THE EFFECT OF PREDICT-OBSERVE-EXPLAIN STRATEGY ON LEARNER'S MISCONCEPTIONS ABOUT DISSOLVED SALTS

by

KEDIBONE MAGDELINE TLALA

MINI DISSERTATION

Submitted in partial fulfilment of the requirement for the degree of

MASTER OF EDUCATION

in

SCIENCE EDUCATION

in the

FACULTY OF HUMANITIES

(School of Education)

at the

UNIVERSITY OF LIMPOPO

SUPERVISOR: PROF. I. KIBIRIGE

2011

DEDICATION

To my husband, Benedict and children, Boipelo; Oarabile and Oreabetse.

ACKNOWLEDGMENTS

To my supervisor Prof. Israel Kibirige for his pieces of advice.
To Dan Musinguzi for his editorial work and to authors and researchers whose ideas have been used in this dissertation.

THANKS

To my mother, my two little sisters, Makie and Mosima who always looked after my kids, while I was completing my studies.

Finally, to the learners and teachers who offered their support and assistance during the data collection stage of this dissertation.

DECLARATION

I declare that the mini-dissertation hereby submitted to the University of Limpopo, for the degree of Master of Education in Science Education has not previously been submitted by me for a degree at this or any other University; that it is my work in design and in execution, and that all material contained herein has been duly acknowledged.

________________________ ____________________

TLALA K M (Mrs) Date

[redacted]

ABSTRACT

Misconceptions learners bring to class are in sharp contrast to acceptable science. These misconceptions emanate from a variety of sources including the way educators teach, textbooks used by teachers and from life experiences. These misconceptions at high school (Grade 10) are a potential source of learning difficulty regarding understanding how salts dissolve in water. To assist learners to overcome such difficulties, learner-centred and activity-based intervention, Predict-Observe-explain (POE), was used in this study. The sample consisted of 93 Grade 10 Physical Sciences learners from two neighbouring schools situated in Moutse West circuit, Sekhukhune District, Limpopo Province. 53% of the students involved in this study were males and 47% were females. The purpose of this study was to investigate Grade 10 Science learners' conceptual understanding of dissolved salts and to explore the use of POE strategy in order to reduce learners' misconceptions about the dissolved salts. The study also, explored students' prior knowledge of concepts related to the dissolved salts and determined the effectiveness of POE strategy on males and females.

A quasi-experimental design was used where the experimental group (EG) used POE strategy during treatment and where the control group (CG) used the traditional teaching using lecturing and demonstrations. Before the start of the study, both groups wrote a pre-test using the Achievement Test (AT) to determine science baseline knowledge. Thereafter the intervention for EG and lecturing for CG followed and lasted for five weeks. After the intervention, both groups wrote the post-test to determine learners' achievements. The post-test was followed by interviews to discover issues that were not identified during the AT. The quantitative data were analysed using both the t-test and the Analysis of Co-variance (ANCOVA). The qualitative data collected through interviews were coded to form themes and later themes were organised in categories. The results show that EG performed better in the post-test than the CG their counterpart. More importantly, this study identified two new misconceptions that have not been reported in the literature: salts dissolve in water when it is in 'fine' grains; and solid sodium chloride is not an ionic compound. Furthermore, findings from AT revealed that students' conceptual understanding of how salts are formed, how salts dissolve in water and how salts ionise improved dramatically especially from the EG, but not for the CG. Data collected on the AT post-test for EG show that males (mean 21.13 ± 9.72 SD) achieved better than females (mean 12.73 ± SD 5.97) and t-test $p = 0.004$. On macro level concepts, females from CG achieved higher scores than the males from the same group. Conversely, on micro level, the CG achievements were lower than the EG in males and females, suggesting that POE favours the reduction of misconceptions not only at macroscopic levels, but also at microscopic levels. The findings in this study highlight the need for educators, curriculum developers and textbook writers to work together in order to include various elements of POE in the curriculum as a model for conceptual change at high school science classroom.

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1. **Background of the study**

South Africa (SA) like any other country has introduced a new curriculum, the National Curriculum Statements (NCS) for Grades 10-12. This curriculum completes the implementation of Outcomes-Based Education (OBE) approach first introduced in Grade 1 in 1998 and this new curriculum policy presents what is to be taught, learnt and assessed in schools, Department of Education, (DoE, 2003). It is developed to uphold constitutional and democratic values in education in order to provide quality education for all.

There are 29 subjects in total in the NCS curriculum. Physical Sciences subject is one of them, which is grouped into learning fields forming a core curriculum for Grades 10-12 (general). It is generally referred to as Natural Sciences in General Education and Training (GET) and it includes Life and Living; Energy and Change; Planet, Earth and Beyond; and Matter and Material (DoE, 2003). On the other hand, in Further Education and Training (Grades 10-12), it is referred to as Physical Sciences and Life Sciences.

Basically the teaching of Sciences is challenged by the paucity of qualified educators. In some schools especially in lower Grades learners are taught by educators who are not qualified in the subject (Mpofu, 2006). This challenge creates many problems to learners. Some of these problems include inadequacy in scientific knowledge, skills, values, attitudes and at best these problems manifest themselves in a number of misconceptions. Consequently, this may explain why learners perform poorly in examinations.

A few studies show that science learning is characterised by misconceptions, which learners develop as they try to understand the world around them (Vosniadou, 2001; Stepans, 1994). These misconceptions emanate from the language used by educators, textbooks and from life experiences (Stepans, 1994). Thus, Stephens purports that for effective teaching there is a need to overcome these misconceptions. Posner *et al.* (1982) indicated that the best-known method when dealing with learners' misconceptions is the use of 'Conceptual Change Model' (CCM). This model involves four conditions: learners must become dissatisfied with their existing conceptions; the new conception must be solved by using the new concept (plausible), the new conception must be clear and understandable for learners (intelligible); and related problems must be solved by using the new concept in future (fruitful). Accordingly, Stepans (1994) preferred way of dealing with learners' misconceptions is to use a strategy, which will identify first-hand learners' views of science concepts, then examine the success or the lack thereof. Though a variety of methods have been tried to eliminate learners' misconceptions, research shows that misconceptions are resistant to change, persistent and difficult to extinguish (Hewson & Hewson, 1983; Demircioglu, Ayas & Demircioglu, 2005). They highlighted that learners may not change their persistent misconceptions due to their lack of active involvement in acquiring knowledge. In addition Novak (1988) and Songer *et al.* (1994) in Demircioglu *et al.* (2005) indicated that once misconceptions are rooted in a learner's theoretical schemes they are extremely hard to remove.

Studies conducted on how learners attempt to understand science concepts indicated that they had poor understanding of the concepts (Ogunniyi, 1999). Another studies conducted by Potgieter, Rogan & Howie (2005) and Mumba, Rollnick & White (2002) in South Africa (in three ex-model C schools, four township schools and University foundation learners taking Physical Science as a major subject) highlighted that it is important for first year Science learners at University to have a required understanding of basic Science concepts from their Grade 12 class. They further purported that Grade 12 learners are poorly prepared for first year chemistry in terms of conceptual understanding. Also, from my experience as a science educator, in GET bands, more often learners encounter problems in understanding science concepts because of their naïve ideas as well as the way they have been taught. At school majority of educators if not all do not teach for conceptual understanding due to lack of experience in relevant approaches for conceptual understanding and due to a time factor as teaching is only done to cover the syllabus. Among other science concepts Grade 10 Science learners experience difficulties in the understanding of how salts dissolve in water. They do not understand the particulate theory of matter and the polar nature of water, both of which play a significant role. Their lack of understanding emanates from the methods used to teach these concepts. Thus, the way in which learners are taught affect the way they learn.

Basically, in science ‘rote learning-memorisation’, ‘cook book recipe’ and ‘content-based’ teaching was emphasised rather than teaching to provoke critical thinking, reasoning reflection and action (Dekkers, 2005). Since the introduction of the new curriculum, ways of teaching are gradually changing from rote learning to learning for understanding. Also, a learner centred approach is advocated for where pedagogical structures position learners at the centre of the instructional process as participants and not as passive recipients of knowledge as in traditional teaching approach (Mahendra et al., 2005). This approach challenges the traditional view of the educator as the person, who determines what, when and how learners will learn and places the responsibility for learning on the learner while the instructor assumes the responsibility of facilitating (Spencer & Jordan, 1999; Arizona Facilities Council, 2000). According to Koeberg Primary School (2008) learner centeredness approach has three components, namely:

- the learner who has to pursue the main task of learning;
- the educator who has to assist the learner to pursue his/her learning responsibility; and
- the classroom which serves as the conducive learning centre.

In learner centred approach the learner is the main participant. Without the learner there will be no learning at all. Learning, as it centres on the learner, begins with understanding the educational contexts from which a learner comes and continues with the educator assessing learner’s progress towards the set learning outcomes (Arizona Facilities Council, 2000). Learning opportunities must be structured in a way that allows each learner to experience a feeling of competence, belonging and usefulness as this will enable the learners to become confident and active participants in their own learning by learning to use their inner resources (Koeberg Primary School, 2008). More emphasise in learner centred approach is on the learner’s competence in demonstrating knowledge, skills, attitudes, values and understanding. Here the learner is asked to achieve and demonstrate competence in academic and professional disciplines, and this may be demonstrated by the learner's application of knowledge in solving real life and stimulated problems (Arizona Facilities Council, 2000). Throughout this process one needs not forget that learning is not an isolated practice, it is influenced by environmental factors including culture, technology, instructional practice, individual differences and diversity. All these need to be catered for, in a manner which will give learners added opportunities to achieve their set objectives. The introduction of a learner centred approach of teaching need to include the educator, as well.

Educators need to be given the human relations skills necessary to manage democratic, co-operative classrooms (Mahendra et al., 2005; Koeberg Primary School, 2008). That is, in the classrooms and in schools is where people can assist one another; learn together either in pairs or in small groups in order to contribute towards finding solutions. In this way no one blames another, but rather help each member of the team to reach the stated outcomes. According to Koeberg Primary School, (2008) for educators to transform their classrooms and schools, the following practices are important:

- making positive relationships a priority;
- engaging in respectful dialogue with learners;
- practicing encouragement and affirmation on daily basis;
- encouraging and making shared decisions and involvement (for example holding classroom meetings);
- resolving conflict before it spirals; and
- having fun with learners on a regular basis.

Throughout this transformation process it is important for educators to know their learners, encourage those who are discouraged. This is important, particularly in a learner centred approach where co-operation is required so that there is a full participation of learners. This approach takes into account that learning is only possible when learners look hopeful and joyful to the future (Koeberg Primary School, 2008). Hence it is important for educators to keep in mind that their classrooms are diversified in nature, and to give their learners an equal chance of learning by adopting alternative learning styles to assist learners to experience environments that are conducive to their diversified needs, particularly the classroom.

Taking learner centeredness into account is about promoting a collaborative, supportive classroom culture not as competitive and individualistic scenarios (Mahendra et al., 2005). This is the learning environment where learners will learn together as a team through stimulating, interactive, thought-provoking experiences and working towards the related learning outcomes. It is a place where all learners will be free and open to air their views, find answers to questions, test ideas learn about what interests them and develop moral autonomy (Mahendra et al., 2005). Creating the learning environment/classroom where all learners will be welcome, learn co-operatively together, accomplish their dreams, learn responsibility, take decisions about how their classrooms are functioning is the responsibility of educators. To sustain this type of a classroom, educators need to understand that helping, sharing, participating, planning and working together are the features of a learner centred classroom because learners enjoy performing classroom activities which are rotated frequently to give every learner an opportunity to participate throughout their learning (Koeberg Primary School, 2008).

Given the learner-centred approaches emphasised by the NCS, I decided to explore the use of CCM and apply specifically, the ‘Predict-Observe-Explain’ (POE) strategy in order to reduce learner’s misconceptions about the dissolved salts. The NCS encourages learner-centred and activity-based strategies with a view of nurturing learners’ personal growth (DoE, 2003). In POE learners hypothesize, test their hypothesis and explain observations as a way of verifying hypothesis. In this format, learners’ participation throughout the lesson will be through predicting, observing and explaining the learning process (White & Gunstone, 1992; Assessment Resource Banks, 2007). Furthermore, POE can be used to find out learners’ initial ideas and this provides educators with information about learners’ thinking.

1.2. Problem statement

Considering that there is a need for science learners to have an adequate understanding of the basic science concepts (Potgieter et al., 2005), but based on my experience as a science educator, learners need to acquire a clear understanding of basic science concepts as early as their secondary school level. This has never been easy due to the fact that science teaching is dominated by procedural teaching rather than teaching for conceptual understanding as advocated in CCM. To contribute towards solving this problem the researcher designed a study which focuses on promoting conceptual understanding for the Grade 10 Physical Science learners about the concept of 'dissolved salts' through the use of POE approach. The NCS encourages POE approach because it is learner-centred and focuses on the outcomes expected at the end of the learning process, stimulates critical thinking and reasoning skills as well as to allows educators to act as facilitators rather than information transmitters (Lemmer, 1999). The use of this approach will contribute towards preparing learners to be able to identify, solve problems in a reasonable way, collect and to analyze information for decision making purposes.

1.3. Purpose of the study

The purpose of this study is to explore the effect of POE teaching strategy on learners' misconceptions about the dissolved salts (common salts Table 1) in Grade 10 science learners in Moutse West circuit. Also to compare the extent to which POE improved achievements compared to those where POE was not used.

Table 1 Soluble and insoluble salts

Salt	**Chemical name in symbols**	**Solubility in water**
Nitrates	**$NaNO_3$**	**Soluble**
Potassium, sodium and ammonium salts	**KCl, NaCl and $(NH_4)_2SO_4$**	**All soluble**
Sodium Chlorides	**NaCl**	**Soluble**

Silver Chloride	**AgCl**	**Insoluble**
Sulphates	**$Pb(SO_4)_2$** **$(NH_4)_2SO_4$**	**Insoluble** **Soluble**
Carbonates	**Na_2CO_3** **$CaCO_3$**	**Insoluble** **Soluble**

Adopted from Brookes et al. (2005)

1.4. Research questions

This study sought to answer the following two research questions. First, what effect will POE strategy have on learners' misconceptions about dissolved salts? Second, to what extent does POE strategy improve learners' achievements regarding the 'dissolved salts' concepts?

1.5. Significance of the study

There are several factors that initiated this study:

- The dire need for first year University learners to have an adequate understanding of basic science concepts (Potgieter et al., 2005; Mumba *et al.* 2002).
- The need to explore and to provide information on the effectiveness of the use of POE strategy in reducing learners' misconceptions.
- The need to contribute towards literature on how learner's misconceptions can be addressed using the conceptual change models (Marx, Blumenfeld, Krajcik, Fishman, Soloway, Geier, & Tal 2004 and Ebenezer 2010).

Before the commencement of this study, I was aware that learners come to class with their pre-knowledge acquired through their day-to-day experiences and exposure to the local environment. This basic knowledge they possess may affect their way of learning science.

Maximising classroom teaching and learning process to a certain extent depends on the creation of a positive learning environment by educators as well as learner participation. This basically requires the use of stimulating teaching approaches that can enhance learning and may lead to a meaningful learning and to achieve improved Grade.

The use of innovative strategies is encouraged by the NCS as it emphasises learner-centred approaches. These are approaches that will require science educators to promote creative and critical thinking about science issues and learners to acquire knowledge as they interact with the learning materials. In this study POE strategy as one of the components of CCM was explored. POE renders an opportunity to work with the Grade 10 science learners in assisting them to develop a better understanding about what happens when salts dissolve in water and it is hoped that the strategy will have a positive effect in promoting learner participation as well as encouraging meaningful learning. It is hoped to positively contribute towards assisting science educators to teach for conceptual understanding rather than procedural teaching, and hence contribute towards literature on how learners' misconceptions can be addressed. The use of POE will contribute towards promoting a meaningful understanding of science concepts and will promote improved grade achievements in science.

1.6. Delimitations of the study

This study confined itself in exploring the effect of using POE teaching strategy to address learner's misconceptions about the dissolved salts on the Grade 10 Physical Sciences learners of the two neighbouring secondary schools in a rural area of Limpopo at Sekhukhune region in Moutse West circuit.

