# Exploring the influence of learners' participation in an after-school science enrichment programme on their disposition towards science: A case study of Khanya Maths and Science Club

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**Declaration**

I declare that the work contained in this thesis is my original work. It has not been previously submitted in any form for assessment or degree in any other higher education institution. All ideas, quotations and other materials used in this study derived from the work of other people have been indicated in the list of references.

Signature:  Date: 10/12/2015

## Dedication

I dedicate this work to the Almighty God, the giver of life and to my late Mom, Deborah Funmi Oyinloye. Mom, I know you are looking down and smiling.

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**Abstract**

The ongoing advancement of science and technology is creating an increasing need for more entrants into science oriented careers. However, numerous studies have fueled growing concerns regarding the poor achievement of learners in science. Over the years, science education researchers have emphasized the importance of the affective domain of learning as a central component of strategies used to address learners' lack of interest and poor achievement in science. In the literature, the affective domain is characterized by constructs such as disposition, attitude, interest, and motivation. Studies showing a correlation between the affective domain and academic achievement suggest that nurturing a positive disposition towards science is an antecedent to learners' improved science achievement and entering science fields. This study focuses on the 'disposition' aspect of the affective domain, and follows in the path of earlier studies which use the term interchangeably with 'attitude'.

Learners' experiences in a particular science education environment influence the development of a positive or negative disposition towards science. However, there is a need to explore the factors in the learning environments which influence learners' disposition towards science. Previous studies have shown that the informal science environment may influence learners' disposition towards science. One example of an informal science environment is the Khanya Maths and Science Club, which is an after-school science and mathematics enrichment programme in Grahamstown, South Africa. This study explores the influence of learners' participation in an informal science education environment on their dispositions towards science, using the case of the Khanya Maths and Science Club.

This study views disposition through the constructivist-developmental lens. The community of practice elements from situated learning theory is drawn on to explore how learners' disposition can be influenced by their interactions in the context of the Khanya Maths and Science Club. The pragmatic paradigm is adopted, which considers how well the research tools work to provide answers to the research questions. This thus, provides an avenue for exploring how learners' disposition towards science is influenced and what factors influenced their shift in disposition through their participation in the club.

A mixed-methods approach is employed when focusing on the affective domain sub-constructs of: enjoyment of science, interest in science and perception of science. These are sub-scales in the test of science related attitude (TOSRA) questionnaire which was adapted for use in measuring learners' attitude before and after 16 weeks of participating in the science club.

The particular mixed-methods approach selected can be summarized as quan $\longrightarrow$ QUAL since the method is primarily qualitative, but sequential with the quantitative phase preceding the qualitative phase. The TOSRA questionnaire was used as the quantitative data collection instrument while semi-structured interviews and learners' journal entries were the qualitative data collection instruments.

The results revealed significant shifts in learners' perception of, interest in science and enjoyment of science though interest in science and enjoyment of science shifted appreciably in a positive direction more than the perception of science. It was also found that learners' attitude towards science was influenced by; instructional characteristics, facilitators/environmental characteristics, learners making connection between science and everyday life and learners' perceived difficulty of science. These factors variably influenced their attitude towards science in the club, corroborating what had been found in similar studies.

This study corroborates what the literature offers for achieving effective outcomes in Afterschool science enrichment programmes. It contributes to the growing body of literature on features for quality outcomes in Afterschool science enrichment programmes. This study also makes a theoretical contribution to science education research particularly with regard to how the emergence of a community of practice framework in the club activities provide useful information for planning club activities and the analysis of learners' evolving disposition towards science.

**Key words:** Khanya Maths and Science Club, disposition, attitude, after-school enrichment programmes, constructivist-developmental approach, situated learning theory, community of practice, Test of Science Related Attitude (TOSRA).

**Table of contents**

## List of Figures

## List of Tables

**List of Abbreviations and Acronyms**

| | |
|---|---|
| ASEP(s) | After-School Science Enrichment Programme(s) |
| ASP | After-school programmes |
| CoP | Community of Practice |
| DBE | Department of Basic Education |
| DoE | Department of Education |
| IL | Interviewed Learner |
| KMSC | Khanya Maths and Science Club |
| LJ | Learner's journal |
| No | Number |
| OST | Out-of-school-time |
| QUAL | Qualitative |
| QUAN | Quantitative |
| SLT | Situated learning theory |
| TOSRA | Test of Science Related Attitude |

**List of Appendices**

# CHAPTER ONE: INTRODUCTION

## 1.1 Introduction

The purpose of this study was to explore how participation in an after-school science enrichment programme influences learners' dispositions towards science using the case of the Khanya Maths and Science Club in Grahamstown, South Africa. This chapter introduces the study by presenting the background, context and significance of the study. It also highlights the focus of the study by outlining the research goal and the research questions of the study. Lastly, I describe the thesis chapters by means of a brief overview of each one.

