Christian and other philosophies of life in the old curriculum structure are now called life and social skills and religious education respectively in the new curriculum. The investigation revealed that students choose between the three languages in the new curriculum: Afrikaans, Xhosa or Sotho as medium of communication instead of Special Afrikaans that used to be compulsory in the old curriculum. Excerpts of unedited responses obtained from the interviews and questionnaire follow:

A.1 & A.2 (Q.6): How do you compare the previous curricula with the current approach?

AR.1: The previous curricula had no impact on the lives of the students. The current COTEP guided curriculum is quite excellent. It is aimed at training the students to meet their social and economic needs and consistent with the reforms in education and training taking place in the country.

AL.2: I had no interest in the previous curricula. It was quite authoritarian as everything came from Pretoria and our duties as lecturers were to carry out instructions.

B.1 (Q. 12.1): To what extent have you involved yourself in your subject area at the college?

BL.1: My way of teaching has very much remained the same as I have always believed in pupil involvement.

BL.2: Disagree with floating curriculum but undue circumstances have been faced to choose my own curriculum.

BL.3: Changed my teaching approach, I am now the facilitator. Students have to read, discuss and do research work on their own to meet the outcomes set for my subject area.

BL.4: By drawing the content of my subject in conjunction with my colleagues and moderator and also by designing the assessment criteria.

BL.5: At departmental level we hold regular meetings to plan activities, design curriculum, etc.

BL.6: I have been involved only once when the 1997 STD curriculum was to be changed.

BL.7: I have been working to modify the curriculum to suit our present day needs. To this end the curriculum has changed to some extent over the last few years.

Table 4.5a: A Summary of the Secondary Teachers' Diploma (STD) 1990 Curriculum structure (old curriculum structure)

Group	Subjects	Duration (years)	Evaluation
Professional Subjects	Education	3	External
	Teaching Practice	3	Internal
	School Management	2	Internal & External
	Subject Didactics: Biology & Maths, OR Maths & Biology OR Maths & Physical Science	3	External
Academic Subjects	Biology, Geography Mathematics, Physical Science	3	External
Background Subjects & Language Skills	English as Medium of Instruction Special Afrikaans Christian and other Philosophies of Life	3	Internal & External
	Student Guidance Library Orientation Introductory Physical Education Music & Singing Art & Craft	1	
Ancillary Subject OR Practical work	Biology OR Physical Science Practical	2	Internal & External

Source: adapted from 1990 STD curriculum (DET old curriculum structure).

Table 4.5b: A Summary of the Secondary Teachers' Diploma (STD) 1995 Curriculum structure (new curriculum structure)

Group	Subjects	Duration (years)	Evaluation
Education	Education	3	Internal & External
Professional Studies	Subject Didactics: Biology & Geography OR Biology & Maths OR Maths & Physical Science	3	Internal & External
	Life and Social Skills; Teaching Media (Institute Practicum); Computer Literacy & Keyboards; Library Education	2 2 3 1	Internal & External
	*General Maths	3	
	Communication & Religious Education	English communication Afrikaans / Xhosa / Sotho communication Religious Education	
Teaching Practice	School Practicum	3	
Academic Subjects	Biology & Geography OR Biology & Maths OR Maths & Physical Science	3	Internal & External
*Ancillary Subject or Practical Work	Biology or Physical Science Practical	3	Internal

Notes: * General Maths: Offered by Biology and Geography students who do not offer Maths as a major subject. Ancillary Subjects: not offered at the college.

Source: adapted from the 1995 STD curriculum (new curriculum structure).