1.7 Definition of terms

Misconceptions: Constructed knowledge which is not scientifically accepted.

Predict-Observe-Explain (POE): A strategy of CCM where teaching and learning involves small group practical activities where learners will be actively involved in hypothesising, testing for their hypothesis and explaining their observations.

Learner-centred approach: The teaching approach which afforded learners to take initiative of their own learning. This is the approach where learners are encouraged to actively participate physically and mentally in the activities which lead to their own learning.

Traditional teaching approach: Teaching approaches which does not afford learners the opportunity to be actively involved in the learning process, but passive learning.

Meaningful learning: It is an act of relating or linking knew knowledge and concepts to relevant concepts already known for a better understanding of new concepts.

Conceptual Change Model (CCM): The commitment to new belief about a principle or a phenomenon and the abandoning of an old one in favour of the new concepts (White & Gunstone, 1989).

Constructivism: The view which encourages construction of knowledge and considers learners prior knowledge in order to make new schema of knowledge.

Salts: Any compound formed by the reaction of an acid with a base.

Dissolved salts: When salts totally ionise in water forming the constituents ions.

CHAPTER 2

2.1. Theoretical/conceptual framework

For learning to take place, the role of the learner to construct knowledge is of vital importance; hence learning is the process of knowledge construction. The educator in this case will have to create conducive learning environments and will have to act as a facilitator. This study acknowledges that learners come to class with prior-knowledge, which has been acquired from their real life experiences, textbooks, educators, peers and from home. The study designed here is situated within the field of socio-cultural constructivist theory as espoused by Piaget (1970) and Vygotsky 1986). Through this theory learners must construct knowledge from their mental and physical experiences with the environment. Therefore, learning takes place as the learner incorporates new experiences with the existing knowledge into mental structures and dares to tackle challenging experiences. This study also is guided by CCM which is in turn based on constructivist theory of learning that learning is a process of personal construction and that, learners, given an opportunity, will construct a scientifically accepted conception of physical phenomenon if they see that the scientific conception is superior to their pre-instructional conception (cited by Posner et al., in Cobern, 1996). Theoretically this study acknowledges the interrelationship between constructivism, conceptual change model and POE. These three concepts espouse the idea which says for learning to begin it must be laid over the foundation/ bases of the existing knowledge. Hence the characteristic/principles or conditions as given in this study below when each one of them is discussed put forward the need to consider learners prior knowledge as the bases of all learning. This will in turn influence the creation of the cognitive conflict with the strange knowledge the learner is bound to receive through learning which will stimulate the need for other conceptions to explain the strange situation. Through observations and interaction with fellow classmates and the teacher learners will construct their new knowledge and explore solutions to the strange situation. Hence this will drive the creation and adoption of the new conception/knowledge learnt.

2.2. Constructivist theory

Learners come to class with their pre-knowledge which may or may not be compatible with the scientific conceptions. This knowledge should be considered because it guides individual understanding of concepts. This knowledge is acquired through their experiences and their learning exposure and may be modified throughout the process of learning as they interact with the learning materials and with the educator. Throughout this process learners may become dissatisfied with their existing knowledge and they may find the new knowledge being plausible, intelligible and fruitful (Posner *et al., 1982)*. Depending on the success of learning process learners may accommodate, assimilate or reject the new knowledge. Learners have to find the new knowledge as being relevant to their daily lives which may affect their level of accommodating, assimilating or rejecting the new knowledge taught and hence they may accept the new knowledge taught or choose to keep their existing ideas.

For learning to take place in a more positive way both the educator and the learner must cooperatively participate and do their roles as required by the learning process. The role of the learner is "constructing the new knowledge". As constructing new knowledge is of paramount importance during learning it needs to be done by the relevant participant, the learner. On the other hand, the educator must create a positive learning environment as well as being a facilitator (Arizona Facilities Council, 2000). It is believed, in this study, that learner's main responsibility during their learning is to construct new knowledge from their physical and mental experiences with the environment because educators cannot construct knowledge on their behalf and give it to them. This is a clear indication that the onus of constructing knowledge is on learners. They must undergo an active process of interpreting issues within their social and cultural environment (Lee, 2002). Hence, critical and creative thinking should be done encouraged by educators, which is in a way, engaging in a learner-centred approach. It will never be denied that although individual learners have to construct their own meaning of the new knowledge, the process of constructing is always embedded in a particular social environment where learners belong (Duit & Treagust, 1998).

2.3. Social constructivist view of learning

Piaget (1970) and Vygotsky (1986) emphasised prior knowledge as the basis for individual understanding and further learning. Vygotsky (1986) in his social constructivism singles out the learner as the constructor of new knowledge and as the active participant throughout the learning process and on the other hand views educators as facilitators as well as the creators of the favourable learning environment (Mahendra et al., 2005; Koeberg Primary School, 2008). Throughout the learning process the learner should be actively involved both physically and mentally and should interact with the environment to construct new knowledge. This leads to a learner-centred-activity based type of learning rather than an educator-centred-learning process which is the new way of learning adopted by the NCS (DoE, 2003). The NCS for Physical Sciences is based on constructivism in the sense that it gives approval of the learner-centred teaching strategies which incorporates the existence on learner's prior knowledge acquired through a variety of ways. It also allows the educator to be the facilitator and creates conducive learning environment. Hence this study is based on social constructivism.

Fosnot (1996) highlighted that constructivism is a learning theory and it does not give a step by step description of teaching and learning styles. No style of teaching can be distracted from the theory and the proposed constructivist teaching approaches, but it provides general principles to be used in order to modify our teaching strategies. Fosnot indicated the general principles of constructivism as follows:

- learning is developed; it is not the result of development. Thus educators need to actively involve learners during the learning event and make the learning environment conducive;
- contradictions resulting from learning process need to be explained, explored and discussed in order to moderate learner's conceptions;
- learning should be encouraged through reflective thoughts and reflective thoughts are facilitated by allowing reflective time through discussions and connections of ideas across their experiences;

- allow learners rather than the educator to justify and communicate their ideas to the classroom community;
- learning proceeds towards the construction of big ideas and can form principles which can be generalised across various experiences.

By virtue of this theory, constructivism envisages active learners who will interact with the physical and social world. “It is a psychological theory of learning that describes how structures and deeper conceptual understanding come about, rather than one that simply characterises the structures and stages of thought or one that isolates behaviours learned through reinforcement” (Fosnot, 1996: 128).

From what is gathered concerning POE and constructivism, the two are intertwined. They both consider the use of learner centred activities; rely on classroom interactions that are definitely and unavoidably aimed at valuing learners' misconceptions, emphasise that interacting with the environment is a stimulant for active thinking, encourage that learners talk about the new concepts to understand and to learn using it. It offers allowance for coexistence concepts rather than only the replacement of conceptions, emphasise that science is basically human construction rather than the endless truth, and recognises the learner as the core of the learning process and that the educator is a facilitator. From what is listed above, it is clear that the thrust of the POE strategy used in this study is the constructivist view of learning. Hence the steps used during POE strategy are based on the principles provided by the constructivist learning theory.

2.4. Identifying learner's concepts

As a starting point for educator to teach learners for understanding of basic Science concepts as needed by first year Science learners at University there is a need for educators to recognise what learners bring to class and then change the way they teach. According to Walker (2001) this can be done by investigating learners' science concepts. This is necessary to make educators aware of what learners have in mind and what they understand about science concepts. Educators should be aware of what learners think and know about concepts from their own conceptions and some of them may be a contradiction to the accepted concept (Duit, Treagust, & Mansfield., 1996). In investigating learners' concepts educators should also be aware that if learners have no prior concepts they can as well develop them on the spot and yet not answer what they actually think (Duit et al., 1996). Educators can really make their choice as to which method they would like to use in revealing learners conceptions. For instance some may use conceptual mapping and diagnostic test or predict-observe-explain (POE) strategies.

Throughout the use of whatever method to reveal learners' conceptions, it must be understood that knowledge cannot be transferred from educators down to learners. Yager (1995) purported that there is little indication that knowledge can be transferred from educators to learners unless learners engage themselves in a thought provoking process often initiated by a problem. Positive processes of learning are those that are less dependent upon educators' presentations and dependent on how learners tend to assimilate and process information encountered through personal mental models of science concepts and predetermined ideas (Glynn & Duit, 1995; Yager, 1995). Each learner has a different way of assimilating information and because of this, a variety of opportunities need to be supplied for them to achieve what is intended. Learners' science achievements depend on their active process of constructing, organising and elaborating knowledge upon their existing conceptual models of science (Glynn *et al*. 1995). In other words, they learn science more meaningfully if their existing scientific knowledge can be activated and related to experiences in learning where they form new mental models of science concepts (Walker, 2001). Thus, educators need to ensure that the learners' existing knowledge and the learners' new experiences are related in a manner that is meaningful for all learners. The interrelationship is indicated in Figure 1.

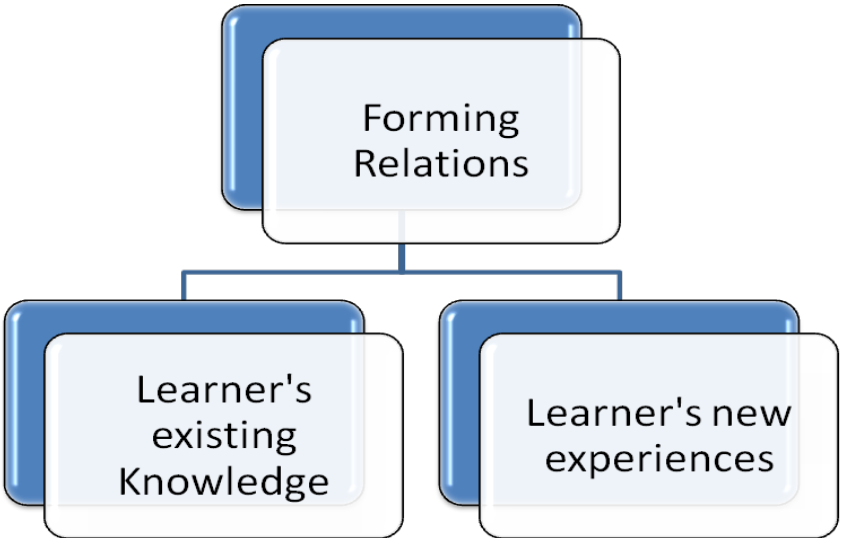


Figure 1. Forming relationships between learners' existing knowledge and learners' new experiences leads to learning, adapted from Walker (2001).

2.5. POE teaching strategy

POE strategy was first developed by White & Gunstone (1992) with a view of revealing learners predictions and their reasons for making that prediction about specific events. This "strategy" worked well with activities that allow immediate observations. POE as a teaching– learning strategy White & Gunstone suggest that it can be adopted in the main theory of constructivism in the following formats in order to:

- find out learners' initial ideas;
- provide educators with information about learners' thinking;
- generate discussion;
- motivate learners to want to explore the concepts;
- generate investigations.

From constructivist theory we realise that learners pre-knowledge should always be considered, hence learners' mind is not regarded as a `tabularasa` (clean slate). They come class to class with prior knowledge which educators must always consider when designing lessons. Given the prior knowledge learners should also be given an opportunity to examine their existing ideas with the new knowledge they gain from the day to day interaction with their educators and the materials. Thus, POE strategy considers learners prior knowledge and offers them an opportunity to examine their existing ideas against the new knowledge. This ultimately drives them towards the process of accommodating; assimilating or rejecting the new knowledge imparted to them or otherwise chooses to keep their existing knowledge.

According to Assessment Resource Banks (2007) POE strategy works as follows:

- learners must predict what will happen before they observe;
- having their prediction motivates them to find out about the correct answers;
- allows learners to explain reasons behind their predictions that assist the educator to understand learners' theories. This can be useful to uncover learners' misconceptions;
- it also provides information for making decisions about the subsequent learning;
- learners discuss and evaluate predictions and listen to others' predictions and to begin evaluating their own learning and then construct new meanings.

POE is a strategy which involves learners in writing down their predictions before doing the activity and the predictions are then followed by an activity in which learners observe their predictions and acclaim on whether or not their predictions were correct or incorrect. It provides a step by step procedure to be followed during its application. Basically there are three steps involved: predict; observe; and explain.

Predict

Learners have to state their predictions and provide reasons for their stated predictions. They have to commit themselves to their prediction by writing it down on their worksheets. These can be done individually or in small groups and after that they have to discuss and agree upon their group or individual predictions.

Observe

Learners have to carry out the demonstrations (in small groups) and enough time must be allocated for observation. To commit themselves to what they have observed they have to write down their observations on their worksheet individually or as a group. This will help them to accept or reject their predictions.

Explain

Learners have to be given enough time to explain their observations and write their explanations on paper. This will assist them to see how their predictions and what they have observed merge. Finally, they discuss among themselves ideas based on what is observed so they get deeper insight.

Though POE strategy provides some simple step by step procedures which might be easy for educators to adopt and use in their classes, its use has some limitations. The following limitations towards the use of POE strategy are cited by Assessment Resource Bank (2007):

- for primary school learners communicating their ideas through writing can be a barrier hence oral response is emphasised;
- for younger Primary learners explaining their reasoning may be difficult for them;
- POE needs suitable topics i.e. " hands-on" topics or topics in which immediate response is possible;
- the often use of POE will require demonstrations which will not give surprising results as this may affect their explanations;
- when using POE one seeks a joint conversation, based on the underlying science ideas, about what is expected to be observed and why.

The use of POE strategy which is more of learner centred than educator centred encourages meaningful learning rather than rote learning which involves memorisation and drilling of facts for the purpose of passing a test or an examination.

This type of learning lasts for a while because it is stored for a short term memory. After examination, one cannot effectively function because such knowledge is easily forgotten. Effective and meaningful learning on the other hand, involves understanding and integrating knowledge which results into a knowledge that will be in one's mind for a very long time and will be easily retrieved. For a meaningful learning to take place learners' existing knowledge needs to be considered in all dimensions. The main purpose of meaningful learning is to assist learners to link their already existing knowledge with the scientifically acceptable knowledge and hence ultimately replace it with the scientifically acceptable knowledge. The process in which learners abandon their prior knowledge that is not scientifically compatible is known as 'conceptual change model' as given by Posner *et al*. (1982). This model is now explained further in the next section.

2.6. Conceptual Change Model (CCM)

Posner *et al.* (1982) and Hewson (1981) developed the view of learning which uses learners prior knowledge into a model of learning known as conceptual change. In this view, learning is not only considered as the creation of new knowledge but also involves considering the existing knowledge as the basis of the new knowledge to be learned and for the two to be reconciled if possible, though some conceptions can be rejected during the process. Hewson & Hewson (2003) stresses that for the new conceptions to be integrated into the existing knowledge it needs to be intelligible, a person considering the conception should know exactly what it means; plausible, the conception must be believed to be true; and fruitful, the new conception must be found to be giving new ways to approach problems. By implications conceptual change encourages educators to consider learners prior knowledge and assist them to find the new subject matter to be intelligible; plausible and fruitful. Given that individuals are different, a variety of teaching strategies will have to be taken into account. This is because what is intelligible, plausible and fruitful to learner (A) might not be intelligible, plausible and fruitful to learner (B). Therefore, there is a need to employ a variety of teaching and learning strategies during each single learning process. According to Hewson & Hewson (2003) possible teaching strategies include:

- integration: Educators should integrate the existing conceptions with the new conceptions: Integrate what is already taught with the new conceptions (what is to be taught).
- differentiation: Differentiate clearly what they already know with what they have to learn.
- exchange: Create a conducive situation for learners to exchange the existing conception with the new conception.
- conceptual bridging: There should be a link between the abstract concept and the meaningful existing experience.

From the literature on conceptual change learners are more compatible with their misconceptions and hence tend to reject new conceptions though some tend to adopt new conceptions. Most learners view scientific conceptions as superior and this might be one of the reasons why they perceive science learning as tricky, inert and unfeasible.