## 1.2 Background to the study

One of the key challenges in the field of science education globally and locally over the years is the decline in learners' engagement in science, interest, achievement and retaining learners in the field of science (Tytler, 2010; Welch, 2010). It has been argued that learners are more inclined towards pursuing subjects in the arts or social sciences (Zubair & Nasir, 2011). One of the main reasons identified is that many learners do not enjoy science even if they perform well in it (Zubair & Nasir, 2011). As a result, there is a continuous decline in the number of learners pursuing science in many countries around the world (*ibid*).

Cameroon (2009) reports that the science education system produces fewer science graduates than required by the global economy. Countries such as the United States of America (USA) have raised concerns over learners' lack of engagement, interest and achievement in science and consequently have made an increased effort to address the problem (White House, 2009). Corresponding trends are also reported among South African learners especially among the historically disadvantaged schools (Reddy, Van der Berg, Janse van Rensburg & Taylor, 2012).

In South Africa, results of assessments show poor science skills with a declining average performance every year over recent years. For instance, the 2011 Trends in International Mathematics and Science Study (TIMSS) shows that South African grade 7 and 8 learners performed very poorly overall in mathematics and science (Reddy, Zuze, Visser, Winnaar et al., 2015). They were ranked last out of 41 participating countries. Reddy et al. (2015) inform that three-quarters of South African learners achieved below the benchmark score.

Moreover, the Physical Sciences results of the National Senior Certificate Examination were among the lowest in the rated achievement of eight selected subjects in 2013 (Department of Basic education [DBE], 2013). In addition, between 2010 and 2013 in the Eastern Cape, the number of learners that attempted Physical Sciences in matric dropped by 7.1%. In 2014, for instance, only 25% of those who attempted the exam achieved at least 50% (Department of Education [DoE], 2014). This suggests that in the future fewer learners will qualify for science-based courses at tertiary institutions. In the long-term, a decrease in number of students enrolled in science fields may lead to an acute shortage in the science workforce in the country (Tytler, Osborne, Williams, Tytler, Clark & Tomei, 2008).

### 1.3 Statement of the problem

Given the significance of a science-driven economy, Mbeki, in his address as the then-president of South Africa (2005) emphasized the importance of mathematics and science in the country's development. Presidents from other countries concur, for instance, President Obama of the USA highlights the importance of Science, Technology, Engineering and Mathematics (STEM) in the development of any country (White House, the Press Secretary, 2009). Muzah (2011) argues that it is a great concern that poor achievement and interest in science is increasing at a time when almost everything in the world involves the application of science and technology. Consequently, lack of interest and poor achievement at the high school level prevents learners from pursuing science related subjects and careers in the future (Reddy et al., 2015).

In order to make a difference to this trend of declining achievement and engagement, science education researchers are increasingly turning their attention to learners' affective domain with regard to science (Aydeniz & Kotowski, 2014). The literature establishes that the affective domain is the most underestimated of the three domains (cognitive, affective and psychomotor) of learning (Anderson, 2006; Oliver & Venville, 2011). This makes the affective domain of learning such as learners' disposition towards science an area worth researching. 'Affective' is coined from the Latin word '*affectus*' meaning 'feelings' (Koballa, 2007, p 4). The affective domain of science in this context is having a feeling or opinion about, or a like or dislike for science, which includes a multitude of constructs such as values, attitudes, motivations, interests, and beliefs (Koballa, 2007).

The affective domain of learning plays a significant role in the learning process (Aydeniz & Kotowski, 2014; Jewell, 2012). Belge-Can and Boz (2012) suggest that if learners' affective domain is positively influenced, it has the potential to predict future career preference of learners and a correlation between affective domain and academic performance exists. More so, Koballa (2007, p. 4) points out that the "affective domain is not just a simple catalyst, but a necessary condition for learning to occur". Pierre and Oughton (2007) state that the affective domain is necessary in learning and if ignored, will have an effect on the cognitive domain. This suggests that when learners are not interested in or motivated towards a subject, it may have an effect on their achievement in that subject. For example, some studies have shown a correlation between learners' affective domains such as disposition or attitude, and achievement in science (George, 2006; Knezek, Christensen, Tyler-Wood & Periathiruvadi, 2013; Welch, 2010).

According to Turner and Ireson (2010), learners' experiences and their environment can influence their feelings (the affective domain) towards science. This provides a rationale for the current study which focuses on learners' affective domain in an informal science environment. One example of such an informal science environment is an after-school science enrichment programme.

### 1.4 After-school science enrichment programmes

In response to declining achievement and interest of learners, many intervention programmes have been developed to provide science enrichment experiences for learners (Stakes & Mares, 2005). Some of these intervention programmes also focus on learners' affective domains (Sneider, 2011; Stakes & Mares, 2005). One type of such intervention is the after-school science enrichment programme (ASEP) or out-of-school-time science programmes. ASEPs are designed to broaden learners' perspectives and also aim to help in improving the academic achievement of learners, especially those who were not achieving as well as they needed to during regular school hours (Hussar, Schwartz, Boiselle & Noam, 2008; Stott, 2014). This informal science environment offers learners a variety of learning experiences outside the classroom which are helpful in strengthening their positive disposition (Graven, 2011).