4.5.3 Student and staff population 1978-2000

The analysis revealed variations in both student and staff populations. It showed a gradual increase in student population between 1978 and 1982 (see table 4.5c). In addition the analysis indicated a reduction in the number of students admitted between 1982 and 1985. Also there was a drastic increase in student population between 1991 and 1994. The largest student population was 1071 in 1994. The investigation further revealed a decreasing student population between 1995 and 2000: from 895 in 1995 to 159 in 2000. Similarly, the staff population was found to have increased gradually from 1978 to 1996, and a large increase between 1990 and 1991. The lowest staff population was 13 in 1983 and the largest was 67 in 1994. It was also found that the staff population started to decrease between 1997 and 2000: from 57 in 1997 to 34 in the year 2000 (see table 4.5c). This is an indication of the rationalisation process that started at the college in 1995.

Table 4.5c: Distribution of Staff and Student Population (1978-2000)

Year	Number of students	Number of lecturers	Year	Number of Students	Number of Lecturers
1978	483	14	1990	560	40
1979	681	22	1991	1032	57
1980	601	28	1992	1006	57
1981	646	24	1993	1005	66
1982	412	23	1994	1071	67
1983	107	13	1995	895	64
1984	178	27	1996	730	66
1985	320	20	1997	557	57
1986	440	26	1998	405	53
1987	425	25	1999	253	50
1988	428	24	2000	159	34
1989	524	32			

Source: adapted from the college admission register (1978-2000).

4.5.4 Impressions of informants about the transformation process

The majority of the informants indicated positive impressions about the re-direction of the college. For example, one lecturer mentioned that the teacher development centre is important in view of the nationwide educational transformation. Equally some lecturers were uncertain about the pace of the transformation. This was attributed to the lack of communication between the college staff and the department of education. Many students mentioned that the development and implementation of learning programmes by educators in the educational transformation lead to understanding. However, one student felt that *the approach is interesting but boring*. (see appendices B.1: Q.16; and B.2: Q. 10). The following responses were identified from the questionnaires.

B.1 (Q.16): What is your impression about the transformation taking place at the college?

BL.2: What transformation? Little to nothing is taking place.

BL.3: There is a big need and demand for INSET. With proper planning, organisation and dedication from staff and the department it can succeed.

BL.4: The transformation process is long overdue. This should have been done long time ago. I am quite happy with the changes except that the department officials appear not to know exactly where they are taking this college (and many others) to.

BL.7: In view of the transformation taking place country-wide in teacher education, I think the college could serve well as a T.D.C. However because of inadequate information flow from the department of education, lecturers feel insecure and remain in a panic. Consequently there is low morale among the lecturers. I think the college administration needs to liaise properly with the head office to be able to inform the lecturers properly. By now there should have been programmes underway to prepare lecturers for the task ahead.

B.2 (Q.10): Educators are to develop and implement learning programmes according to the needs of learners and the community they serve. What is your opinion about this?

BS.1: On my opinion I think its very challenging concerning the transformation

BS.2: I like it because it help us to understand and give us better knowledge.

BS.3: You find it interesting although you have boring part of it.

BS.4: They develop programmes which involve skills for future of learners in communities.

4.5.5 Participant observation

Many lecturers appear to be interested with the rationalisation process. This was revealed from the remarks made by some lecturers through personal communication. However, the majority of the lecturers expressed concern about the delay in the transformation process especially the pace of re-direction of the college. The following remarks were identified:

- *What transformation? What will happen to the college is a secret so staff cannot equip themselves if they do not know what for.*
- *This is a matter of concern. The re-direction of the college is necessary but to date the department of education has not come out with any programme for next year.*
- *I support the idea of transformation. On the other hand it appears the Department of Education has no clear cut function for the college.*
- *Good in so far as planning ahead but wish head office at Bisho are supportive and did not dither.*

CHAPTER FIVE

5.1 Discussion of Results and Conclusion

This study looked at the readiness of a college in transition in the Eastern Cape province to implement Outcomes-Based Education in an Education Development Centre. Semi-structured interviews, questionnaires, document analysis, and direct participant observations constituted the data sources for the investigation. It is important to note that any meaningful use of the results of this study must be tempered with caution based on the design limitations and inconsistencies in the responses from the informants associated with the investigation.