2.7. Learners' misconceptions

Learner's misconceptions are often referred to as learner's conceptual misunderstanding, which in science are cases in which a person's idea or knowledge or beliefs are not compatible with scientific knowledge of which most people possessing these ideas are not aware that they are scientifically erroneous (Hanuscin, undated). The problem with misconceptions is that they are resistant to change persistent and difficult to extinguish and they hamper learners learning because learning is built on the existing knowledge and understanding (Hewson & Hewson, 1983; Dermicioglu *et. al.,* 2005). Misconceptions held by learners emanate from a variety of sources which will be looked at below.

2.7.1. Sources of misconceptions

A variety of sources has been listed by literature but only a few will be looked at here given the scope of time.

2.7.1.1. Prior knowledge

Learners' posses a certain amount of knowledge even before instruction occurs (Posner *et. al.,* 1982). This knowledge is most likely gained from home, peers, previous grade, educators, text books and everyday life experiences which are culturally embedded (Mpofu, 2006; Stepans, 1994). Unfortunately it is based on experiences rather than rules, laws, theories and principles accepted in science. This knowledge they posses is neither compatible with the scientific conceptions as indicated in Table 2 below. What they have in mind only becomes known to educators during instructions and mostly only when the proper instructional methods are used. Through instructions some of this knowledge can be abandoned and some may not. This is because misconceptions are resistant and difficult to extinguish.

Table 2 Representation of scientific conceptions and misconceptions

Scientific conception	Misconception
• Salt dissolve in water.	• When salt is poured in water it is eaten by water.
• When matter dissolves the particles of solvent and solute are completely mixed, and the particles of the solute in some cases fill up the previously empty spaces in the solvent.	• The solvent eats the dissolved salts.
• There are empty spaces between the particles of matter.	• Spaces between the particles of matter are made up of air.

Adopted from Tlala (2006)

2.7.1.2. Under qualified educators

South Africa has long since had a problem of qualified science educators if I remember well during my secondary school years I was taught in Mathematics, Biology and Physical Science by educators from other countries. Although efforts are made by the government to equip educators with skills to teach science, it is not yet enough, and as such some schools are still using under-qualified educator in junior secondary schools as well as primary schools (Mpofu, 2006). These educators obviously do not have adequate skills and experiences in dealing with learners' pre-conceived knowledge and misconceptions learners bring to science classes. Some instructional methods used by these educators may also develop or encourage learners' misconceptions. Learners will proceed with these misconceptions to their next science classes and will continue hampering their learning until realised along the teaching and learning process and dealt with accordingly.

2.7.1.3. Medium of instruction

Science like other subjects has its own vocabulary which learners need to be aware of. It is the responsibility of science educators to create a favourable environment for learners to be able to practice the language used in science. Educators as they do this, must bear in mind that, it might not be that easy for learners hence a valuable time is efficient. The other contributing factor is that the instructional language for science in South Africa is either English or Afrikaans, and not all science learners are using English or Afrikaans as their home language (Mpofu, 2006). Blacks in South Africa are using Sepedi, Setswana, Xitsonga, IsiZulu, Tshivenda, Xhosa etc, as their home language. So the use of either English or Afrikaans as an instructional language is foreign and will not be easy for them to learn (Mpofu, 2006). The use of foreign instructional language will in most cases lead to develop to them misconceptions as they try to understand and relate what they have learnt in their science classes to their real life. Naidoo (2000) cited by Mpofu (2006) approves the use of home language for instructional purposes as it enhance learners understanding and improve academic performance and provide evidence of the power of the use of home language. Educators are to see to it that they assist learners using foreign language for instructional purposes in order to use this language to learn and to have a better understanding of scientific concepts.

Basically, the ability to read is the basis for all subjects because it enables learners to interact with the learning materials (text) and at times it acts as a barrier for learner's academic achievements. As such a special attention should be given to help learners develop a deep understanding of what they are reading. Though the significance of reading in other subjects like languages, social and human sciences is acknowledged, and often assumed that the success gained in those subjects is enough to grant success in mathematics and sciences. Yet the value of reading and understanding complex scientific concepts and problem solving procedures in these disciplines is often over looked (Bohlmann *at al.,* undated). They further highlighted that reading is an important learning tool as a means of constructing new meanings, acquiring new knowledge, consolidating, modifying and expanding knowledge basis. Hence, it is important for learners to be good readers and if this is not mastered as early as possible the success of learning context will be handicapped. Educators are therefore advised to assist learners on integrating reading skills with other learning areas in order to enhance the understanding of concepts.

Teaching and learning is a two way process between the educator and the learner hence it is essential for the two to understand each other. In successful learning environments, it is important that the educator and learners understand how to interact and communicate with each other, as well as how to relate academic disciplines to learner's previous knowledge and experiences (Lee, 2002). If the educator and learners do not understand each other it will result in miscommunications and misunderstandings throughout the learning process. This is because classroom communication and interactions take place mainly through verbal communication, oral and written, understanding discussion patterns of learners from different cultures and language is an essential means in an educator's didactical methods (Lee, 2002). Educators need to understand the cultures and languages of their learners because what learners know from their cultures may be incompatible with what the educator is teaching in their science classroom, the educator must then be able to relate the science knowledge at hand with what is happening in their cultures and language. This is because learners take advantage of their cultural and linguistic resources that are compatible with the science knowledge to understand it (Lee, 2002). Learners may have an increased opportunity to learn when educators' lessons and other related activities that are conducted in a manner consistent with the standards and norms of their culture (Lee, 2002). Learning is improved when it occurs in contexts that are cognitively meaningful and relevant to learners as it is through their home cultures and languages that learners create foundations for their new understanding (Lee, 2002). The type of teaching that does not consider learners' home languages and cultures ignores the fundamental tools learners have to construct their basic knowledge and understanding, tools that can provide a meaningful basis for construction of new knowledge (Garcia, 1999). Hence there is a need for educators to accommodate all learners in their day to day teaching and learning processes for better result at the end of the day.

2.8. Reflective teaching

A successful teaching and learning of science requires educators to teach towards conceptual understanding. To accomplish this, the way educators teach in the science classroom is precisely of great significance, as this should assist learners to have the required understanding of basic science conceptions as alluded by first year science lecturers (Potgieter, Rogan & Howie, 2005; Mumba *et al.* 2002). The necessary shift as per the introduction of OBE and NCS is towards a learner-centred approach rather than educator-centred approach (DoE, 2003). Educators are gradually changing to accommodate this transition though monitoring, support and assistances are of great importance. Though a variety of teaching and learning techniques can be selected and used by educators to improve their practice assisting educators to adapt to the new way of teaching is also important. As a way of assisting educators adapt to their new way of teaching reflective teaching by Pollard can be opted for. Reflective teaching involves the eagerness to engage in constant self-appraisal and progress or development (Pollard, 1997).

In reflective teaching educators are expected to monitor, observe and collect data about their own teaching in order to reflect about it (Pollard, 1997). Pollard further highlighted that information collected then need to be critically analysed and evaluated to make judgements and decisions about the teaching observed. This may lead to the educator revising his/her plans and classroom policies before moving to the next cycle of reflecting about own teaching as this is a cyclical process. Educators need to follow the cyclical process below in figure 2 as given by Pollard as they reflect about their own teaching when they shift from educator-centred to learner-centred or from procedural teaching to conceptual teaching approaches. Figure 2 below shows a model for conceptual change teaching

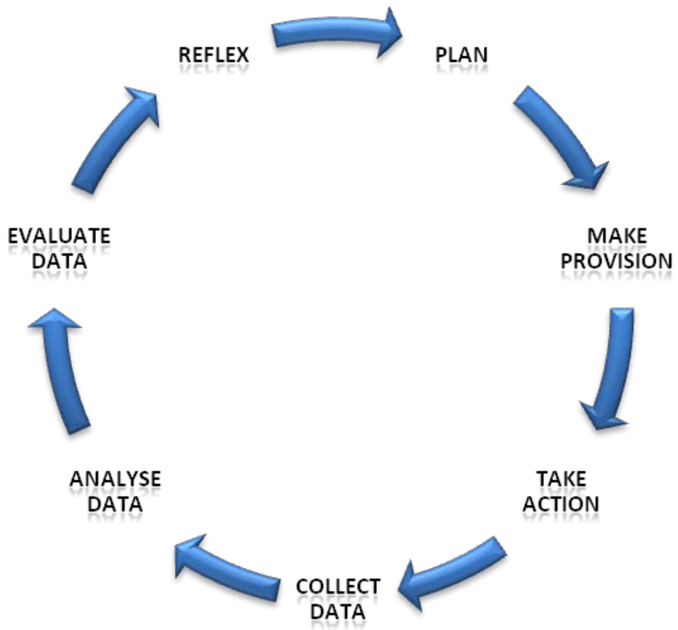


Figure 2 Reflective teaching process that can be used in POE strategy (adopted from Pollard 1997).

Through the use of the reflective teaching processes educators may be guided through self monitoring and evaluation as to whether they are teaching towards the desired change or aims and objectives of their own individual lessons. Reflective teaching is a way of committing to self-monitoring during teaching as a continuous process. Given that one of the significance of this study is to provide information on the effectiveness of the use of POE strategy in reducing learners' misconceptions, whereby learners were engaged with learner-centred approaches, there is a dire need for them to evaluate and monitor their progress. A reflective teaching which is cyclical in nature will be of help. For example, there will be a need for teachers to plan as to what is expected, then make provisions, take action which in this case involve teaching, collecting data, analysing, evaluating data, reflecting and hence plan again until the expected results are positive.

2.9. Conceptual understanding and traditional teaching

Traditional teaching and conceptual teaching envisage totally opposite directions. In traditional teaching the educator is always the main participant, chalk and talk is encouraged, teaching towards examination or test takes its tall as teaching is time bound, there is no wait-time when questions are asked, active learner participation is not encouraged (Kasanda, Lubben, Cambell, Kapenda, Kandjeo-Maringa & Gaoseb, 2003). Whereas teaching for conceptual understanding envisage learner-centred approaches, class discussions and sharing of ideas, discourage “spoon fed” learners (Kasanda et al., 2003: 134), allow wait-time, build new understanding using the ideas of others and existing learner ideas (Menegoni, undated), allow learners to hypothesise and to test their hypothesis. From the two concepts discussed above POE which is the intervention strategy for the EG, it is to uplift compared to a traditional teaching used in the CG. Traditional teaching embraced teacher demonstrations as used in the CG with little conceptual emphasis. On the other hand, teaching through POE strategy implies teaching towards conceptual understanding.

CHAPTER 3

3.1. RESEARCH DESIGN AND METHODOLOGY

3.2. Design of the study

A mixed-methods design was used because both quantitative and qualitative methods were used to collect data and participants are from the same socio-economic conditions or they are as alike as possible. Also, I wanted to see if the intervention would make a difference in the performance of the experimental group over control group. The design is shown in Table 3 below.

Table 3: Representation of the design

Experiment	T_1	I	T_2
	--		
Control	T_3		T_4

Where T_1 represents pre-test for EG, T_2 represents post-test for EG, I is the intervention strategy using POE activities, T_3 represents pre-test for CG, T_4 represents post-test for CG and the dotted line indicates that the two groups have not been equated by randomisation.

3.3. Sample

The sample consisted of 93 Grade 10 Physical Sciences learners from two neighbouring schools with ages ranging from 16 years (youngest) to 20 years (oldest). Both schools are situated in the similar rural environment, which implies that participants are familiar with socio-cultural practices in these schools (Fakudze, 2004). The schools are situated at Moutse West circuit, a rural area at Sekhukhune District in Limpopo Province (according to the new demarcations made in 2006). When these learners leave school in the afternoon they rush to their respective homes where they are faced with lack of the availability of water. They have to wait for trucks to come and sell water to them in their respective streets in their communities. In most cases they have to wait for the trucks in the morning (as from 4 o'clock) before they come to school. During lunch time they also rush home to have their meals because they do not buy meals in the tuck shops due to lack of money as parents are working in the nearby farms and earn enough to just buy basic food, clothes and water. On the other hand, most of these learners are de-motivated and view themselves as failures to extend that they do not consider themselves worth of proceeding to Universities or Colleges due to their parents' poor financial status.

I conveniently used 49 learners (31 males and 18 females) from school A as the Experimental Group (EG). The Control Group (CG) is also conveniently chosen as 44 learners (18 males and 26 females) from the neighbouring school B which are situated in different villages. These schools are conveniently chosen to have a minimal travelling distance from one school to another during data collection. The EG utilised POE teaching strategy as a treatment and the CG utilised traditional methods of teaching, chalk-and-talk as well as demonstrations. Given the conditions that these learners live in, this implies that learners from school A are unlikely to meet and discuss with learners from school B, which reduces the possibility of the contamination of data (Mpofu, 2006). Nevertheless, such cases are minimal to offset the intended outcomes.

3.4. Instruments

To limit problems that might be caused by collection of the distorted data at the end of the study a variety of instruments are used (Pollard, 1997).The instruments are: Achievement test (AT) which was the pre- and post-test (see Annexure 1). A pre-test was administered to both groups before the intervention, to determine their level of understanding of the dissolved salts concepts and to determine learners' conceptions about the dissolved salts. After the intervention, a post-test was given to all learners in both groups to determine the level of achievements compared to what they have scored in the pre-test.

1. Learners' interviews (see Annexure 2) are conducted at the end to verify data collected through AT. Since interview schedule and AT have similar questions

learners will be tempted to provide similar answers which will clearly indicate consistency in their level of achievement. Only five randomly selected learners from each group were interviewed. Five learners from each group were selected to keep the number to be interviewed as minimal as possible. Interviews occurred during leisure time and lasted for five days as leisure time takes only one hour per day and, though learner's still needed to utilise part of this hour for their personal reasons. Each interview lasted for seven to ten minutes depending on how learners elaborated their responses. Interview responses were audio-recorded following learner's permission.

2. Instructional materials. Three worksheets (see Annexure 3) on experiments conducted − used for experiment procedures and to test the learners understanding of the dissolved salts during the teaching and learning process. Data from these worksheets were not part of the results as these worksheets were used for the purpose of teaching and learning only.

3.5. Achievement Test (AT)

The AT was developed based on Physical Sciences Subject Statement, Grade 10 work schedule and Physical Sciences Learners guide, (Brookes et al., 2005), to measure the level of understanding of the dissolved salts in both EG and CG. It consisted of three questions namely, True or False questions; multiple choice questions and a few open-ended questions. All these questions were based on how salts are formed, ionisation of salts and how salts dissolve e in water. Salts that were used were common to learners, these are salts normally used in chemistry lessons. Question one consisted of five statements which learners had to classify either as true or false and if the statement is false, they have to write the correct (true) statement. In this way their knowledge, reasoning as well as their conceptions about salts could be revealed. Question two consisted of eight questions which were used as diagnostic tool which help with the designing of the teaching and learning materials in addressing the knowledge gaps and misconception based on their prior knowledge. Question three with only two questions was open-ended. It was designed for learners to reveal their own views based on how salts actually dissolve in water. This was another way of checking the knowledge learners possess and how they could reason out what they know. In all the three answered questions, each correct answer was allocated one tick which translates to one mark and there was a total of 16 marks.

The NCS require all learners to be continually assessed so in most cases if you give them a task they like to know if it was for the continuous assessment (CASS) or not, as such they become restless if the task given is for CASS. For this reason, to have them relaxed and to participate freely they were assured that the task given was not for CASS purposes and that it would not affect their class grade at the end of the term.

3.6. Validation and reliability

To ensure that the designed instruments measure what they were designed to measure, they were tested for validity and reliability. For face validity, three Physical Sciences experts (two Physical Sciences educators and one researcher) examined all the instruments with specific reference to Mpofu (2006):

1. suitability of the language used to the targeted group;
2. structure and clarity of the questions;
3. checked for overlapping questions and;
4. checked if the content was relevant to what would be taught and measured.

For the reliability, the study was piloted over the period of two weeks for consistency purposes. Grade 10 learners from the school which was not part of the sample were used. This process was done for the refinement of the tools−so the results emanating from the pilot study was not part of the main study. All teaching and learning tools were administered one after another over that period (these were the AT, experiments and interviews). Instruments were then reshaped according to comments and suggestions. Language, spelling errors, structure and clarity of questions were the main concerns indicated by educators and these concerns were incorporated in designing of instruments. The language, spelling errors, structure and clarity of questions were mainly on question 1 and 3.