Matterson and Holman (2012) assert that schooling helps learners cover the required breadth of content and develop formalized general principles. ASEPs give meaning, relevance and context to the ideas that schools offer. Lending support, Graven and Stott (2012) assert that after-school programmes are designed to contrast the formal classrooms features and practices. They further expound that an after-school environment is less structured compared to the formal classroom setting, although it seeks to create a connection with the curriculum and instruction offered by schools. The difference between an after-school programme environment and the formal classroom are detailed in Section 3.4 (Table 1) in this thesis.

There are various examples of after-school science enrichment programmes around the world. These include among others: For Inspiration & Recognition of Science and Technology (FIRST) in New York, Girls Excelling in Maths and Science (GEMS) club in Chicago, Science Olympiad summer programme in Perth, and the Khanya Maths and Science Club (KMSC) in Grahamstown (South Africa).

The research field for this study is the Khanya Maths and Science Club (KMSC). An overview of the KMSC club will now be presented.

## 1.5 Khanya Maths and Science Club (KMSC)

Khanya Maths and Science Club (KMSC), an example of ASEPs, was the case chosen for study in this research. The overview of KMSC presented here will cover the following: its geographical location, objectives, entry criteria, grouping of learners, activities and range of facilitators.

KMSC is located in Grahamstown, in the Eastern Cape Province of South Africa. The club runs at the Albany Museum in Grahamstown and members meet for two hours every Saturday morning during school term. KMSC is one of the community engagement activities undertaken by the Department of Chemistry at Rhodes University, in Grahamstown. It was established in 2000 with the aim of inspiring science learners and engendering in them a love for maths and science (Sewry, Glover, Harrison, Shallcross & Ngcoza, 2014). To achieve this objective, learners in the club are engaged in hands-on activities while increasing their knowledge of science concepts (Maselwa & Ngcoza, 2003; Sewry et al., 2014).

Learners in the club attend different Grahamstown schools, both public and private. The majority of learners are from the historically disadvantaged schools which have either no science equipment or only poorly funded laboratories (Sewry et al., 2014). There is no entry criterion as participation in the club is voluntary for learners from grade 7-12. This is markedly different from other ASEPs with entry criteria such as gifted learners, high achievers (Stakes & Mares, 2005) and under-represented groups (Waldron, 2006).

Learners attending the club are divided into three groups: a grade 7 and 8 group, grade 9 and 10 group, and grade 11 and 12 group. The grades 7-8 group is mainly involved in different science activities with the aim of demonstrating the everyday nature of science, and exploring different aspects of science (Sewry et al., 2014). Learners in grades 9-10 and 11-12 are taught curriculum-based mathematics and science. At the start of this study (2015), the group of grades 7-8 consisted of about 96 learners, both male and female (although females were in the majority). The focus of this study was in particular grade 7 learners in the grades 7-8 group. According to Knezek et al. (2013), the middle school (in which grade 7 falls) is a crucial stage in learners' development as it "prepares them for a fast changing future". It is also the last grade at primary school level in South Africa. Other rationales for choosing grade 7 learners are detailed in Section 4.4.

Individual and small group interaction with peers and facilitators is practiced in the club. The medium of instruction at the club is English, though *isiXhosa* is the mother-tongue of the majority of learners in the club. Facilitators in the club include undergraduate students, postgraduate students and academic staff volunteers from the Rhodes University Science Faculty. The club has helped many learners struggling with mathematics and science to the extent that some of the former members of the club are now university science graduates (Sewry et al., 2014). It is in this context that the current study aimed to explore the influence of learners' participation in an ASEP on their disposition towards science.

### 1.6 Significance of the study

Learners' decline in achievement and engagement in the field of science (Section 1.2) calls for a concerted effort to facilitate improvement. Many studies (for example, Muzah, 2011; Reddy et al., 2015) have identified a range of factors associated with achievement and engagement in science. These factors include teachers' knowledge, teaching time/resources, and the language of instruction, curriculum and learners' disposition. Muzah (2011) offers a context-specific perspective of why the problem persists. He outlines the features of South African science classrooms where learning is constrained in various ways and where there is no focus on the affective domain.

As alluded to by Turner and Ireson (2010), learners' experiences in different science environments is associated with developing their affective domain of learning science. Moreover, learners' disposition is identified to be central in learners' participation and achievement in science (Aydeniz & Kotowski, 2014; Oliver & Venville, 2011). There is a scarcity of literature that explicitly explores the influence of an informal environment such as ASEPs on learners' disposition towards science in general, and thus also in the wider South African context. This gap provides a validation for the current study.

While studies by Graven (2011), Hewana (2013) and Stott (2014) do begin to address the gap in research in South Africa, their focus is on mathematics. There are thus strong grounds for exploring the influence of learners' participation in KMSC on their disposition towards science – focusing on science in the South African context. Moreover, research on the impact of the KMSC on learners' disposition towards science was recommended by an earlier study (Sewry et al., 2014). It is hoped that the findings from this study will provide insights into the role of context-based learning in developing learners' disposition which is one possible way to improve learners' science engagement and achievement in South Africa.