However, the results of the study draw some insights into the changes taking place at the college. First, the findings revealed that since 1994 a democratically elected governing council has replaced a council appointed by the 'director general' of education in the previous Ciskei administration. A democratic system of schooling should facilitate the participation of all legitimate interest groups in governance (NEPI, 1992). Kaplan (2000) echoes this statement that the relationship of teacher and student is democratic when both are confronting problems that are meaningful to them.

The results indicate a process of rationalisation in terms of staff number and student admission. Table 4.5a shows a gradual increase in both student and staff population between 1978 and 1990, a drastic increase between 1991 and 1994, and a decline between 1995 and 2000. Though the statistics of past examination results were not included, the increase in student intake especially between 1991-1994 is indicative of the weak admission grades and the backlog of students who write supplementary examinations. The decline in student and staff population (1995-2000) is in line with the governments' policy of rationalisation of Colleges of Education in 1995. This approach is consistent with the view that South African Education problem is to improve the quality of educators rather than improving quantity (COTEP, 1996). The investigation revealed that the pace of the re-direction of the college is slow due to inconsistencies on the part of the provincial Education Department in terms of policy implementation.

The results showed that the planning of the old curricula structures of 1981, 1985, and 1990 drawn up by the DET did not involve the lecturers. They were content-laden and did not make students aware of their needs and feelings. In contrast, it was evident from the study that the 1995 curriculum was planned and developed by the college lecturers, and moderated by Rhodes University according to the guidelines of the COTEP, 1996 document. This curriculum seems to integrate the teaching of content with skill development and more flexible than the old curriculum. It provides at least in part an endorsement to the view that curriculum designed by the people on the spot suits students, and the design of curriculum and assessment lies especially with teachers (Malcolm, 1999). However, the 1995 curriculum structure appears to have some elements of replication of subjects from the old structure. For example, in spite of the changes to the old curriculum, it was found that the content and structure seem to remain the same as before. Majority of courses that already existed are still there. Though there is an emphasis on skill development with the introduction of practical subjects in the new curriculum, the main difference noted from the investigation lies in subject grouping. Some subjects were found to have been given new names e.g. School management and Christian and other philosophies of life are now called life and social skills and religious education in the new curriculum respectively (see tables 4.5a and 4.5b).

The study revealed that majority of the lecturers have post-graduate qualifications, and few possess only professional diploma qualifications. This is at least in part an endorsement to the view that teacher knowledge is central to learning and the success of OBE as a system (Malcolm, 1999). However, it may also happen that a teacher could be highly qualified on paper but incompetent in the classroom. Indeed, the large increase in student population in the early nineties might have caused the appointment of many lecturers though qualified on paper, may have been incompetent for teacher development education. This may have partly contributed to the poor quality of teachers produced by the college for the past years.

It became evident from the investigation that, many informants at the college have access to OBE information, and the lecturers update themselves professionally through attending workshops, reading of educational bulletins and journals. Further, it emerged from the study that inadequate research work, and staff development programmes are organised by the college. In view of this, Hartshorne (1992) argues

that whatever the educational problem to be faced, the key to the situation is the teacher: the academic background, professional training, personal and professional development during the career and conditions of service.

Cooperative learning, in particular group work, and individual activity were indicated to be the main teaching strategies. Though one lecturer indicated the use of other activities that were not included in the questionnaire, teachers' demonstration was found to be the least used teaching activity. This seems to give positive indications about learner-centred teaching/learning approaches but requires further investigation to authenticate this finding. Curriculum design for OBE is learner-centred as opposed to subject-centred and core-centred design of traditional curriculum (Claassen, 1998). However, it should be noted that learner-centred education is a matter of emphasis and philosophy among alternatives, and OBE is system-centred that leads prescribed tuition according to the OBE model in use (Malcolm, 1999).