3.7. Interviews

There were five open-ended interview questions which were meant to provoke learners to explain what they really understand about how salts are formed, ionise and dissolve in water. The interview session that lasted for a minimum of five minutes per learner depending on how each learner presents his/her explanations throughout the process. A total of 10 learners, five from each group were interviewed. Before the commencement of the interview each participant was asked for the permission to use the audio-recorder. Each interview session per learner took a maximum of 15 minutes. The purpose of using this instrument was clearly explained, that it will assist the researcher during data transcription using open coding process and data was further categorised into statements with either acceptable scientific meaning or statements with unacceptable scientific meaning.

3.8 Procedure

Teaching and data collection took five weeks for both EG and CG. Five weeks were used because it was not possible to visit the two schools in parallel. The researcher analysed learners' answers after the pre-test, to grasp misconceptions in both groups. Treatment lessons were conducted after pre-test analysis for proper designing of the teaching materials. After the pre-test, answers were not revealed to learners for the post-test that was yet to be done. Both EG and CG were taught similar content knowledge over the same time interval, one hour period per contact session, the only difference was that the teaching strategies (POE) was taught to EG group only.

3.9 Instructional materials

Instructional materials used were aimed at addressing misconceptions learners have and to develop scientific conceptual understanding about the dissolved salts. Materials consisted of three worksheets on: how salts are formed, ionisation of salts, and how salts dissolve in water. The use of these worksheets required an active participation of learners (EG) as they were using POE strategy. They were asked to state their hypothesis or predictions; set up the apparatus as indicated in the worksheet in order to perform experiments; observe to verify their predictions and to answer questions based on their observations as well as explaining their findings. This helped them to integrate new conceptions with their existing conceptions. The same content was taught to the CG through traditional teaching approaches. Figures 3-5 below are flow diagrams that show the instructional sequence used in the EG. Directions of arrows indicate the order of presentation of ideas. Teaching procedures in these diagrams are depicted as arrows between actions taken by learners during their learning process.

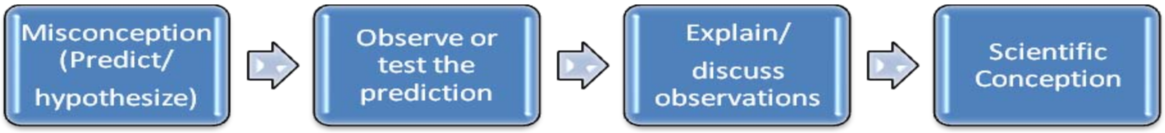


Figure 3 Representation of teaching procedures in POE strategy.

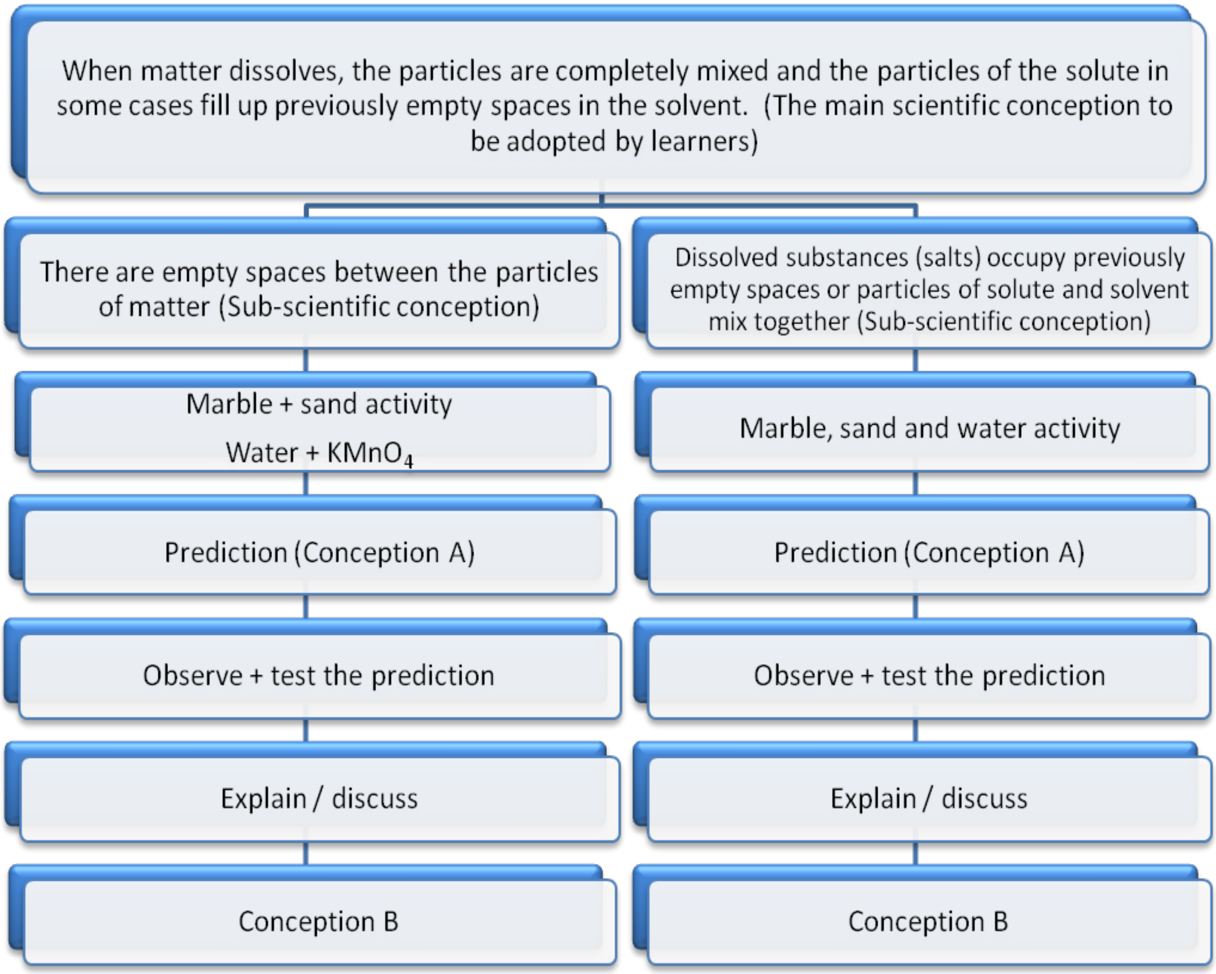


Figure 4 Representation of instructional procedures, Misconception (conception A or learner's misconceptions as stated in their prediction) and scientific conception (conception B or scientifically accepted concept emanating from what they have observed and discussed as a group during the treatment).

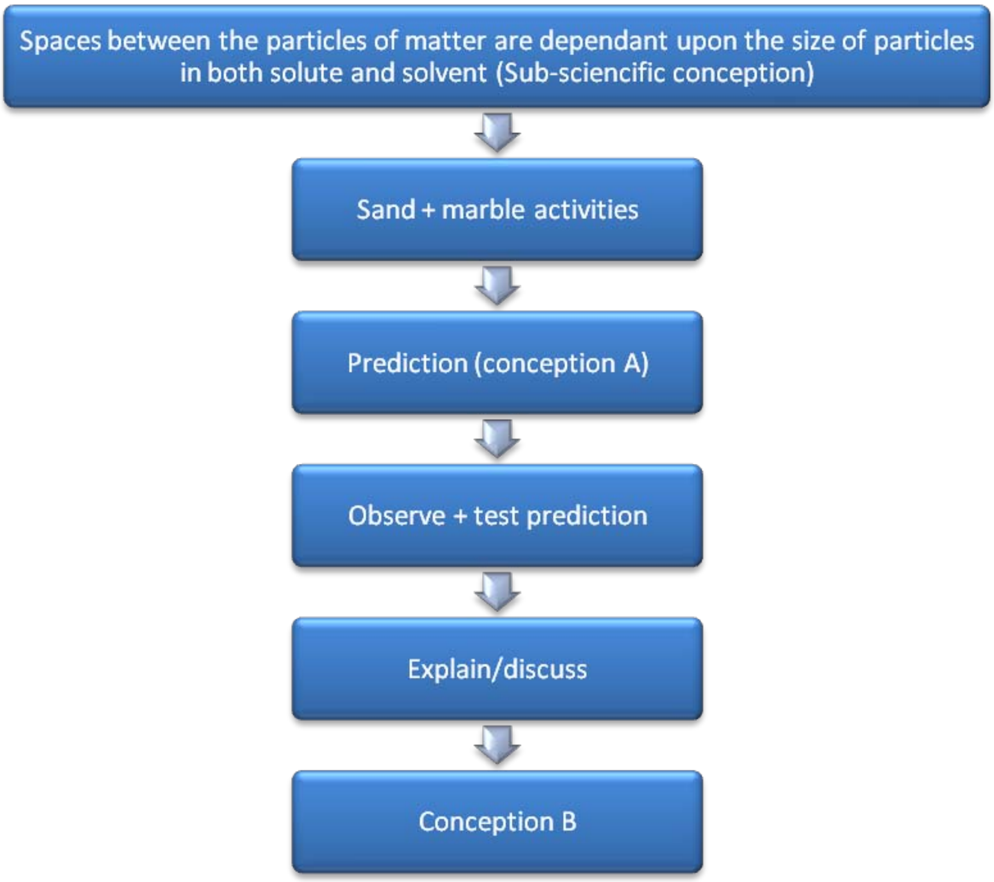


Figure 5 Representation of instructional procedure, misconceptions (conception A or learner's misconceptions as stated in their prediction) and scientific conception (conception B or scientifically accepted concept emanating from what they have observed and discussed as a group during the treatment).

3.10. Data analysis

Due to the nature of data collected through pre-and post test and interviews both qualitative and quantitative descriptions were used to analyse data. For quantitative data analysis the Statistical Package for Social Sciences (SPSS) version 17 was used. To find out if there is a significant difference in learners' achievements the t-test was used. Analysis of Co-variance (ANCOVA) was also used to reduce the variation due to error that might have occurred prior to intervention. Thus establishing homogeneighty. The t-test (the independent sample t-test) used was similar to the one used by Cibik, Diken & Darcin (2008) in their study about the effect of group works and demonstrative experiments based on conceptual change approach: Photosynthesis and respiration conducted at Gazi University. Their results revealed that group work and demonstrative experiments based on conceptual change seem to be effective in eliminating misconceptions in photosynthesis and respiration in plants. The qualitative data collected through interviews were coded using open coding process to form themes that were organised into categories.

3.11. Limitations of the study

For convenient this study was limited to two neighbouring schools where the permission was granted from the principals, departmental head educators and learners themselves. The type of learners used in this study did not have enough time to work together to discuss most of their issues due to their social challenges, especially after school hours. The convenient sampling procedures used in this study decrease the ability to generalise the findings since the sample does not represent the total population of Grade 10 Physical Sciences in Moutse West circuit. Though, the findings yield an overview of the effect of the POE intervention in reducing learners' misconceptions about the dissolved salts.

3.12. Ethical issues

The design of this study implies subjecting two groups involved to two different teaching strategies. For equity and fairness the two groups were exposed to the same content knowledge. Permission for all these was earnestly sorted out with principals, departmental head educators and learners themselves. All data collected were handled with anonymity throughout this report. The audio-recorded data made through the permission of the participants was only used for the purpose of reporting in this study.

CHAPTER 4

4.1. RESULTS

Data obtained from the pre- and post-test was analysed using descriptive statistics, t-test and the ANCOVA. Data obtained from the interviews were coded according to their similar meaning and categorised into two groups, group one which are scientifically acceptable meanings and group two scientifically unacceptable. Both results obtained from the quantitative and qualitative analysis are reported below.

4.2. Results of quantitative analysis

Data analysed under this category was mainly from pre-post tests attempted by both groups with the aim of comparing their achievements before and after teaching using POE (intervention) in the experimental group and using traditional teaching approach in the control group. Different tables represent results obtained in this study.

Table 4: Achievement Test (AT) scores from pre-test of control and experimental group (* significant at p < 0. 05).

Question	Pre-test	Mean	SD	*P*
1.1.	Control	0.50	0.51	0.39
	Experimental	0.53	0.50	
1.2.	Control	**0.23**	**0.48**	**0.00***
	Experimental	**0.55**	**0.54**	
1.3.	Control	0.89	0.32	0.34
	Experimental	0.86	0.35	
1.4.	Control	**0.77**	**0.42**	**0.03***
	Experimental	**0.59**	**0.50**	
1.5.	Control	0.70	0.46	0.29
	Experimental	0.76	0.43	
2.1.	Control	0.45	0.50	0.05
	Experimental	0.29	0.46	

2.2.	Control	0.80	0.41	0.19
	Experimental	0.71	0.46	
2.3.	Control	0.43	0.50	0.36
	Experimental	0.47	0.50	
2.4.	Control	0.59	0.50	0.34
	Experimental	0.63	0.49	
2.5.	Control	0.41	0.50	0.07
	Experimental	0.27	0.45	
2.6	Control	**0.27**	**0.45**	**0.04***
	Experimental	**0.24**	**0.43**	
2.7	Control	0.25	0.44	0.15
	Experimental	0.16	0.37	
2.8	Control	0.20	0.41	0.41
	Experimental	0.22	0.42	
3.1	Control	0.00	0.00	##
	Experimental	0.00	0.00	
3.2.	Control	0.00	0.00	##
	Experimental	0.00	0.00	

indicates that there was zero achievements in the test that cannot be tested using t-test

When Table 4 above was analysed, no significant difference was found among pre-test achievement scores of the control and experimental groups for questions 1.1, 1.3, 1.5, 2.1, 2.2, 2.3, 2.4, 2.5, 2.7, 2.8, 3.1 and 3.2. The p value for each of the later questions is greater than 0, 05. To avoid biasness only questions where there was no significant difference in achievement were used in data analyses. The ## indicated in the table above implies that since there was a zero achievement the t-test failed to compare the performance in both question 3.1 and 3.2 and these also appear in Table 7 below.

The post-test AT was conducted in both experimental and control groups in order to identify if there are any significant differences in the learners Achievements of the two groups. The results obtained are illustrated in Table 5 .1 below:

Table 5.1: Achievement Test (AT) scores from post-test of control and experimental group (* significant at $p < 0.05$).

Question	**Post-test**	**Mean**	**SD**	***P***
1.1	Control	0.64	0.49	0.00*
	Experimental	0.90	0.31	
1.2	Control	0.23	0.48	0.00*
	Experimental	0.55	0.54	
1.3	Control	0.77	0.42	0.00*
	Experimental	0.96	0.20	
1.4	Control	0.77	0.42	0.03*
	Experimental	0.59	0.50	
1.5	Control	0.52	0.51	0.00*
	Experimental	0.80	0.41	
2.1	Control	0.39	0.49	0.00*
	Experimental	0.88	0.33	
2.2	Control	0.82	0.39	0.01*
	Experimental	0.96	0.20	
2.3	Control	0.55	0.50	0.00*
	Experimental	0.84	0.37	
2.4	Control	0.52	0.51	0.00*
	Experimental	0.86	0.35	
2.5	Control	0.27	0.45	0.45
	Experimental	0.29	0.46	
2.6	Control	0.27	0.45	0.04*
	Experimental	0.24	0.43	
2.7	Control	0.59	0.50	0.01*
	Experimental	0.82	0.39	
2.8	Control	0.30	0.46	0.39

	Experimental	0.33	0.63	
3.1	Control	0.00	0.00	0,00*
	Experimental	0.22	0.42	
3.2	Control	0.00	0.00	0.01*
	Experimental	0.10	0.31	

The results illustrated in Table 5.1 above show that learner's achievement in question 2. 5 and 2.8 were not significantly different for two groups (p > 0. 05) and this form only 13. 3% of the questions learners attempted compared to 86.7% questions in which achievement was significantly different (p < 0.05). Generally, in 12 cases, the mean scores of the experimental group were higher than that of the control group with exception of item 1.4 where the mean scores of the experimental group was less. The overall post-test results for both control and experimental groups were also conducted using a t-test and the results are illustrated in Table 5.2 below:

Table 5.2 Overall Post-test results from both control and experimental groups (* significant at p < 0.05).