### 1.7 Research goal

The goal of this research was to explore the influence of learners' participation in an after-school science enrichment programme on their disposition towards science. Khanya Maths and Science Club is the case studied in this research. The focus was on how learners' dispositions evolved as they participate within the club.

### 1.8 Research questions

To achieve the above goal the overarching research question was:

**What is the influence of grade 7 learners' participation in Khanya Maths and Science Club on their disposition towards science?**

In order to answer this main question, the following sub-questions were explored;

- What is the nature of grade 7 learners' disposition towards science prior to participation in KMSC?
- In what ways do the grade 7 learners' dispositions towards science change over time as a result of participating in KMSC?
- What are the factors influencing the dispositions that grade 7 learners attending KMSC have towards science?

### 1.9 Outline of the study

This thesis consists of six chapters. Chapter one outlines the background/context of the study, the rationale for and the significance of the study, the research goal and questions as well as detailing the chapters of the thesis. In Chapter two, the constructivist-developmental and situated learning theoretical frameworks informing this study are described. Chapter three presents a review of the literature on disposition and attitude as synonymous concepts. Literature on after-school programmes and their various benefits are also detailed. In Chapter four, the research methodology of this study is discussed. It also outlines research issues relating to ethics, validity and reliability of the study. In Chapter five, the result of analyses carried out in this study are presented and discussed. Chapter six contains the conclusion drawn from the study, its limitations, as well as some recommendations arising from the findings that need to be addressed by future research.

### 1.10 Concluding remarks

In this chapter, I have introduced the study, presenting the background, context, significance of the study, research goal, questions and the outline of the whole thesis. The next chapter presents the theoretical perspectives of this study.

# CHAPTER TWO: THEORETICAL FRAMEWORK

## 2.1 Introduction

In this chapter, the theoretical perspectives that inform this study are presented. Wortham (2004) describes learning as a change in participation through which one becomes a different person based on the practices of the settings in which we find ourselves. Similarly, Gresalfi (2009) argues that disposition is not a fixed personality trait but a learnable quality that can shift in the positive or negative for learners over the course of their school years. Gresalfi and Cobb (2006) consider learning as a way of being in the world while engaging in its interactions. They further define learning as developing a disposition.

From these authors' views, it can be deduced that an individual's disposition can be influenced by different experiences in different settings.

This study thus draws from the constructivist-developmental approach on disposition as described by Diez (2007) and situated learning theory as presented by Lave and Wenger (1991) as theoretical frameworks. A constructivist-developmental perspective describes how an individual changes because of experiences in a particular environment. The situated learning theory describes 'ways of being' as influenced in and through interactions in a particular context. These perspectives are important in this research as they relate to how learners' dispositions are influenced by their experiences and environments. I describe the essence of these theories and attempt to integrate them to build an overview of the theoretical framework used in this study.

## 2.2 Constructivist-developmental perspective

Diez (2007), in her study of teachers' disposition, developed two approaches to disposition: the perceptual approach and the constructivist-developmental approach. These two approaches were grounded in the theories of human intelligence as an 'entity' or 'incremental' respectively. The perceptual approach views disposition as a fixed, stable entity that cannot be changed. In contrast, the constructivist-developmental perspective describes disposition as able to change and grow through influence from experiences and environments (Diez, 2007). Diez explains that an individual's disposition develops over time, being influenced by experience and interaction in a particular context. This notion of an evolving disposition offers a necessary lens through which the influence of an informal environment such as an after-school science enrichment programme can be investigated.

The constructivist-developmental perspective of disposition is derived from Dewey's (1922) work on habits of mind wherein disposition is explained as the promptness to act in a specific way when the opportunity presents itself. Dewey argues that disposition can be acquired, developed and is different from inherent traits that are fixed (Nelsen, 2015). Other literature (Carr & Claxton, 2002; Katz, 1993; Ritchhart, 2001) describes disposition as habits of mind involved in one's thinking and judgment which can be learned or developed. Ritchhart (2001) explains further that disposition is active and embedded in each individual.

According to Dewey, habits are formed as one learns from experiences in the environment, and so disposition is also shaped into a particular form of activity or in response to the environment (Nelsen, 2015). Oja and Reinman (2007), agreeing with Diez (2007), explain that learners' dispositions evolve as they engage in constant interactions with and exposure to a particular kind of learning experience in a supportive and challenging environment. They emphasized that for disposition to develop, there should be optimal interaction with the environment. Thus, it could be deduced that one's disposition towards science can be shaped in the science classroom as you interact directly with teachers and engage with peers during science activities.

Earlier theorists such as Vygotsky support the notion of individuals having the potential to change who they are, based on interaction with the environment, while involved in cooperative activity with peers (Vygotsky, 1978). Vygotsky indicates that people are social beings and the social environment/experience influences what is learned and developed. Supporting this view, Bertram and Pascal (2002) consider disposition as environmentally sensitive, having the ability to be fostered, refined and even weakened by interactions with others in such environments.