From the study, tests and examinations emerged as the main assessment strategies at the college. Portfolios, peer group and journals as assessment forms were found to be used by the lecturers on a limited scale. This was one of the weaknesses identified from the study. Johnson (1998) suggests that, tests and examinations are only forms of assessment, they must not be discarded but rather form part of a larger battery of assessment strategies. Worth mentioning is that, the investigation revealed that both lecturers and students were not consistent with their responses to the assessment practices. For example, students in the same group were found to indicate different assessment practices in their responses. Also, all students indicated that standardized tests and written examinations are often or sometimes used but three lecturers noted that they had never used them. This may be quite understandable in considering the problems associated with self-completed questionnaires. Also, in view of the inconsistency in some responses, it would have helped if I had done follow-up interviews. The study revealed that most of the lecturers monitor the progress of their work mainly by self- and student evaluation. Few lecturers were found to evaluate the progress of their work by outside experts and peers.

The results from the study indicated that the resources/facilities are available, accessible and to some extent utilised. However, some facilities like the micro-

teaching centre was found to be under-utilised or not accessible by the informants. The probable lack of qualified personnel in micro-teaching at the college may also have contributed to the under-utilization of the micro-teaching centre.

Direct participant observations and informal remarks made by some informants from the study showed that many lecturers are interested in the re-direction of the college and the implementation of OBE at the Education Development Centre. Equally, the majority of the lecturers feel quite uncertain about the future of the college in view of the slow pace of the transformation process, and the inconsistencies in terms of policy implementation by the officials at the Department of Education.

Conclusion

Given the findings and deductions raised above, the implementation of OBE in the proposed Education Development Centre may take hold, first if much attention is given to research in terms of curriculum development and staff development programmes. As Mackrory (2000) suggests, in the new millennium, qualifications can become outdated and knowledge inadequate for the needs at the workplace. In support of this, Outcomes-Based Education should be seen as a theoretical framework that gives clarifications about learning situations but lacks a clear articulation of what learners and teachers may do to facilitate learning. As such, group work and continuous assessment per se should not be made synonymous with Outcomes-Based Education. For example, the fact that many lecturers in this study seem to endorse the principles of learner participation, activity-based tasks and the use of group work does not necessarily guarantee the effective application of OBE principles in practice. Teaching and learning approaches, and assessment practices should be geared to facilitate learning, enhance and deepen the understanding of learners.

There should be maximum utilisation of available resources, new mindsets and new ways of thinking on the part of educators and officials tasked with the re-direction of the college into an effective Education Development Centre. Finally, the difficulties raised against Outcomes-Based Education should not be seen as obstacles but challenges to be faced by educators so that the implementation of OBE at the proposed Education Development Centre (EDC) can lead to improved changes in the practice of educators at the centre and the country as a whole. As an extension to the

study, there is a need for future research to look into the strategies to monitor the classroom practice of teachers in-service after having professional development at the proposed Education Development Centre.

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APPENDICES: A.1, A.2 & A.3, B.1, B.2

APPENDIX A.1: INTERVIEW SCHEDULE ON CURRICULUM 2005 WITH THE RECTOR OF A COLLEGE

On 14 March 2000, an interview was conducted between the rector of a college in the Eastern Cape province and the writer on the above subject. Below are the questions that emerged:

Q.1: What year was the college started?

Q.2: What was the purpose for the establishment of the college in this part of the province?

Q.3: Where did the funding come from and the original location of the college?

Q.4: What has been the trend in the governance of the college?

Q.5: The college has undergone a history of curricula changes. Could you briefly give the trend?

Q.6: How do you compare the previous curricula with the current approach?

Q.7: How effective has OBE been implemented at the college?

Q.8: Does the college organise staff development programmes?

Q.9: A lot of educators have been found to be incompetent in the schools. In your view what are the possible causes?

Q.10: The provincial education task team has recommended the re-direction of the college from a pre-service to a teacher development centre (INSET). What is your impression about this?