Group	**Number**	**Mean**	**SD**	**Df**	**T-test**	***P***
Control	**44**	**20.87**	**12.31**	**43**	**2.62**	**0.00***
Experimental	**49**	**34.07**	**15.12**	**48**		

From Table 5.2 above, the achievements of the experiment group after treatment (mean 34. 07 ± 15. 12 SD) was higher than the control group (mean 20. 87 ± 12. 31 SD) and these means were significantly different (t = 2.62; p < 0. 05).

Are there any significant differences between post-test achievements of the experimental group and the pre-test achievements?

In order to determine if there were any significant differences in achievement for each question between post- and the pre-test of the experimental group, a t-test was used and the results are shown below (Table 6).

Table 6 Pre- and Post-test Achievement Test (AT) scores from Experimental group per question (* significant at p < 0.05).

Question	Test	Mean	SD	*P*
1.1	Pre-test	0.53	0.50	0.00
	Post-test	0.90	0.31	
1.2	Pre-test	0.55	0.54	0.00*
	Post-test	1.10	0.85	
1.3	Pre-test	0.86	0.35	0.04*
	Post-test	0.96	0.20	
1.4	Pre-test	0.59	0.50	0.27
	Post-test	0.65	0.48	
1.5	Pre-test	0.76	0.43	0.32
	Post-test	0.80	0.06	
2.1	Pre-test	0.29	0.46	0.00*
	Post-test	0.88	0.33	
2.2	Pre-test	0.71	0.46	0.00*
	Post-test	0.96	0.20	
2.3	Pre-test	0.47	0.50	0.00*
	Post-test	0.84	0.37	
2.4	Pre-test	0.63	0.49	0.00*
	Post-test	0.86	0.35	
2.5	Pre-test	0.27	0.45	0.41
	Post-test	0.29	0.46	
2.6	Pre-test	0.24	0.43	0.00*
	Post-test	0.73	0.45	
2.7	Pre-test	0.16	0.37	0.00*
	Post-test	0.82	0.39	
2.8	Pre-test	0.22	0.42	0.17
	Post-test	0.33	0.63	
3.1	Pre-test	0.00	0.00	0.00*
	Post-test	0.22	0.42	
3.2	Pre-test	0.00	0.00	

	Post-test	0.10	0.31	0.01*

Table 6 above shows that there was a significant difference between pre- and post-test scores in the experimental groups' achievement test in 11 questions out of 15 attempted. This implies that learners achievement in 73.3% of the questions are significant ($p<0.05$). In the remaining 26.7%, 20% of learners were mixing dissolving, disappear and melting in their responses whereas 6.7% of learners were uncertain about the ionic nature of salts.

Are there any significant differences between post-test achievements of the control group and the pre-test achievements?

In order to determine if there were any significant differences in achievement for each question between post- and the pre-test of the control group, a t-test was used and the results are shown below (Table 7).

Table 7 Pre- and Post-test achievement Test scores from control group (* significant at p < 0.05).

Question	**Test**	**Mean**	**SD**	***P***
1.1	Pre-test	0.50	0.51	0.10
	Post-test	0.64	0.49	
1.2	Pre-test	0.23	0.48	0.00*
	Post-test	0.91	0.71	
1.3	Pre-test	0.89	0.32	0.08
	Post-test	0.77	0.42	
1.4	Pre-test	0.77	0.42	0.12
	Post-test	0.77	0.48	
1.5	Pre-test	0.70	0.46	0.41
	Post-test	0.52	0.47	
2.1	Pre-test	0.45	0.50	0.26
	Post-test	0.39	0.49	
2.2	Pre-test	0.80	0.41	0.40

	Post-test	0.82	0.39	
2.3	Pre-test	0.43	0.50	0.15
	Post-test	0.55	0.50	
2.4	Pre-test	0.59	0.50	0.26
	Post-test	0.52	0.51	
2.5	Pre-test	0.41	0.50	0.09
	Post-test	0.27	0.45	
2.6	Pre-test	0.27	0.45	0.16
	Post-test	0.18	0.39	
2.7	Pre-test	0.25	0.44	0.00*
	Post-test	0.59	0.50	
2.8	Pre-test	0.20	0.41	0.17
	Post-test	0.30	0.46	
3.1	Pre-test	0.00	0.00	##
	Post-test	0.00	0.00	
3.2	Pre-test	0,00	0.00	##
	Post-test	0,00	0.00	

indicates that there was zero achievements in the test that cannot be tested using t-test.

Table 7 above shows that there was significant difference between pre- and post-test scores in the control groups' achievement test in two questions of the 15 attempted. This implies that learners achievement in 13.3% of the questions were significantly different ($p < 0.05$).

Are there any significant difference in Achievement Test between post-test of control and experimental group for males versus females?

In order to determine if there were any significant differences in achievement for each question between post-test of the control and the experimental group for males versus females, a t-test was used and the results are shown below (Table 8 and 9).

Table 8 Post-test experimental AT for males versus females (* significant at $p < 0.05$).

Gender	Number	Mean	SD	Df	T-test	*P*
Males	**31**	**21.13**	**9.72**	**30**	**2.85**	**0.00***
Female	**18**	**12.73**	**5.97**	**17**		

Table 8 above shows the comparison of the gender differences in the Achievement Test scores of the experimental group. The table further shows that the males (mean 21.13 ± 9.72 SD) had higher means than females (mean 12. 73 ± 5. 97 SD) and their differences were significant ($t = 2.85$; $p < 0.05$). For the post-test control the results are shown below: (Table 9).

Table 9 Post-test control group AT for males versus females (* significant at $p < 0.05$).

Gender	Number	Mean	SD	Df	T-test	*P*
Males	**18**	**9.13**	**8.43**	**17**	**-1.22**	**0.12**
Female	**26**	**12.53**	**6.80**	**25**		

Table 9 shows that the females (mean 9.13 ± 8. 43 SD) had higher means than males (mean 12. 53 ± 6. 80 SD) although these differences were not significant ($t = -1.22$, $p > 0.05$).

In order to ascertain whether the intervention had an effect on the experimental group ANCOVA was used on control and experimental pre- and post-tests. Thus, ANCOVA ″adjusted″ post-test scores for variability on the covariate (pre-test). The ANCOVA summary results below indicate that for experimental group (SS 57. 37 ± 13. 38 F; $p < 0.05$) and for control group (SS 6. 34 ± 1. 49 F; $p < 0.05$) (Table 10). This implies that the two groups are homogeneous and hence they are comparable.

Table 10 ANCOVA summary of pre- and post test scores of experimental and control groups (* significant at $p < 0.05$).

Source	SS	DF	F	*P*
Control	**6.34**	**1**	**1.49**	**0.23**
Experimental	**57.37**	**1**	**13.38**	**0.00***
Error	**386.03**			

4.3. Results of qualitative analysis

The following results were obtained from three questions analysed separately with the aim of investigating on how learners performed in all the questions.

4.3.1. Results for question 1.

This was a true or false question with five statements. Learners were asked to provide a true statement when they feel that the statement given is false. From the five statements provided, only statement number 1.2 (All salts can dissolve in water) was false. Before treatment using POE strategy the mean score value was 0.55 which was found to be lower than the mean score value of 1.10 obtained after the treatment which is an indication of the improved performance. Below are some of the true statements provided by learners from the experimental group, who said statement 1.2 is false before the intervention process.

Learner 1: "Salts are not ionic compounds".
Learner 2: "Salts melt and disappear in water".
Learner 3: "Other salts can dissolve when they are fine".
Learner 4: "Because salts disappear when they dissolve in water".
Learner5: "They are chosen salts that dissolve in water".

From the above statements provided by learners it is clear that learners who provided correct answer "false" for statement 1.2 during a pre-test do not have a clear understanding of what a salt is, though they may be aware that not all salts can dissolve in water.

After the treatment in the experimental group most learners' were able to provide an acceptable answer, that is, "false" with the true statement "some salts cannot dissolve in water or not all salts can dissolve in water" hence the improved performance.

Learner 1: "Some salts cannot dissolve in water."
Learner 2: "Some salts cannot dissolve in water"
Learner 3: "Not all salts can dissolve in water"
Learner 4: "Some salts cannot dissolve in water"
Learner5: "Not all salts can dissolve in water"

From the control group, before teaching occurred, all learners provided "true" for statement 1.2 (All salts can dissolve in water) and only a few numbers of learners were able to provide the correct supporting statements for this question. After teaching there was a slight increase in achievement for this question as the mean score value managed to increase from 0.23 to 0.91. Below are some of the supporting statements provided by learners who said statement 1.2 is false after the intervention process, these statements indicate that there is still retention of misconceptions.

Learner 1: "Some salts are not ionic compounds".
Learner 2: "Salts melt when they dissolve in water"
Learner 4: "Because salts disappear when they dissolve in water".

4.3.2. Results for question 2

This was a multiple choice question based on how salts are formed, how do they ionise and how they dissolve in water. The crux of this question was on question 2.8 as indicated below:
"The diagram below represents a mixture of H_2O and NaCl in a closed container.

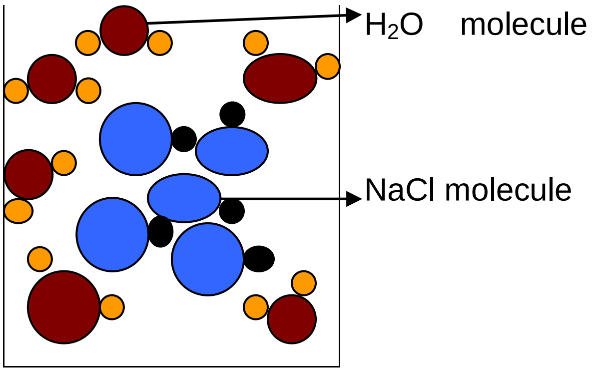


Figure 6 Water and sodium chloride molecules mixtures in a closed container.

Which diagram shows the results after the mixture reacts as completely as possible according to the equation $NaCl_{(s)} + H_2O_{(l)} \leftrightarrow Na^+_{(aq)} + Cl^-_{(aq)}$. Give a reason for your choice.

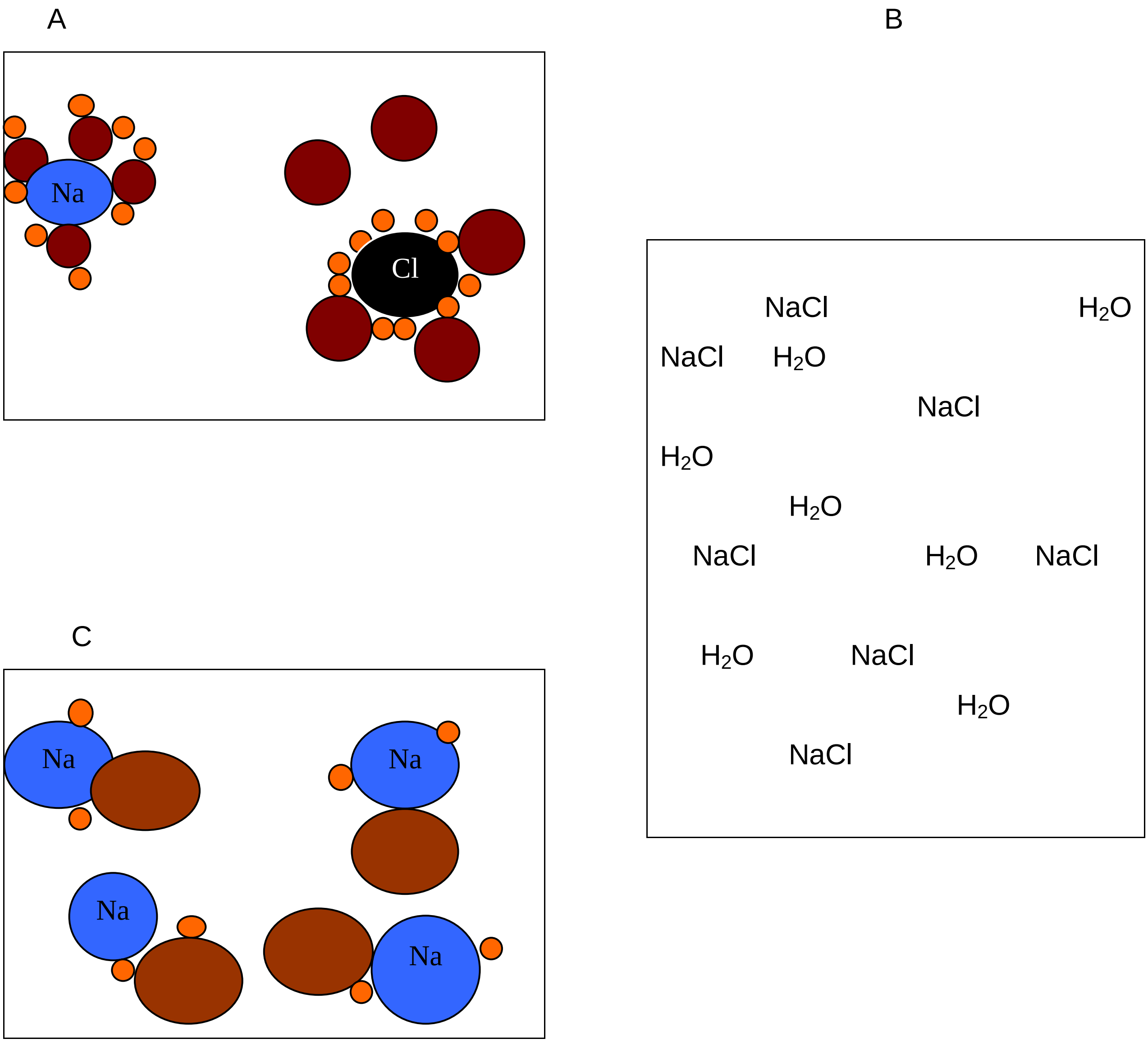


Figure 7 Possible results of the mixture of water and sodium chloride a, b, c.

The correct answer for this question is C and the correct reasoning is that: “NaCl dissolve completely in H_2O. During that process the δ^- ends of the water molecule (oxygen end) attract the positive ion (Na^+_{aq}) and the δ^+ ends of the water molecule attract the negative ion (Cl^-_{aq})”. The mean score value managed to increase from 0.22 to 0.33 indicating a slight improvement in achievement by the experimental group learners after the treatment. Below are the statements used by experimental group learners before treatment occur as responses for question 2.8 above:

Learner 1: "Because it shows a good combination".
Learner 2: "Because it represents the separated ions".
Learner 3: "Because it shows the results after the mixture reacts as completely as possible".
Learner 4: "Because salt has dissolved in water".

4.3.3. Results for question 3

This question was having only two sub-questions as indicated below:

3.1. In your own view what happens when salt like NaCl dissolves in water. Use a diagram/s and chemical equation/s to support your opinion.

3.2. Some salts do not dissolve in water. In your own view what happens when salts do not dissolve in water. You may use diagram/s and chemical equation/s to support your opinion.

This question needed learners own understanding of what happens when salts dissolve in water or what happens when it does not dissolve in water. Before the intervention the two sub-questions for both experimental and control groups, none of learners provided the correct answers as indicated in Tables 6 and 7 above. After the intervention there was a slight change in the experimental group unlike in the control group where there was absolutely no change in learners' achievement. The mean score values in the experimental group managed to increase from 0.00 to 0.22 (question 3.1) and from 0.00 to 0.10 (question 3.2). Below are sample answers provided by experimental group learners before treatment:

Learner 1: No. 3.1. "Because water change to a substances which you cannot taste. Salt dissolves in water in a similar particle."
No. 3.2. "When some salts are not dissolved in water it means it is not fine, when it is fine it can dissolve in water."

Learner 2: No. 3.1. "When salt dissolve and melt in water chemically it will turn the water salty"
No. 3.2. "Some salts that do not dissolve in water have no enough ionic

acid and we may say that no chemical is added."