Drawing from the above, it points to the fact that if ASEP is seen as a social environment that influences learning and development, disposition could be learned and developed in the process. In addition, Bourdieu (1993) notes that dispositions are acquired and manifest themselves in a social setting as a personality feature. Likewise, Splitter (2010) suggests that dispositions are conscious responses to situations, where learned dispositions are applied in related settings.

Drawing from these views, it can be argued that learners could develop their disposition towards science in science-related settings such as the KMSC. They could also demonstrate these dispositions during club activities as well as in other science related environments.

However, Thomas and Brown (2007) reveal that disposition is not about skills being acquired, but ways to affect or events which prompt the disposition. They explain that the environment may not necessarily inspire the development of disposition, especially if there are no challenging or novel situations. This idea complements Muselwa and Ngcoza's (2003) view of how the environment shapes individuals. They explain that if the environment is designed favourably for a desired behaviour, for example, during hands-on activities, individuals can be influenced in that environment toward the desired behaviour.

From the constructivist-developmental perspective, disposition is conceptualized as part of the abilities that include knowledge, skills, values and beliefs. Carr (1999) indicates that disposition involves knowledge and skills. In later writings, Carr and Claxton (2002) move on and argue that disposition should be separated from capabilities because the attributes involved in disposition are different from knowledge and skills. However, other studies (Borda, 2007; Raths, 2001) have supported the earlier view of Carr (1999) which describes disposition as closely related to knowledge and skill and that these cannot be separated. In support of this, Carr (2006) proffers the idea that knowledge, skills and feelings combine as disposition.

According to Diez (2007), the constructivist-developmental perspective provides a way of looking at how disposition develops in relationship to the development of understanding and skill. Oja and Reiman (2007), drawing from a constructivist-developmental approach, suggest that disposition can be learned in the same way as knowledge and skills. They explained that developing disposition could be understood using Piaget's theory of the cognitive development stages. Piaget describes how development occurs as individuals interact with and within an environment in stages (Oja & Reinman, 2007). This notion suggests that disposition, like cognitive development, develops in stages through interaction in an environment.

Brown and Duguid (2000), view learning as enculturation, and suggest that "…dispositions are acquired in precisely the same way that learning is enculturated; through institutional and interpersonal level of social contact" (p. 17). The enculturation perspective of learning implies that it is a collective enterprise that occurs in a community of practice (Brown, Collins & Duguid, 1989; Lave & Wenger, 1991; Wenger, 2000). It thus suggests that disposition is acquired and influenced by participation in a community of practice (Wenger, 1998; Wortham, 2004). In addition, Tishman, Perkins and Jay (1995) discuss development of disposition using a social basis for the development. They opined that thinking and learning are social activities, pointing out that disposition is grounded in values as it is in the cognitive structure. In other words, dispositions are acquired through social activities.

Brown and Duguid (2000) assert that, 'learning to be' indicates that learning is understood from an exploration of disposition and identity through enculturation. This is congruent with Wortham (2004) who explains that learning is not just about what the learner knows, but also who the learner is (identity) and becoming. Learning is a process of transforming who we are and what we can do. To learn is to take one's position in a community, thus changing self and identity (Wortham, 2004). Learners in a science classroom not only learn science, but in the process of engaging in the science activities, they become people who participate in science.

In this science-rich environment, learners' 'ways of being' are transformed accordingly to the practices experienced in the science environment. It thus follows that learning and identity are inseparable aspects of social practice as they have a continuous set of relations (Lave & Wenger, 1991). Hence, learning also implies development of identities (Wenger, 2000). Accordingly, Diez (2006) states that dispositions are not stable traits but can be "changed by knowledge and skills development in context in *a connected* view" (p. 65, emphasis original).

The context and connected view is the relationship between knowledge and skills acquisition in an appropriate environment, which relates to activities in a community of practice as espoused by Lave and Wenger (1991). The idea that places learning in the context of evolving identity and disposition, relative to the environment, is associated with the situated learning theory of Lave and Wenger (1991). As discussed above, disposition refers to the habitual tendency to respond to situations, evolving ways of becoming as learners participate in a community of practice (CoP) (Diez, 2006; Wortham, 2004; Hewana, 2013). The evolving ways of becoming as learners participate in CoP is coherent with the constructivist-developmental approach of disposition.

Therefore, it is necessary to discuss identity and community of practice in situated learning theory as it relates to the present study.

## 2.3 Situated learning theory

The emphasis on the importance of context and participation in situated learning theory, suggests that it might be a suitable theory for exploring the activities in an informal education setting. The model of situated learning developed by Lave and Wenger (1991) involves, 'doing', 'being', 'knowing' and 'engaging' (Aguilar & Krasny, 2011). This theory examines individual identity formation and transformation though membership and participation in various contexts. Identity as defined by Lave and Wenger (1991) is a 'way of becoming'.

Ritchhart (2001) too, defines identity as evolving ways of being or becoming. Some recent studies connect disposition to identity (Carr & Claxton, 2002; Falk, 2009; Gresalfi, 2009; Graven, 2012; Hewana, 2013; Tytler, 2010). Identity and disposition are contested concepts in the literature - though there are intersections, no clear distinction between these concepts could be found. However, some authors view identity and disposition from two different angles. Falk (2009) asserts that individuals have numerous identities, which are constructed and expressed in different situations. From his point of view, identity is a dimension of personality, which is emergent and not permanent. It could be argued that identity is an individual disposition that is expressed at specific moments.