Q.11: Does the college have the necessary resources/facilities to implement the INSET?

Q.12: Does the college have the efficient manpower to meet the challenges posed by INSET?

Q.13: What preparatory arrangements have been made at the college for the INSET?

14: Your morale and vision at the moment regarding the transformation at the college?

**APPENDIX A.2 & A.3: INTERVIEW SCHEDULE WITH TWO LECTURERS
(A.2 & A.3) OF A COLLEGE ON CURRICULUM 2005**

On 10 March 2000, an interview based on some aspects of the institutional conditions at a college in the Eastern Cape province was conducted with some members of staff. Below are the questions raised in the interview.

Q.1 What year was the college started?

Q.2 In your view what do you think motivated the establishment of the college?

Q.3 How was the college started?

Q.4 Who provided the funding?

Q.5 What has been the system of governance at the college to date?

Q.6 How do you describe the curricula changes that have taken place at the college?

Q.7 What aspects of the previous traditionally based curriculum interested or disinterested you?

Q.8 Did the courses run at the college have any relevance to the needs of the learner and the community?

Q.9 Do you attend any staff development courses?

Q.10 Does the college provide any staff development programmes?

Q.11 How do you intend to share your experiences gained in the courses attended with your colleagues?

Q.12 The College has been recommended by the provincial education task team to redirect into a teacher development centre. An INSET involves the training of skills in classroom management, improved assessment techniques etc. Does the college have the necessary resources/facilities to effect the implementation of INSET programmes?

Q.13 How can the implementation of the INSET programmes be made effective at the college?

Q.14 Most educators in the schools have been found to be inadequate in terms of competence. In your opinion what are the possible causes of this problem?

Q.15 What is your suggestion to improve this situation?

Q.16 Do you think the introduction of the new curriculum (OBE) in the INSET programme can improve the situation?

Q.17 What is your vision for the college?

Q.18 Your morale at the moment?

APPENDIX B.1: QUESTIONNAIRE ON CURRICULUM 2005 TO LECTURERS

Please make a tick (✓) in the boxes provided or comment in the spaces to indicate your responses to the questions found below:

1. Your gender: () male () female .

2. Your age:

- Younger than 30 years ()
- 30 to 39 years ()
- 40 to 49 years ()
- above 50 years ()

3. Teaching experience:

- less than 5 years ()
- 5 to 10 years ()
- 10 to 15 years ()
- 15 to 20 years ()
- Over 20 years ()

4. Number of years of teaching at a college.

- Less than 5 years ()
- 5 to 10 years ()
- More than 10 years ()

5. What qualifications do you have ?

- Standard 10 ()
- Professional diploma ()
- Bachelors degree ()
- Postgraduate degree ()

(Please specify others) -----

6. Are you presently engaged in further studies ? () Yes () No

7. If you answered ' Yes ' to question (6), what are you studying ?

8. Curriculum 2005 stresses professional development in order to remain effective in your subject area. How do you remain effective in your subject area?

- | | Yes | No |
|----------------------------------------------|------------|-----------|
| 8.1. Attend conferences | () | () |
| 8.2. Attend workshops | () | () |
| 8.3. Read educational bulletins and journals | () | () |
| 8.4. Through research work | () | () |

Others (Please specify)-----

9. Does the college provide staff development programmes? () Yes () No

9.1. If 'yes' to question (9), which of the following areas are covered?

- | | Yes | No |
|----------------------------------------------|------------|-----------|
| 9.1.1. Curriculum development | _____ | _____ |
| 9.1.2. Teaching / instructional enrichment | _____ | _____ |
| 9.1.3. Management and leadership development | _____ | _____ |
| 9.1.4. Research development | _____ | _____ |
| 9.1.5. Others (Please specify) ----- | | |
| ----- | | |

10. Do you attend training in Curriculum 2005? () Yes () No

11. Do you teach OBE as a subject separately or included in your teaching?

- | | |
|------------|-----|
| Included | () |
| Separated | () |
| Don't know | () |