Learner 3: No. 3.1. "When salts dissolve in water they form a mixture of NaCl and H_2O."

No. 3.2. "The salt that do not dissolve in water stay down and the water is on top."

Learner 4: No. 3.1. "When salt like NaCl dissolve in water, the water began to change colour"

No. 3.2. "If salts do not dissolve in water, nothing happens with water. There is no change."

4.4. Results from semi-structured interviews

Individual semi-structured interviews were conducted with five learners from each group (control and experimental: a total of 10 learners, three males and two females from each group) immediately after the post-test was written. This was intended to grasp what learners' understanding about what they had learnt throughout the process of teaching and learning in this study. Learner's responses were audio-taped and transcribed during data analysis. Responses were coded according to their similar meanings and categorised as scientifically accepted or unaccepted meaning. Learner's responses are listed and tabulated below:

Data from interviews.

Question 1 Can you briefly explain how salts are formed?

Experimental group:

Learner 1: "Salt is the product of an acid and a base."

Learner 2: "It is formed when metals react with acids."

Learner 3: "It the product of an acid and a metal hydroxide."

Learner 4: "Product of acids and bases."

Learner 5: "We get salts out of the acid and base reaction."

Control group:

Learner 1: "Salts are formed when acid react with bases."

Learner 2: "When base and an acid react."

Learner 3: "Product of acid and base."

Learner 4: "Product of acids and bases."

Learner 5: "When acids react with metals."

Question 2 Mention the few salts that you know and please tell which salts are soluble in water from what you have mentioned.

Experimental group:

Learner 1: "NaCl, KCl and $CaCl_2$ they are all soluble in water."

Learner 2: "KCl, $NaNO_3$, NaCl and AgCl and AgCl are not soluble."

Learner 3: "$CaCO_3$ and NaCl and they all dissolve in water."

Learner 4: "$CaCl_2$, NaCl and $NaNO_3$ they all dissolve in water."

Learner 5: "$PbNO_3$, AgCl and NaCl only NaCl dissolves in water."

Control group:

Learner 1: "NaCl, KCl and $NaNO_3$ they are all soluble in water."

Learner 2: "$CaCl_2$ and NaCl all soluble in water."

Learner 3: "NaCl, KCl all soluble in water."

Learner 4: "KCl, NaCl, they are all soluble in water."

Learner 5: "AgCl and NaCl and NaCl dissolve in water."

Question 3 Is water a polar or a non polar substance? Are salts ionic or polar in nature?

Experimental group:

Learner 1: "Salts are ionic and water is polar."

Learner 2: "Salts are ionic in nature and water is polar."

Learner 3: "Water is polar in nature and salts are ionic in nature."

Learner 4: "Salts are ionic and water is polar."

Learner 5: "Salts are ionic and water is polar."

Control group:

Learner 1: "Salts are ionic and water is polar."

Learner 2: "Salts are ionic and water is polar."

Learner 3: "Water is polar and salts are ionic in nature."

Learner 4: "Water is polar in nature and salts are ionic in nature."

Learner 5: "Salts are ionic and water is polar."

Question 4 What will happen to the salts, which will not dissolve in water?

Experimental group:

Learner 1: "Undissolved salt will settle at the bottom of the container."

Learner 2: "Salt which did not dissolve will precipitate."

Learner 3: "A precipitate of undissolved salt will form at the bottom of the container."

Learner 4: "Undissolved salt will settle itself at the bottom of the container."

Learner 5: "All undissolved salts will settle at the bottom of the container."

Control group:

Learner 1: "All salts will dissolve and no salt will be undissolved."

Learner 2: "Undissolved salt will settle at the bottom of the beaker."

Learner 3: "Undissolved salts will form at the bottom of the container"

Learner 4: "Salts and water will be separated from one another and it will not dissolve in water".

Learner 5: "Salt will not mix with water they will be separated so it does not dissolve."

Question 5 Explain how salts dissolve in water.

Experimental group:

Learner1 : "When salts melt in water it disappears and turn the water salty."

Learner 2: "As salt dissolve in water the $\partial+$ end of water attract the - Cl ion and the $\partial-$ end of water attract the + Na ion the water become salty in that way."

Learner 3: "In that process it means that when NaCl dissolve in water the $\partial+$ side of water attract the negative Cl ion and the $\partial-$ side of water attract the positive Na ion and water become salty."

Learner 4: "When salt dissolves the $\partial+$ end of water attract the negative Cl ion and the $\partial-$ end of water attract the positive Na ion the water become salty in that way."

Learner 5: "As soon as salt dissolves in water the positive ions of NaCl become attracted to the $\partial-$ end of water and the negative ions of NaCl become attracted to the $\partial+$ end of water then water become salty."

Control group:

Learner 1: "Water will just be salty when salt melt and disappear in it."

Learner 2: "When sodium chlorine salt dissolves in water the $\partial+$ end of water attract the - Cl ion and the $\partial-$ end of water attract the + Na ion."

Learner 3: "When salts dissolve in water they disappear and turn the water salty."

Learner 4: "When salt dissolves in water the negative end of water attract the oppositely charged ion of NaCl and the positively end of water will attract the negative chlorine ion."

Learner 5: "Sodium chlorine melts in water it makes water too salty."

Table 11 Learners interview responses from both control and experimental group.

QUESTION NUMBER	ACCEPTABLE RESPONSES	PERCENTAGE OF ACCEPTABLE RESPONSES FROM CONTROL GROUP	PERCENTAGE OF ACCEPTABLE RESPONSES FROM EXPERIMENTAL GROUP
1	"Salt is the product of an acid and a base." "It is formed when metals react with acids." "It the product of an acid and a metal hydroxide."	**100%**	**100%**
2	"KCl, $CaCO_3$, $CaCl_2$, $PbNO_3$ $NaNO_3$, NaCl and AgCl. AgCl and $PbNO_3$ are not soluble."	**100%**	**100%**
3	"Salts are ionic and water is polar."	**100%**	**100%**
4	"Undissolved salt will settle at the bottom of the container."	**40%**	**100%**
5	"As salt dissolve in water the ∂+ end of water attract the – Cl ion and the ∂- end of water attract the + Na ion the water become salty in that way."	**40%**	**80%**

CHAPTER 5

DISCUSSION

5.1. Summary of findings

As outlined in chapter 3, two groups of Grade 10 learners consisting of the experimental and control group participated in the study. Both groups wrote the pre- and, post-test and five learners from each group were interviewed after the post-test. Experimental group was exposed to POE teaching strategy while the control group was exposed to traditional teaching. Thus, the study aimed at finding out the effectiveness of POE strategy on learners' performance compared to those learners who were taught using traditional strategies. The results show that the experimental group outperformed the control group (Table 5.2 and Table 10). Interviews show that learners from experimental group have a better understanding on how salts dissolve in water than the control group (Table 11). But the table shows that questions 1-3 all groups achieved 100% and it was questions 4 & 5 where control got 40%. Also, the understanding of scientific concepts regarding dissolving of salts differed significantly between learners taught using POE and those taught using traditional strategies. This significant difference is evident from the t-test in Table 5.1 questions 3.1 and 3.2 where the mean of the control group is 0.00 (SD 0.00) in both questions and that of the experimental group is 0.22 (SD 0.42) and 0.10 (SD 0.31) respectively. The differences in the mean scores obtained by the two groups suggest that POE learners performed better. Thus, POE approach based on the principles of constructivism was able to assist learners to achieve what they achieved at the end of the intervention. POE emphasises the use of learner's prior knowledge as the basis of their learning. The importance of learner's prior knowledge is also emphasised by Piaget (1970) and Vygotsky (1986) in his social constructivism where the learner is singled out as the constructor of new knowledge and the active participant throughout their learning event. The success of POE as a teaching approach is not just viewed as a step by step strategy, but a strategy which take into consideration the constructivist approach that includes reflective teaching process unlike the traditional approach which emphasises chalk and talk (Kasanda *et*. *al*., 2003).

To assist learners to realise and abandon their misconceptions learner-centred activity-based strategy was used in the experimental group as a package of POE. This strategy is also emphasised and preferred by the NCS, which encourages learner-centred and activity-based strategies rather than educator-centred activities (DoE. 2003). The learner-centred approach requires learners to be active in the classroom and participate at all levels as they make sense of their learning materials (Mahendra *et. al.,* 2005). “Learner-centred teaching implies the use of teaching strategies such as group work and class discussions maximised learner participation in the lesson” (Kasanda *et*. *al*., 2003: 133). The two frames of learner-centred teaching are the crux of POE strategy used in this study. In POE, learner-centred teaching acknowledges the social construction of knowledge and the basis of all learning, that is, ‘learner’s prior knowledge’. In this study both prior knowledge, group work and class discussions were incorporated. On the other hand, the traditional teaching strategy used by the control group was educator-centred and learners were in most times passive in their learning process. The educator gave information to learners and the learners’ duty was to learn information provided by the educator in order to reproduce it during the test without making sense or meaning of what was to be learnt. In the teaching and learning process the role of both the educator and the learner should be compatible with the contemporary learning theories. Science was taught through ‘rote learning-memorisation’, ‘cook book recipe’ and ‘content-based’ teaching was emphasised rather than teaching to provoke critical thinking, reasoning reflection and action (Dekkers, 2005) and little if any is achieved by learners (Yager, 1995).

The findings that were gathered from Chapter 4 will be discussed under two headings in relation to the major themes emerging from this study. These themes are: the effect of POE strategy on learners’ misconceptions about the dissolved salts, and the effect of POE strategy on learners’ achievement on the test regarding the dissolved salts.

5.2. The effect of POE strategy on learners' misconceptions about the dissolved salts.

Judging from the mean values the results of the two groups were not significantly different before the intervention ($p > 0.00$) at least in 80% of the questions. Pre-test revealed that there are a number of misconceptions held by learners in both groups. Learners believe that salts 'disappear' when dissolving in water (37% of the responses in the 80% from the pre-test) and that salt 'melt' when dissolving in water (27% of the responses in the 80% from the pre-test). Interview results as shown in Table 11 show that learners from experimental group had better understanding of concepts because out of 5 learners only one exhibited some misconceptions. On the other hand, three learners out of 5 from the control group exhibited some misconceptions. These misconceptions are similar to misconceptions found by Piaget & Inhelder (1974) in their study conducted in London concerning the child's construction of quantities, and similar to Cosgrove & Osborne (1981) study, in New Zealand, regarding Physical change: A working paper of the Learning in Science Project (no. 26). The same misconceptions are also listed by Hapkiewicz (1999) in his list of common Physical Science misconceptions. Sixteen percent (16%) of the responses from the 80% of the questions learners answer show that salts dissolve in water when it is in 'fine' grains and that solid salt (sodium chloride) is not an ionic compound. To the best of my knowledge, these two misconceptions are identified for the first time. Thus, these misconceptions can be added to the existing list of misconceptions in the literature and more research is needed in order to find out how prevalent these misconceptions are among South African learners as well as in other countries.

From the post-test results in Table 6, learners achievement in 73.3% of the questions were significantly different ($p < 0.05$) in the experimental group which implies that learners had acquired acceptable science concepts whereas learners achievement in only 13.3% of the questions in the control group exhibited the acceptable science concepts. In the experimental group 20% of learners held misconceptions on dissolving as the disappearance and at times they called it a melting process in their responses whereas only 6.7% were uncertain about the ionic nature of salts. These findings agree with what other researchers found in their work about conceptual change strategies, that though a variety of teaching methods are tried to minimize learners' misconceptions, not all learners abandon their misconceptions. Misconceptions are resistant to change, persistent and difficult to extinguish (Hewson & Hewson, 1983; Hubber, 2005; Demircioglu *et. al* 2005). Conversely, no learner from experimental group mentioned that salts dissolve in water when they are in 'fine' grain. This suggests that this misconception was eliminated in the experimental group after the treatment, but not in their control group counterpart.

What transpired from the interviews is that in both groups learners were confident and seemed to be sure of what they were saying when attempting question 1-3 and they both scored 100%. In question 4 and 5, three learners (not necessarily the same learners as seen from the interview data) in each question from control group were uncertain of what they were saying as they could not explain as to how salts dissolve in water and what happened to the undissolved salt. From the experimental group only one learner was uncertain about how salts dissolve in water. Interview data was categorised into three themes (1) macroscopic understanding of dissolving, (2) microscopic level for salts (3) microscopic level for solvent. In these three themes learners did well on the first. The control group missed both 2 & 3. For experimental, they were able to explain salt at microscopic level where they talk of + and – charged ions. They forgot the solvent which was water and also could form ions. These ionic formation would explain the concept of 'like dissolve in like'. Two major categories are the observable (macro) and the micro (the unobservable like ions) which was further divided into acceptable and unacceptable scientific meaning as seen in Annexure 4 further simplified into Table 11.

Question 4 and 5 were not the same but they were interrelated. Question 4 seeks learners to understand what will happen to undissolved salt. It was only looking to a simple answer that the undissolved salt will precipitate. Two learners in the control group know that the salt will not dissolve but they did not have the relevant scientific term to be used and the third learner could not remember that some salt may not dissolve in water. Question 5 seeks for learner's understanding of how salts dissolve in water and learners were expected to show their understanding of how ions from salts and polar ends of water attract one another as salts dissolve in water-'like dissolve like' principle. Three learners from control group and one learner from the experimental group could not provide the expected answer, but they only could remember that salt will disappear and turn water salty. Though this is the truth these learners could not explain in details. They were at macroscopic level and this suggests that these learners could not explain how in essence the two could mix with one another, suggesting that even at the microscopic level of chemistry these learners had difficulties to account for the observed changes. On the other hand, learners from the experimental group explained clearly how salts dissolve in water through the help of the class activities they have participated in, such as ionisation of salts in worksheet number 2 and work sheet number 3 about how salts dissolve in water using POE strategy. Thus, the experimental group had clear understanding of what they observed and were able to explain at this macroscopic level. Conversely, learners encountered difficulties when explaining question 4 and 5 as these are based on micro-chemistry. They could not account for the concept of 'like dissolve like' in their explanations.

5.3. The effect of POE strategy on learners' achievement on the test regarding the dissolved salts

The achievement of the experimental and control group from pre-test results were not significantly different which suggest that the two groups had similar achievements and similar understandings of concepts. Conversely, results from the post-test after the treatment revealed significant differences: the experimental group had (mean 34.07 ± 15.12 SD) which was higher than the control group (mean 20.87 ± 12.31 SD) ($t = 2.62$**;** $p < 0.05$) Table 5.2, suggesting that the experimental group had better understanding regarding the dissolving of salts. The ANCOVA results from the post-test scores for both control and experimental group (Table 10) show that the experimental post-test results were significantly different (SS 57.37 ± 13.38 F and $p = 0.0004$), while the control group post-test was not significant (SS 6.34 ± 1.49 F and $p = 0.2254$). This suggests that indeed the intervention had a positive effect on the understanding of concepts dealing with dissolving of salts.

All in all these results suggest that the experimental group achieved better than the control group and that the POE used in the experimental group had a significant impact in the achievement of the experimental group. This improved achievement was due to the impact of POE strategy which reduced learners' misconceptions regarding the dissolving of salts. POE has proved to be an effective strategy, at least in this study, in improving learners' achievement. Learners in experimental group seem to have undergone a conceptual change in their understanding of dissolved salts. These results are in agreement to the study by White & Gunstone, (1992), where conceptual change had positive results and misconceptions were significantly reduced. The results obtained, in this study, are in agreement with the findings of Tomita & Yin, (2007) in their study about diagnosing and dealing with learners' misconceptions in floating and sinking objects. The understanding of concepts exhibited in the control group is also in agreement with Hubber (2005) study about explorations of year 10 learners' conceptual change during instruction where POE strategy was a significant factor in understanding and better retention of acceptable conceptions. In this study the achievement of the experimental group can be attributed to the following properties of POE: (1) activation of learners' misconceptions through hypothesising, (2) presentation of a situation that could not be explained with learner's existing concepts, (3) creation of cognitive conflict with this strange situation, (4) the need for other conception/s to explain this strange situation, (5) active construction of learners' own knowledge thus where learners construct their new knowledge through observation and discussions with fellow classmates, (6) learners interaction with each other to share their ideas about the strange situation and it's possible solution, and (7) the creation and adoption of the new conception learnt. These are in harmony with the principles of both constructivism and conceptual change theory posed by Posner et al., (1982).