From this position, Moll (2011) illustrates the link between identity and disposition. He points out that learners' science identity represents an affective construct emergent from an expression of emotion which influences their disposition. He further indicates that identity and disposition are interconnected and are a nested part of the learning system. Tytler (2010) who describes identity as disposition that learners bring to a learning community provides a similar explanation. He identifies identity as disposition to portray that learners recognize or change who they are based on their engagement in the learning situation.

In a related view, Hewana (2013) argues that disposition is an aspect of learners' identities. Gresalfi and Cobb (2006) connect these perspectives by indicating that disposition involves 'ways of being' (the same as describing identity), the ways people come to relate with each other within a particular setting. A similar view by Graven (2012) is that disposition relates to a learner's form of participation and 'ways of being'.

Wenger (1998) recognizes that disposition is embedded in personal values and evolving personal identities. He argues that disposition and identity are not inseparable but are aspects of the same phenomenon. Most literature associates learning, identity and disposition to how a learner's way of becoming unfolds through participation in a community of practice (Lave & Wenger, 1991; Graven, Hewana & Stott, 2013; Gresalfi & Cobb, 2006). If learning is considered a change in participation through which one becomes a different person with respect to the practices of that setting (Wenger, 2000; Wortham, 2004), and disposition is regarded as a way of being as we relate with each other in a particular setting (Gresalfi & Cobb, 2006; Thomas & Brown, 2007), it could be argued that learning is a change in participation through which one's disposition evolves with respect to the practices of that setting. Furthermore, it could be surmised that learners' dispositions towards science could evolve as they learn through participation in science activities in a science-rich environment.

According to Diez (2010), dispositions are not inbuilt capabilities of the learners but an outcome of their experiences. They are shaped by their participation in different circumstances, for example, in educational settings. Many researchers (Crick & Yu, 2008; Tytler, 2010) concur on the evolution of disposition based on response to or action in a particular situation, especially through educational experiences. In the same vein, Cummins and Asempapa (2013) as well as Ros-Voseles and Fowler-Haughey (2007) affirm that dispositions are not developed naturally but rather in a socially situated way and are acquired in a 'community effort'. This implies that learners have to be in the 'learning community' where educators and experienced professionals provide the necessary scaffolding related to the development of a particular disposition. Crick and Goldspink (2014) emphasize the importance of the structure of and interactions in the learners' environment as having a significant role in the way they come to their very being and belief about themselves. This relates very strongly to the ideas posited by a 'community of practice'.

Wenger (2000) describes a community of practice (CoP) as an informal type of organization structure. It involves a group of people who share a passion about a subject, coming together to interact and deepen their knowledge/expertise about that subject of concern. Wenger emphasized interactions, activities and learning in a community of practice and how members' ways of being in communities of practice change over time.

A group of people engaging in the "sustained pursuit of a shared enterprise" (Wenger, 1998, p. 45) is a community of practice, such as group of learners in a science club. For instance, in the context of this study, learners in the KMSC coming together to learn and engage in mathematics and science activities is considered a CoP. However, not just any group is considered a community of practice; rather it is a group that actually engages in shared repertoires in which their interactions in the group influence who they are. This concept suggests a framework that focuses on learners' participation in authentic, context-related activities (in this case, science activities). A community of practice is identified by three main elements; mutual engagement, joint enterprise and a shared repertoire (Wenger, 1998). These elements are explained in detail.

According to Wenger (2000), CoP exists around people with mutual engagement; people that are engaged in certain common ideas or practices. Members interact with one another and build relationships to reflect these interactions and competency in the community. This involves how learners participate in the club, working in collaboration with other members of the club as they engage in science activities. Through this interaction, they develop knowledge and transform their way of being. This coheres with the constructivist-developmental perspective which emphasizes optimal interactions in the environment for disposition to develop.

Wenger states the importance of joint enterprise as members create mutual accountability among themselves. Members negotiate their response to the conditions and goals of the community of practice. Gresalfi (2009) asserts that learners in a community of practice over a period of time, begin to participate and interact with content and other members which defines who they are. She explains that disposition is connected to the activities in this community of practice - disposition will evolve according to the evolving of the community of practice.

The third element is shared repertoire. In a CoP a shared repertoire consists of communal resources such as words, routines, ways of doing things, tools and styles which are specific to the community. Members in a CoP have access to this repertoire and are able to use it appropriately.

In an after-school science enrichment programme learners interact with each other as they engage in science activities, sharing resources such as science equipment and materials. The ASEP could be considered a community of practice through which learning occurs and dispositions are acquired and nurtured (Honig & MacDonald, 2005). In other words, through participation, learners transform who they are as they engage in different science activities. It could be said that their participation in that particular context influences their dispositions. Thus, the community of practice framework allows examination of the process through which activities in the community of practice (KMSC) shape an individual learner's disposition.