11.1. Do you integrate the teaching of content with the training of skills in your subject area?

- () Yes () No

11.2. To what extent do you integrate content with the teaching of skills in your subject area?

- | | |
|------------------|-----|
| Very well | () |
| Moderately | () |
| Just a little | () |
| Not particularly | () |

11.3 Which of the following classroom activities do you use in your subject area?

(You may tick more than one activity)

- Individual activity ()
- Group activity ()
- Teacher's demonstration ()
- Cooperative learning ()
- Others (Please specify)-----

11.4. How do you encourage active learning and independent thinking in your subject area?

12. Curriculum development is the task of educators at the site of delivery according to OBE

12.1. To what extent have you involved yourself in your subject area at the college?

12.2. How do you intend to share your experience gained in OBE with your colleagues?

13. Do you have facilities/ resources available to improve your teaching at the college?

() Yes () No

13.1. Which of the following facilities are available at the college?

	YES	NO
Audio-visual centre	-----	-----
Computers	-----	-----
Well-equipped laboratories	-----	-----

Micro-teaching rooms -----
Well-resourced libraries -----

13.2. Indicate which of the facilities are well-utilised?

13.3. Which facilities are not well-utilised?

14 How do you monitor the progress in terms of development in your teaching and learning at the college?

	YES	NO
14.1. Self evaluation	_____	_____
14.2. Peer evaluation	_____	_____
14.3. Student evaluation	_____	_____
14.4. Evaluation by head of department (H.O.D)	_____	_____
14.5. Evaluation by outside experts	_____	_____

15 Assessment is a central feature in authentic OBE. Below is a list of different forms of assessment. Indicate by a tick the extent to which each is applied in your teaching.

	OFTEN	SOMETIMES	NEVER
15.1. Standardised tests	_____	_____	_____
15.2. Written examinations	_____	_____	_____
15.3. Daily oral and written responses	_____	_____	_____
15.4. Peer group assessment	_____	_____	_____
15.5. Portfolios and journals	_____	_____	_____

16. The College has been earmarked for a teacher development centre (INSET) according to the recommendation by the provincial education task team.

16.1. What is your impression about the transformation taking place at the college?

16. Learners are to be allowed to progress at their own pace according to OBE. What is your opinion about this?

17. Describe how you intend to share your ideas gained in OBE with your colleagues.

APPENDIX B.2: STUDENTS QUESTIONNAIRE ON CURRICULUM 2005

1. Which of the phases of the General Education and Training band does your training involve?

- Foundation phase
- Intermediate phase
- Senior phase

2. Did you receive any induction course when you were admitted at the college?

- Yes No

3. If you responded 'Yes' to question (2) which of the following areas were involved?

	YES	NO
Orientation on college policy	_____	_____
Orientation on course requirements	_____	_____
Orientation on Curriculum 2005	_____	_____

4. How do you receive instructions and training on Curriculum 2005 at the college?

	YES	NO
Included in tuition at the college	_____	_____
Taught separately	_____	_____
Reads OBE documents	_____	_____
Not at all	_____	_____

5. Do you receive teaching and learning methods based on OBE in all or some subjects at the college?

- Some subjects
- All subjects
- Not at all

6. Does your training at the college integrate knowledge with the teaching of skills?

- Yes No

7. What forms of classroom activities are available to you at the college?

	YES	NO
Individual activity	_____	_____
Group activity	_____	_____
Teacher's demonstration	_____	_____

8. Do learning materials available to you at the college encourage active learning?

- Yes No

9. Are the learning support materials e.g. textbooks written in appropriate language to your level of understanding? () Yes () No

10. Educators are to develop and implement learning programmes according to the needs of learners and the community they serve. What is your opinion about this?