In the experimental group post-test males (mean 21.13 ± 9.72 SD) outperformed females (mean 12.73 ± 5.97 SD, and their differences were significantly different ($t = 2.85$; $p < 0.00$) as seen in Table 8. This implies that in terms of concept understanding in this study males achieved better than females and hence POE used seem to have favoured males than females. This is in agreement with Cetin, Kaya & Geban (2008) in their study dealing with facilitating conceptual change in gases concepts and also Baser (2006) in his study about fostering conceptual change by cognitive conflict based instruction on learners' understanding of heat and temperature concepts. The POE strategy is activity-based as well as hands-on based which is similar to the laboratory method used by Odubunmi & Balogun (1991) in their study about the effect of laboratory and lecture teaching methods on cognitive achievement in integrated science where males in this study preferred laboratory method to lecture method when compared with their female counterparts, the study also revealed that females in the control classes performed better than males of the same group. In other words males unlike females are in favour of hands-on activities. Well though female learners did not achieve better than males when POE was used I still regard it as the best teaching strategy as it assist learners to bring into consideration their prior knowledge and through discussion to realise whether what they know is in par with the accepted science conceptions and to be able to go back and forth along the steps involved in POE strategy in order to clear some of their doubts.

On the other hand, there could be un-tested factors that female learners experience different way of learning science as opposed to male learners which the current educator who happened to be a female may have ignored. For instance educators who teach science are mostly males and these may readily intimidate female learners. This intimidation syndrome may have continued even though the educator this time was a female, in this study. Also, the limited number of female role models in science may also have had a de-motivating effect on the female learners. Nevertheless, these areas need further study in order to establish real reasons and solutions behind the failure to improve female learners' performance in sciences. The results of this study, also, put forward that teaching for content coverage using traditional approaches does not guarantee that learners will successfully understand the basic concepts they are required to learn and it may not improve the achievement of female learners in science. Therefore, it is necessary to convince educators to teach towards conceptual understanding in order to improve learners' performance. Contrary to the findings from this study regarding the achievement of female performance, female learners can achieve similar results like the males regardless of the educator being a male or a female in chemistry class (Diamond, 1995).

Throughout the interview session learners showed a sense of uncertainty in questions 4 and 5. Thus, both groups did not do well although the experimental group outperformed the control group as seen from Table 11. The experimental group achieved 100% in all questions except in question 5 where only one learner did not provide an acceptable response. Coincidentally, this was a female learner out of the two female learners volunteered to be interviewed in the experimental group (50% female achievement in this case). In the experimental group females were also outperformed at micro-chemistry but they outperformed their counterparts in the control group. Both females in the control group did not provide the acceptable responses for questions 4 and 5 (learner 1 and learner 5 from interview data). If it were not for the intervention the experimental learners undertook, it is likely that all the females would have missed the acceptable answer as their control group counterpart. Thus, interviews revealed that more learners have problems with the microscopic category as compared to macroscopic category and this has implication in teaching chemistry.

5.4. Implications of the study

The results have implications to educators who have an important role in facilitating the process of realization of the acceptable science concepts with the help of relevant teaching strategies. Looking at the data provided in chapter four learners using POE strategy made significant improvements to make sense of the concepts involved in this study. They even did their best in improving their achievements after using the POE strategy. While the constructivist view basically focuses on actions of the learner in developing and constructing information the role of the educator and their teaching methods are of paramount importance. Choosing POE and using learner-centred teaching will primarily be the best for concept understanding, and will encourage learners to be engaged in discussions that enhance their conceptual understanding (Kasanda *et. al*., 2003). Thus, educators, curriculum developers and textbook writers need to work together to select and organise learning materials in such a way that they encourage learners to take charge of their own learning by constructing meaningful schema from what they study. On the other hand educators should pay attention to the explanations of the observable in terms of the unobservable. That is to encourage learners to move from macro to micro level during their explanations of dissolving and indeed in other chemical reactions.

5.5. Suggestions for Further Research

This study explored the effect of POE strategy on learners' misconceptions and achievement about the dissolved salts on Grade 10 learners. However, this study did not look at the effect of this strategy in understanding of concepts in males versus females *per se*; it briefly looked at their achievements. The study also did not look at learners attitudes towards the use of POE strategy in understanding concepts about the dissolved salts. These areas may be looked at through further studies.

5.6. Conclusion

I have been aware that learners did not develop the depth of understanding of concepts through the use of ordinary teaching approaches. In this research project, the use of conceptual change strategies which encourage learner-centred-activity-based strategies was emphasised though the pressure to cover the content stipulated by the learning programmes remains as a challenge to schools. The main findings of this study is that the use of POE strategy, which includes learner-centred-activity-based strategy, increased learners' performance and improved concept understanding about the dissolved salts. Although it did not significantly improve female performance possibly due to other factors beyond the scope of this study, it is recommended for science educators in the province with similar challenges. Further, research is needed to ascertain the validity of this teaching approach possibly with large sample in the province as well as from other provinces.

References

Arizona Facilities Council (AFC). (2000). Definition of Learner Centered Education. http://www.abor.asu.edu/4-special-programs/lce/afc-defined-lce.htm, Retrieved, August 06, 2008.

Assessment Resource Banks. (2007). Predict, Observe, Explain (POE). http://arb.nzcer.org.nz/nzcer3/strategies/poe.htm, Retrieved March 03, 2007.

Baser, M. (2006). Fostering conceptual change by cognitive conflict based instruction on students' understanding of heat and temperature concepts. *Eurasia Journal of Mathematics, Science and Technology Education, volume 2 number 2, July 2006.*

Bohlmann, C.A. (undated). Reading skills and Mathematics. Department of Mathematics, UNISA.

Brookes, D., Alant, B., Gibbon, D., Nkopodi, N., and Patrick, M. (2005). OBE for FET Physical Sciences Grade 10, Learners Book. Cape Town, Nasou Via Afrika.

Cetin, P.S., Kaya, E., and Geban, Ö. (2008). Facilitating conceptual change in gases concepts. *Journal of Education and Technology volume 18, number 2. Publisher Springer Netherlands, pg. 130-137.*

Cobern,W.W. (1996). Worldview Theory and conceptual change in science education. *Science Education 80 (5): 579-610. 1996 John Wily and sons. Inc.*

Cosgrove, M. R., and Osborne, R. (1981). Physical change: A working paper of the Learning in Science Project (no. 26) University of Waikato, Hamilton. New Zealand.

Dekkers, P. (2005). Modules SCED 811 and 815. Teaching and Learning Science/Contemporary Issues In Science Education, Programme outline 2005.

DoE (2003). National Curriculum Statement Grades 10 – 12 (General) – Physical Sciences. Sol Plaatjie House, Pretoria.

Demircioglu, G., Ayas, A., and Demircioglu, H. (2005). Conceptual change achieved through a new teaching program on acids and bases. KTU Faith Education Faculty, Department of Secondary Science Education, Sogutlu Mevkii 61335, Akcaabat/TRABZON,Turkey.http://www.rsc.org/Education/CERP/issues/2005-1/conceptual.asp. Retrieved March 06, 2006.

Diamond, E. L. (1995). Female and male success in chemistry classroom. Division of Science and Mathematical Education. http://dsme.msu.edu/phyabstracts.htm. Retrieved, August 26, 2010.

Duit, R., and Treagust D.F. (1998). From Behaviourism Toward Social Constructivism and Beyond. In: B.J.Fraser and K. G. Tobin (Eds) *International Handbook of Science Education*. Dordrecht: Kluwer. Pp. 3-25.

Duit,R., Treagust, D.F., and Mansfield, H. (1996). Investigating students understanding, as a prerequisite to improve teaching and learning in science and mathematics (pp. 17-31). New York: Columbia University Teachers College Press.

Duit, R. and Confrey, J. (1996). Reorganising the curriculum and teaching to improve Learning in Science and Mathematics. In D.F. Treagust, R. Duit, and B.J. Fraser (Eds.). *Improving teaching and learning in science and mathematics (pp.79-93).* New York: Columbia University Teachers College Press.

Ebenezer, J, Chacko, S, Kaya, O. N., Koya, S.K., & Ebenezer, D.K. (2010). The effect of demonstrative experiments based on conceptual change approach on overcoming misconceptions in electrochemistry concept to the achievements of high school students. *Journal of Research in Science teaching*, 47(1): 25-46.

Fakudze, C., G. (2004). Learning of science concepts within a traditional socio-cultural Environment. *South African Journal of Education 24* (4) 270-277.

Fosnot, C. F. (1996). Constructivism: A phychological theory of learning. In C.T. Fosnot (Ed). Constructivism: Theory, perspectives and practice,(pp. 8-33). New York: Teachers College Press.

Garcia, E. (1999). Student Cultural Diversity: understanding and meeting the Challenge (2nd ed.) Boston: Houghton Mufflin.

Glynn, S.M., and Duit, R. (1995). Learning Science meaningfully: Constructing Conceptual models. In Glynn S.M. and Duit, R. (Eds), Learning Science in the Schools. Research Reforming Practice, pp. 3-33. Mahwah, N.J: Lawrence Erlbaum.

Hanuscin, D. (undated).E328: Elementary Methods. Hapkiewicz, A. (1999). Naïve Ideas in Earth Science. MSTA Journal, 44 (2) (Fall' 99), pp. 26-30. http://www.msta-mich.org.

Hewson, P. W. (1981). A conceptual change approach to learning Science. *European Journal of Science Education.* 3: 383-396.

Hewson, M. G., and Hewson, P. W. (1983). Effect of Instruction Using Students' Prior *Knowledge* And Conceptual Change Strategies On Science Learning*. Journal of Research In Science teaching.* 20 (8), 731-744.

Hewson, M. G., and Hewson, P. W. (2003). Effect of Instruction Using Students' Prior *Knowledge* And Conceptual Change Strategies On Science Learning*. Journal of Research In Science teaching. 40 (3), S86-S98.*

Hubber, P. (2005). Explorations of year 10 students' conceptual change during instruction. *Asia-Pacific forum on Science Learning and Teaching,* 6 (1) article 1.

Kasanda, C. D., Lubben, F., Campbell, B., Kapenda, H. M., Kandjeo-Marenga, H. U. and Gaoseb, N. (2003). Learner-Centered Teaching-The Rhetoric and Practice, The Case of Namibia. In: Putsoa, B., Dlamini, M., and Kelly, V (Eds). *Proceeding of the 11th Annual SAARMSTE Conference.* SAARMSTE: Mbabane, pp. 457.

Koeberg Primary School. (2008). National Curriculum. http://www.koebergps.wcape. School.za/academicinformationframe.htm, Retrieved August 06, 2008.

Lee, O. (2002). Promoting Scientific Inquiry With Elementary Students from Diverse Cultures and language. *Review of Research in Education, 26, 23-70.*

Lemmer, E. (1999). Contemporary Education: Global Issues and Trends. Sandton: Heinemann.

Mahendra, N., Bayles, K.A., Tomoeda, C.K., and Kim, E.S. (2005). Diversity and Learner-Centered Education. *The ASHA Lender,*

Marx, R.W., Blumenfeld, P.C., Krajcik, J.S., Fishman, B., Soloway, E., Geier, R., & Tal, R.T. (2004). Inquiry-based science in middle grades: Assessment of learning in urban systemic reform. *Journal of Research in Science Teaching*, 41, 1063–1080.

Menegoni, B. (undated). Promoting conceptual understanding in the classroom: An Examination of interactive engagement pedagogies. Harvard University Summer RET programme.

Mpofu, N.V., (2006). Grade 12 students' conceptual understanding of chemical reactions: A case study of fluoridation. A thesis submitted in partial fulfilment of the requirements for Masters in Education. University of the Western Cape.

Mumba, F. Rollnick, M. and White, M., (2002). How wide is the gap between high school and first year university chemistry at the University of the Witwatersrand. *South African Journal of Higher Education*, 16(3), 148-157.

Odubunmi, O. and Balogun, T. A. (1991).The effect of laboratory and lecture teaching methods on cognitive achievement in integrated science. *Journal of Research in Science Teaching*, 28, 213–224.

Ogunniyi, M.B. (1999). Chemical change: Assessment of grades 7-9 Pupils Knowledge and Interest in Science and Technology. Cape Town, RSA: School of Science and Mathematical Education, University of the Western Cape.

Piaget, J. (1970). Structuralism. New York: Basic Books.

Piaget, J. and Inhelder, B. (1974). The child's construction of quantities. Routledge and Kegan Paul: London.

Pollard, A. (1997). Reflective Teaching in the Primary School. A handbook for the Classroom (3rd edition), London: Cassell Education.

Posner, G. J., Strike, K. A., and Hewson, P. W. (1982). Accommodation of a scientific conception: towards conceptual change. *Science Education*, 66, 211-227.

Potgieter, M, Rogan, J. M., and Howie, S. (2005). Chemical Concepts Inventory of Grade 12 learners and UP foundation year students. *African Journal of Research in Mathematics, -Science and Technology Education,* 9 (2): 121-134.

Spencer, J.A. and Jordan, R.K. (1999). Learner Centred approaches in medical Education. Medical Education, Faculty of Medicine, University of Newcastle, Newcastle Upon Tyne NE 24 HH BMJ.

Stepans, J. (1994). Targeting Students' Science Misconceptions, Physical Science Concepts Using the Conceptual Change Model. Idea Factory, Inc, River View.

Tlala, K.M. (2006). Conceptual Understanding: Teaching Grade 11 (eleven) Science with Limited Resources. A Snap short paper presented at the 14th South African Association For Research In Mathematics, Science And Technology Education (SAARMSTE) Conference in Pretoria on the 9th January 2006.

Tomita, M., and Yin., Y. (2007). Promoting conceptual change through formative assessment in the Science classroom. Paper presented at the Hawaii Educational Research Association annual conference, Honolulu.

Treagust, D. F., Duit, R., and Fraser, B, J. (1996). Overview: Research on students' Pre- instructional Conceptions-The Driving Force of Improving Teaching and Learning in Science and Mathematics. In: D.F. Treagust, R. Duit and B.J. Fraser (Eds.), *Improving Teaching and Learning in Science and Mathematics*. pp.79-93. New York and London: Teacher College Press.

Vygotsky, L. (1986). Thought and language. Cambridge, MA: MIT Press. (Original work published 1962).

Vosniadou, S. (2001). Conceptual change research and the teaching of science. In: Behrendt, H, Dahncke, H, Duit, R, Graeber, W, Komrek, M, Kross, A., and Reiska, P (Eds). *Research in Science Education-Past, Present, and Future*. (pp 177-188). Dordrecht: Kluwer, Academic Publishers.

Walker, S. (2001). GIS and students as scientists: Constructivist approaches to science curriculum restructuring in-service supplement [online]. San Antonio, Texas: Our Lady of the Lake University, Education Department. Available: http://education.ollusa.edu/edtech/educ6306s1/reading/GIS and student as scientists inservise supplement .pdf Retrieved March 04, 2006.

White, R.T., and Gunstone, R.F. (1989). Metalearning and conceptual change. International *Journal of Science Education,* 11, 577-586.

White, R.T., and Gunstone, R.F. (1992). Probing Understanding. Great Britain: Falmer Press.

Yager, R.E. (1995). Constructivism and the learning of science: In Glenn, S.M. and Duit, R. (Eds). Learning Science in the schools: research reforming practice. Mahjwah, N.J: Lawrence Erlbaum. pp. 35-38.

ANNEXURE 1

WORKSHEET NO. 1

HOW SALTS ARE FORMED

Salt is the product of acid-base reactions. It is formed when appropriate base, metal, metal oxide or carbonate reacts with an acid. When an acid reacts with a base, salts and water are formed

Three ways of salt formation

1. Neutralization
2. Direct combination
3. Reaction of metal oxides and acids

Formation of salts

Use HCl and metal of group 1 (K, Na) and 2 (Ca) to predict salts that can be formed.