The synthesis of the constructivist-developmental approach of disposition and the situated learning theory, specifically the community of practice model, offers a framework by means of which learners' dispositions in a community of practice such as the KMSC can be examined. The constructivist-developmental approach describes disposition as being influenced by experiences and interactions in a particular environment. Equally, the situated learning theory explains that one's way of becoming is influenced in and through participation in a community of practice. These perspectives offer a unique way to explore how learners' participation, interaction and experience in the KMSC (CoP) influence their dispositions towards science.

### 2.4 Concluding remarks

In this chapter, I discussed the theoretical frameworks that I used to inform this study. I discussed how the constructivist-developmental and situated learning theories state that the learning environment and experience can influence learners' disposition. More specifically, the community of practice model (CoP) provides a useful lens for examining how learners' dispositions are influenced as they participate in an after-school club. In the next chapter, literature related to this study is reviewed.

# CHAPTER THREE: REVIEW OF RELATED LITERATURE

## 3.1 Introduction

In this chapter, the review of literature that informs this study is detailed.

Firstly, I discuss the various arguments about the concepts of disposition and attitude, the relationship between them and the key sub-constructs relevant to this study.

Secondly, different studies pertaining to learners' attitude towards science and how it could be influenced is presented and discussed. Following this is the exploration of the nature of after-school programmes in general and I elaborate on their potential benefits.

Lastly, reviews of studies on after-school mathematics and science enrichment programmes and more specifically science enrichment programmes, are discussed. Studies on after-school mathematics programmes are included because most after-school science programmes include mathematics and the case studied in this research is a mathematics and science club. This is followed by exploring the various studies on after-school science enrichment programmes.

## 3.2 Disposition

As mentioned in Chapter one, Dewey was the first to use the term disposition in the literature when he described 'motive of act' as habit and disposition (Nelsen, 2015; Ritchhart, 2001). The overall concept of disposition is difficult to define (Carr & Claxton, 2002) which has led to it being defined in various ways in the literature. Dewey defines disposition as the "readiness to act overtly in a specific fashion whenever the opportunity is presented" (Nelsen, 2015, p. 90). For Dewey, habits and disposition are closely related concepts, both pointing to the "readiness to act overtly" in a given context and so these terms can be used interchangeably. Damon (2005) who describes disposition as a trait or character that defines 'who we are' or 'become' provides a similar explanation.

Bourdieu (1993) affirms that disposition is an enduring feature of a personality trait. He explains that disposition could be referred to as attitude or attitudinal tendency. Facione (2000) supports Dewey and Bourdieu by suggesting that disposition is a "characterological attribute" of an individual. He also mentions that disposition is a personality trait, to behave or act to a 'subject' or ‘object’ in a certain manner. As for Nelsen (2010), disposition is a cluster of habits to draw upon modes of responses within a specific context. Similarly, other authors propose that disposition is a dimension of personality such as habits of the mind (Mall, 2012), personality characteristics, recurrent/pattern of behaviour (Raths, 2001) attitude and beliefs (Ritchart, 2001; Siegel, 1999) and habits of thinking and doing (Ros-Voseles & Fowler-Haughey, 2007). These authors view disposition as one’s ability to act or respond in a conscious, controllable manner towards an object or a subject.

An individual’s disposition makes them act in a characteristic way in a particular situation as Graven (2012) rightly puts it. She argues that disposition is the habitual tendency to act in a particular way when opportunity presents itself. Crick and Yu (2008) agree with this statement and point out that disposition is a behavioral tendency that endures over time, which can be developed and enhanced. They assert that disposition comes from a desire or motivation which gives the promptness needed for an action. Likewise, other authors describe disposition as the action taken in a particular situation (Perkins, Jay & Tishman, 1993), and contextualized pattern of behaviour (Ritchart, 2002). A review of literature suggests that disposition involves behaving or acting in certain ways, in a particular situation as well as the desire and willingness to do so.

Disposition is distinguished from inborn traits such as temperament. Dewey clearly pointed out that disposition is not fixed but can be acquired and developed through educational experiences while inborn traits cannot (Nelsen, 2015). From Dewey’s description, it can be understood that disposition develops through interaction with the world and in response to problems in the social and physical environment (Nelsen, 2015). Similarly, other authors share this view in varying degrees (Oja & Reinman, 2007; Ritchart, 2002) indicating that disposition is not fixed but a learnable and changeable human quality. Ritchart (2002) emphasizes that dispositions are acquired patterns of behaviour, which are dynamic and can manifest in a specific context.

In contrast to the perspective of a learnable disposition, Perkins, Tishman, Ritchart, Donis and Andrade (2002) posit that dispositions are a stable trait. Supporting Perkins et al. (2002), Wasicsko (2002) argues that disposition is a stable trait and cannot be changed. Contrary to this view, Carroll (2005) indicates that disposition is embedded in experience, beliefs and values which are shaped by interactions with others in a social circle thus suggesting that disposition can be developed or learned.