11. Does the college have adequate resources/facilities to support your learning ?
() Yes () No

12. If you responded 'Yes' to question (11) which of these facilities are accessible to you?

	YES	NO
Computers	_____	_____
Audio-visual centre	_____	_____
Micro teaching centre	_____	_____
Well-resourced Library	_____	_____
Well-equipped science laboratories	_____	_____

13. How often do you have access to these facilities?

- Always ()
- Sometimes ()
- Never ()

14. Assessment plays a central role in OBE. Indicate by a tick the extent at which these assessment forms are applicable to you at the college.

OFTEN SOMETIMES NEVER

Standardised tests	_____
Examination	_____
Daily oral and written responses	_____
Individual and group projects	_____
Peer group assessment	_____
Portfolios	_____

15. OBE emphasises the use of continuous assessment. In your opinion to what extent has this approach been applied at the college?

- Often ()
- Sometimes ()
- Never ()

16. Learners are to be allowed to progress at their own pace according to OBE. What is your opinion about this?

17. Describe how you intend to share your ideas gained in OBE with your colleagues.

A CRITICAL REFLECTION ON THE RESEARCH REPORTS

Research can be confusing and demanding because no one can anticipate the difficulties that lie ahead from the beginning to the production of the research report. Peters (1966) notes that, to be educated is not to have arrived at a destination, it is to travel with a different view. Clearly, in my opinion, I considered the research projects undertaken by me as not necessarily aimed at getting an academic qualification but as a way to improve on my classroom practice as an educator. My aim has always been the confidence to stand on my feet independently to undertake a research. In the light of this, the constraints that emerged from this research endeavour were seen not as obstacles but as challenges to be faced.

My choice of the research topics was influenced by the new curriculum and the challenges posed to educators in the country. Deciding exactly what I wanted to investigate for the two empirical researches was not an easy task let alone the formulation of the research questions.

The next hurdle to cross, and indeed one of the major difficulties I faced during this research journey was the design and presentation of the research proposal on one of the empirical researches (**Research project two**). This part of the research was quite challenging because I had never involved myself with any research study for the past 15 years. It was also frustrating because I had to write six draft research proposals before a final approval was made. The criticisms from my M.Ed. colleagues and supervisors during the presentation of the proposal to the entire class nearly shattered my initial hope and enthusiasm for the course of study.

Nonetheless, this did not discourage me because the criticisms and suggestions obtained, and my involvement in critiquing the research proposals of other colleagues rather encouraged and helped me to restructure my own research proposal and to get my ideas as focused as possible. This was an empowering exercise as the proposal outlined the route map of the investigation.

The research methodology course opened my eyes to locate my research approach within the qualitative paradigm. My main intention was to look at the reasoning and

meaning individuals attach to their experiences, in this case at a typical educational institution located in a rural area. On the contrary, I ended up with a lot of quantitative data especially with the situational analysis. This was confusing as I thought I had deviated from my original plan. However, I got focused after the seminar presentations. It was at this seminar that I learnt that there is no clear demarcation between qualitative and quantitative data and that much depends on how one interprets the results. Indeed, this awareness made it easier for me to interpret the results of my studies.

Apart from the document analysis included in research project three, interviews, questionnaires and observations constituted the main data gathering instruments used for the two empirical researches. It is of interest to mention that the sample was convenience as the researcher was at the same time a lecturer at the research site. As such my close involvement with the respondents put me at an advantage in terms of data collection. For instance some of the respondents were more likely to give positive responses to satisfy me. I wish therefore to remind the readers of the research reports to be cautious in the use of the findings of the studies based on the limitations associated especially with the responses gathered from the investigation.

However, the research projects chosen by me were extensions of the coursework assignments. As such, the comments from my supervisors after marking the assignments and critiques from the peer group assessment by my M.Ed. colleagues during the individual presentations of assignments to the group helped a lot to refine my research instruments. The research instruments were also pilot-tested during the coursework assignments at the same research site so that they were ready for implementation.