Write the chemical equation as:

Acid + Metal $\longrightarrow$ Salt

Acid + Metal hydroxide $\longrightarrow$ Salt

Acid + Carbonate $\longrightarrow$ Salt

Acid + Base $\longrightarrow$ Salt

Discussion (Learners + Educator) on the above activity for correcting learners.

Complete the following equation as a way of depicting which salts will be formed

1. K + Cl $\longrightarrow$
2. Na + HCl $\longrightarrow$
3. Ca + Cl $\longrightarrow$
4. NaOH + HNO_3 $\longrightarrow$
5. $CaCO_3$ + HCl $\longrightarrow$
6. MgO + HCl $\longrightarrow$

7. $NaOH + H_2S \longrightarrow$

WORKSHEET NO 2

IONISATION OF SALTS

Some molecular compounds produce ions their solution - thus they undergo ionization in water for example

$HCl_g + H_2O_l \longrightarrow H_3O^+_{aq} + Cl^-_{aq}$

$H_2O \longrightarrow H^+_{aq} + OH^-_{aq}$

$HCl_g \longrightarrow H^+_{aq} + Cl^-_{aq}$ $\quad H_2O_l + H_{aq} \longrightarrow H_30_{aq}$

Write down the corresponding ions of the chemicals below

1. **HCl** $\longrightarrow$
2. **NaCl** $\longrightarrow$
3. **$CaCl_2$** $\longrightarrow$
4. **$NaNO_3$** $\longrightarrow$
5. **$MgCl_2$** $\longrightarrow$
6. **Na_2SO_4** $\longrightarrow$
7. **KCl** $\longrightarrow$

WORKSHEET NO.3

How salts dissolve in water

Because water molecules are polar, they can interact strongly with ions of ionic compounds such as sodium chloride

The **ą**$^{+}$ ends of water molecules attract the **Cl**$^{-}$ ions on the surface of the solute, and the **ą**$^{-}$ ends of water attract the Na^{+} ions.

These attractions help to overcome the electrostatic attraction between the **Na**$^{+}$ and **Cl**$^{-}$ ions in the solid. The **Na**$^{+}$ and **Cl**$^{-}$ ions move into solution surrounded by water molecules.

This process is called **hydration**

NB: In some ionic solids, the attraction between ions is strong enough to prevent them from dissolving in water. Hence some salts do not dissolve in water.

CLASS ACTIVITIES (POE Activities, group work)

ACTIVITY 1

Materials needed

- Water
- Transparent container (glass or plastic)
- Fine NaCl, $NaNO_3$, KCl, $(NH_4)_2SO_4$, AgCl, $Pb(SO_4)_2$, Na_2CO_3, $CaCO_3$

Predictions: What will happen if NaCl is added to water and why?

Group prediction (discussed and agreed upon)

……………………………..………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

Prediction testing

Steps to be followed

Each group takes water in the container.

Add a few particles of the salt you have in your group (you may stir if necessary).

Observe and explain what happens

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

Activity 2

Materials needed

- Transparent container (glass or plastic)
- Marbles (plenty of mables)
- Sand
- Measuring cups

Prediction: what will happen if you pour mables first and the sand into the same container?

Group prediction: (discussed and agreed upon)

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

…………………………………………………………………………………………………
…………………………………………………………………………………………………

Predicting testing

Steps to be followed

Fill the container up to the brim with marbles. Will it be possible to add any other materials to this full container? Explain.

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

Add sand to the container with marbles (shake to settle the sand in between the marbles). Explain your observation.

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

Explain why it was possible for the container to hold the added amount of sand?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

(Measure off the amount of sand added to the marbles (by measuring how much is left over in a measuring cup).

NB: Be aware that marbles and sand is only illustrating how molecules of matter behave and that they are not molecules themselves, they are only used as models.

Explain

Student explore questions in the group discussion template below

Group discussion template

Why the container filled with marbles could still hold the added sand?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………….

Could we have started with sand and then marble? Explain what difference it makes?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

……………………………………………………………………………………………
……………………………………………………………………………………………
…………………………………………………………………………………………..

What would you infer about the size of molecules of different materials or substances?

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

ACTIVITY No. 3

Materials needed

- A transparent container (glass or plastic)
- Marbles (plenty of marbles)
- Sand
- Water
- Measuring cups

Prediction: What will happen if you pour sand first and then marbles into same container?

Group prediction: (discussed and agreed upon)

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………..

Prediction testing

Steps to be followed

Fill the container up to the brim with sand. Will it be possible to add any other materials to this full container? Explain.

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………..

(Add marbles to the container with sand and shake the container).

Explain your observation.

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

…………………………………………………………………………………………………
…………………………………………………………………………………………………..

Explain why it was not possible for the container to hold the added amount of the marbles?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………..……..…………………………………………………………………………
…………………………………………………………………………………………………

ANNEXURE 2

PRE/POST TEST

QUESTION 1

STATE WHEATHER THE FOLLOWING STATEMENTS ARE **TRUE** OR **FALSE. If the answer is FALSE, provide the correct statement.**

1.1. A salt is formed when the appropriate base, metal, metal hydroxide or carbonate reacts with an acid.
1.2. All salts can dissolve in water.
1.3. Salts are ionic compounds.
1.4. When salts dissolve in water they form ions.
1.5. An example of an ionic compound formed when salts dissolve in water is:

$KCl_{(s)} \leftrightarrow K^{+}_{(aq)} + Cl^{-}_{(aq)}$

MULTIPLE-CHOICE QUESTIONS

2.1. When acids react with metals they form
 A. bases
 B. water
 C. salts
2.2. Which formula represents a salt?
 A. KCl
 B. $NaNO_3$
 C. $MgCO_3$
2.3. Which salt cannot dissolve in water?
 A. AgCl
 B. NaCl
 C. KCl
2.4. The following salt can be formed through neutralization of an acid and a base
 A. NaCl

B. $Ca(NO_3)_2$

C. NH_4Cl

2.5. Through direct combination of some substances the following salt can be formed

A. NaCl

B. $Ca(NO_3)_2$

C. NH_4Cl

2.6. Through the reaction of metal oxide and acid the following salt can be formed

A. NaCl

B. $Ca(NO_3)_2$

C. NH_4Cl

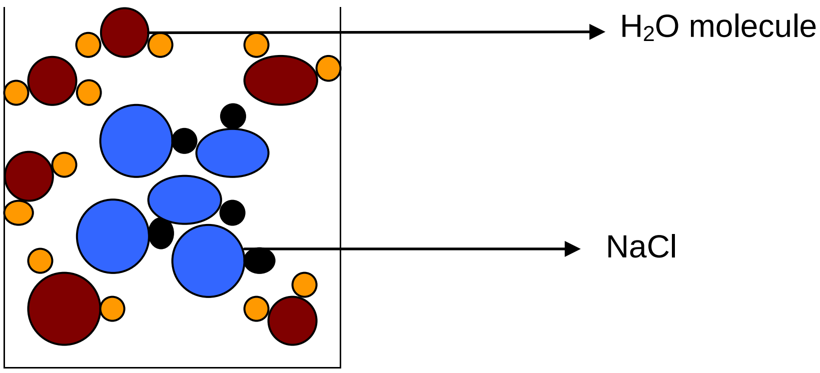
2.7. Which equation represents the dissociation of NaCl?

A. $NaCl_{(s)} \leftrightarrow Na^{-}_{(aq)} + Cl^{+}_{(aq)}$

B. $NaCl_{(s)} \leftrightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$

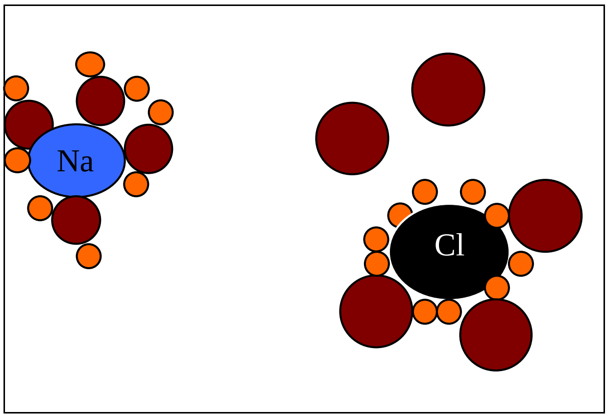
C. $NaCl_{(s)} \leftrightarrow Na + Cl_{(aq)}$

2.8. The diagram below represents a mixture of H_2O and NaCl in a closed container.

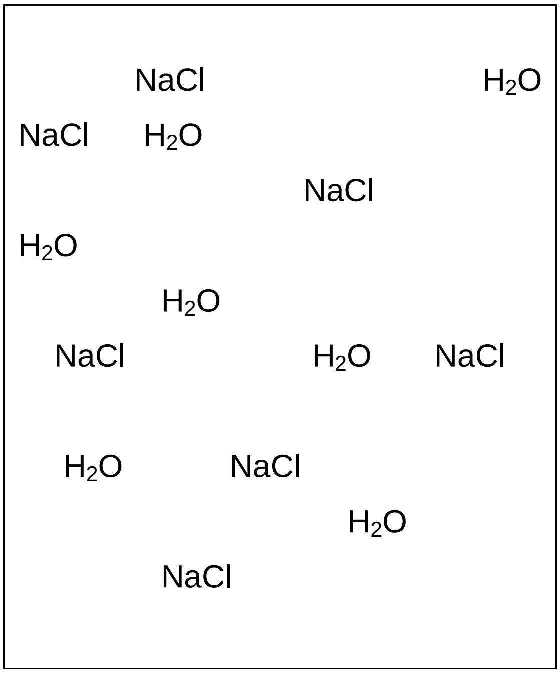


Which diagram shows the results after the mixture reacts as completely as possible according to the equation $NaCl_{(s)} + H_2O \leftrightarrow Na^{+}_{(aq)} + Cl^{-}(aq)$. Give a reason for your choice.

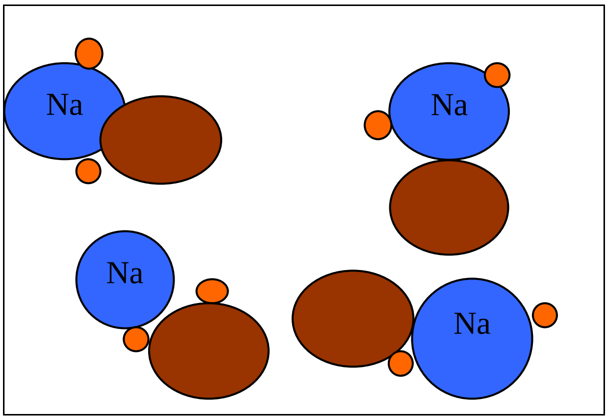
A



B



C



QUESTION 3

3.1. In your own view what happens when salt like NaCl dissolve in water. Use a diagram/s and chemical equation/s to support your opinion.

3.2. Some salts do not dissolve in water. In your own view what happens when a salt do not dissolve in water. You may use diagram/s and chemical equation/s to support your opinion.

ANNEXURE 3

INTERVIEW SCHEDULE

1. Can you briefly explain how salts are formed?
2. Mention the few salts that you know and please tell which salts are soluble in water from what you have mentioned?
3. Is water a polar or a non polar substance? Are salts ionic or polar in nature?
4. What will happen to the salts, which will not dissolve in water?
5. Explain how salts dissolve in water.

ANNEXURE 4

Learners interview responses from both control and experimental group.

Question number	**Learner's responses and number of learners who gave that response per group**	**Categories of learners answers**	
		Acceptable scientific meaning	**Unacceptable scientific meaning**
1	**Experimental group**		
	Learner 1: "Salt is the product of an acid and a base."	✓	
	Learner 2: "It is formed when metals react with acids."	✓	
	Learner 3: "It the product of an acid and a metal hydroxide."	✓	
	Learner 4: "Product of acids and bases."	✓	
	Learner 5: "We get salts out of the acid and base reaction."	✓	
	Control group		
	Learner 1: "Salts are formed when acid react with bases."	✓	
	Learner 2: "When base and an acid react."	✓	
	Learner 3: "Product of	✓	

	acid and base."		
	Learner 4: "Product of acids and bases."	✓	
	Learner 5: "When acids react with metals."	✓	
2	**Experimental group**		
	Learner 1: "NaCl, KCl and $CaCl_2$ they are all soluble in water."	✓	
	Learner 2: "KCl, $NaNO_3$, NaCl and AgCl and AgCl are not soluble."	✓	
	Learner 3: "$CaCO_3$ and NaCl and they all dissolve in water."	✓	
	Learner 4: "$CaCl_2$, NaCl and $NaNO_3$ they all dissolve in water."	✓	
	Learner 5: "$PbNO_3$, AgCl and NaCl only NaCl dissolves in water."	✓	
	Control group		
	Learner 1: "NaCl, KCl and $NaNO_3$ they are all soluble in water."	✓	
	Learner 2: "$CaCl_2$ and NaCl all soluble in water."	✓	
	Learner 3: "NaCl, KCl all soluble in water."	✓	
	Learner 4: "KCl, NaCl,	✓	

	they are all soluble in water."		
	Learner 5: "AgCl and NaCl and NaCl dissolve in water."	✓	
3	**Experimental group**		
	Learner 1: "Salts are ionic and water is polar."	✓	
	Learner 2: "Salts are ionic in nature and water is polar."	✓	
	Learner 3: "Water is polar in nature and salts are ionic in nature."	✓	
	Learner 4: "Salts are ionic and water is polar."	✓	
	Learner 5: "Salts are ionic and water is polar."	✓	
	Control group		
	Learner 1: "Salts are ionic and water is polar."	✓	
	Learner 2: "Salts are ionic and water is polar."	✓	
	Learner 3: "Water is polar and salts are ionic in nature."	✓	
	Learner 4: "Water is polar in nature and salts	✓	

	are ionic in nature."		
	Learner 5: "Salts are ionic and water is polar."	✓	
4	**Experimental group**		
	Learner 1: "Undissolved salt will settle at the bottom of the container."	✓	
	Learner 2: "Salt which did not dissolve will precipitate."	✓	
	Learner 3: "A precipitate of undissolved salt will form at the bottom of the container."	✓	
	Learner 4: "Undissolved salt will settle itself at the bottom of the container."	✓	
	Learner 5: "All undissolved salts will settle at the bottom of the container."	✓	
	Control group		
	Learner 1: "All salts will dissolve and no salt will be undissolved."		✓
	Learner 2: "Undissolved salt will settle at the bottom of the beaker."	✓	

	Learner 3: “Undissolved salts will form at the bottom of the container”	✓	
	Learner 4: “Salts and water will be separated from one another and it will not dissolve in water”.		✓
	Learner 5: “Salt will not mix with water they will be separated so it does not dissolve.”		✓
5	**Experimental group**		
	Learner 1: “When salts melt in water it disappears and turn the water salty.”		✓
	Learner 2: “As salt dissolve in water the∂+ end of water attract the – Cl ion and the∂ - end of water attract the + Na ion the water become salty in that way.”	✓	
	Learner 3: “In that process it means that when NaCl dissolve in water the∂+ side of water attract the negative Cl ion and the ∂ - side of water	✓	

	attract the positive Na ion and water become salty.”		
	Learner 4: “When salt dissolves the ∂+ end of water attract the negative Cl ion and the ∂- end of water attract the positive Na ion the water become salty in that way”.	✓	
	Learner 5: “As soon as salt dissolves in water the positive ions of NaCl become attracted to the ∂ - end of water and the negative ions of NaCl become attracted to the ∂+ end of water then water become salty.”	✓	
	Control group		
	Learner 1: “Water will just be salty when salt melt and disappear in it.”		✓
	Learner 2: “When sodium chlorine salt dissolves in water the ∂+ end of water attract the - Cl ion and the ∂ - end of water attract the + Na ion.”	✓	

	Learner 3: "When salts dissolve in water they disappear and turn the water salty."		✓
	Learner 4: "When salt dissolves in water the negative end of water attract the oppositely charged ion of NaCl and the positively end of water will attract the negative chlorine ion."	✓	
	Learner 5: "Sodium chlorine melts in water it makes water too salty."		✓