I had a lot of information from different authors for the literature review on social constructivism but putting them together with a critical view was a problem. I wrote five draft reports but there was a lack of coherence in the presentations. However, I got a better understanding of the theory behind social constructivism when I used it to design and implement the learning module in research project two with a group of students within the classroom situation.

For research project two, the planning, design and implementation of the learning module were not without problems. They were quite demanding and time consuming. In particular, much difficulty was faced in the change of instructional strategies associated with a constructivist model of teaching and learning. For instance, the use of interviews at the inventory phase of the lessons to elicit the students' initial ideas on the selected topic was not familiar to the students. This problem was exacerbated when the students had to grapple with their own ideas at the centre of instruction, and to take responsibility of their own learning. Almost all the students appeared confused initially as they did not know what to do exactly because they had become familiar with the traditional didactic approach. However, the worksheets for the subsequent lessons were designed as the lessons progressed. This enabled me to rephrase and restructure some aspects of the instructional strategies to the understanding of the students. They were also given opportunities to take their learning as their own and as relevant to them through interesting experiments, group work and class discussions.

The implementation of the lessons could not be completed as intended and was extended because of the interruptions caused by the college activities. Also, in spite of the small size of the group of students used for the investigation, their poor attitude to learning greatly affected the progress of the lesson implementation. At times some lessons were postponed when two or more students out of the total number of five were absent for practical reasons. In some instances, some lessons were arranged in the afternoons and I had to move around the township to fetch the students, and provided lunch in order to get them ready for the lessons.

However, they were often reminded that the lessons were not for their physical science assessment but formed part of the routine teaching periods meant to improve teachers' classroom practice. This approach made them to cooperate and develop some interest in the lessons. Though the implementation of the learning module in research project two was quite daunting, it was quite interesting as the students became aware that their ideas are valued in the teaching process. This was an empowering exercise to me.

The research project on the situational analysis of the college in transition (**Research project three**) was the most frustrating. Firstly, the pace of this research was deeply

affected by the inconsistencies in policy making and implementation by the provincial Education Department. Secondly, the redeployment exercise together with the slow pace for the redirection of the college made the majority of the lecturers to be hesitant in accepting the research questionnaires. Some felt that it was part of an exercise to get them out of the proposed college programme. This was evident in the sort of embarrassing questions posed by some lecturers during the distribution of the questionnaire. In addition, some questions were either left unanswered or not properly answered. I had to further explain the aim of the research project to them before they agreed to complete the questionnaire. Yet there were inconsistencies in the responses to some questions in the lecturers' questionnaire. The only problem with the students' questionnaire was that some of them did not understand for example the terminologies used in outcomes-based education. I rephrased and explained them to their understanding and they completed the questionnaire accordingly. Access to some college documents was another area of difficulty to me. Most of the important documents were kept at the rectors' office and it was difficult for me to get hold of them because of the busy schedule of the rector. After several attempts I gained access to the college admission register and some past syllabi. However, in spite of the difficulties faced, I discovered that every step in the research projects was part of a learning experience as a novice researcher.

As a second language speaker, I always referred draft copies of the research to two colleagues for proof reading before submission to my supervisor. Putting the data collected into categories for the analysis of the results of the two empirical researches was another difficult task. Many draft copies of the analysis of the results were sent to my supervisor whose constructive criticisms and suggestions assisted me to put the results of the research into a better shape for submission.

Finally, I wish to state that, this research process has been a long journey full of obstacles. In particular, it is of interest for the readers of this report to note that my aim for the research projects, especially research project three, was to improve teaching and learning in a proposed Education Development Centre. However, I am highly disappointed to mention that, the college was disestablished at the end of the year 2000. The implementation of the proposed Education Development Centre had not materialised at the time of writing this research report.

On the other hand, the research journey has been worthwhile and challenging: the theoretical knowledge gained during the research process has enabled me to better identify my own ideas and views about teaching and learning, and my classroom practice as an educator.