Wenger (1998) describes how disposition can be acquired or shaped in a community of practice as discussed in the theoretical framework informing this study in Chapter two. Katz (2002) also mentions that disposition may be positive or negative. Although there is no consensus on the definition of disposition among researchers, they all seem to agree that developing positive disposition is essential for success and achievement in learning (Cummins & Asempapa, 2013).

In some of the literature reviewed, disposition is used synonymously with attitude. Some authors actually refer to disposition as attitude (Ajzen, 2001). It is thus necessary to discuss these concepts as they relate to this study.

### 3.2.1 Disposition and attitude

Researchers have defined the concept 'attitude' and its relation to disposition differently. Some claim that attitude is a multidimensional construct consisting of three characteristics; the cognitive, affective and behavioral domains (Sagir, 2012; Ajzen, 2001). Ajzen (2001) argues that attitude is not just a behavioral tendency or feeling but also the integration of cognition, feeling and behaviour. He explains that the cognition is having knowledge or rating the importance of the object/issue, the feelings explain how pleasurable the object of attitude is and the behavioral involves action towards the object/issue.

Attitude signifies a positive or negative response to people, things or ideas (Simpson, Koballa, Oliver & Crawley, 1994) or feelings about engaging in a particular activity (Koballa, 2007). Ajzen (2001) likened attitude to a personality trait that could be inferred from observable responses that influences human behaviour. A similar view from Simpson et al. (1994) is that attitude can be viewed as one's belief or feelings of like/dislike around an object/idea or people which cause a particular response in some preferential manner. Vogt (1997) agrees with Simpson et al. (2007) and defines attitude as beliefs, feelings and traits of an individual towards an event, things or people.

Facione (2000) and Siegel (1999) like the authors above, affirm that disposition is a personality trait of an individual geared to respond in a certain manner to an event. Facione argues further that disposition can be referred to as attitude. Ajzen (2001) who affirms that attitude is interchangeable with disposition supports Facione. Authors in the field describe disposition, attitude and other related concepts such as belief, personality, behavior and value differently. For some, disposition is attitude, belief, personality trait or observed behaviour (Katz, 1993; Raths, 2001; Vogt, 1997). Others (such as Damon, 2005; Mall, 2012) argue that attitude and belief drives disposition. Mall (2012) explains further that an individual's attitude is inferred from observed behaviour.

In addition, Raths (2001) points out that belief influences the way an individual acts which is reflected in disposition. Her idea suggests that belief, personality trait and attitude can be referred to as disposition that manifest in an individual's behaviour. Furthermore, other authors offer that attitude and disposition are integrated to define one's behaviour (Atallah, Bryant & Dada, 2010; Mall, 2012). Wasicsko (2002), who views disposition as descriptive of attitude or belief, which forms a basis of behaviour, echoes the latter point that attitude and disposition integrate to define behaviour. In the literature, disposition is commonly used interchangeably with attitude, belief, behaviour, personality trait, feelings, skills, values and competence (Jung & Rhodes, 2008). This suggests disposition can be described as a set of interrelated habits.

Drawing from the views of the authors above, attitude and disposition could arguably be used interchangeably as they both reveal one's mind-set or tendency to behave or feel in a particular manner to given stimuli in specific contexts. The present study considers attitude as disposition, so in studying learners' disposition towards science, the term 'attitude' is used as a synonym and discussed as 'disposition'. Based on this understanding of disposition and attitude as it is used in this study, a review of literature on attitude towards science is presented in the next section.

### 3.2.2 Attitude towards science

Attitude towards science is considered one of the most important affective concepts in science education (Cook & Mulvihill, 2008; Koballa, 2007). Attitude towards science may be a favourable or unfavourable feeling which centres on one's evaluation of science (Koballa, 2007). Lakshmi and Rao (2003) define attitude towards science as the positive or negative feelings one has towards science. In the literature, many studies measuring attitude are inconclusive on the definition of attitude, making it difficult to determine what exactly they measured. Some defined attitude as a cognitive domain while others defined it as an affective domain (Osborne, Simon & Tytler, 2009). It is therefore important to distinguish between these two domains as they relate to attitude.

The cognitive domain involves processing of information, construction of knowledge and meaning linked to learning outcomes. The affective domain deals with the emotion, feelings, values and perceptions of learning tasks and consequently helps learners in their approach to learning activities (Osborne et al., 2009).

Gardner (1975 cited in Osborne, Simon & Collins, 2003) makes a clear distinction between cognitive and affective domains as they relate to attitude. He states that the cognitive domain is described as ‘scientific attitude’ while the affective is ‘attitude towards science’. Bennet (2003) asserts that attitude towards science are the views developed by learners as a result of their experiences in different science environments. For the purpose of this study, attitude is discussed in the affective domain - attitude towards science. This encapsulates the study’s aims, which is looking at learners’ feelings and views about science.

Ramsden (1998) describes attitude towards science as a concept often used interchangeably with interest, enjoyment and perception in the literature. Likewise, Osborne et al. (2003) suggest that attitude towards science consists of different sub-constructs. They point out that attitude towards science encompasses feelings, perception of science, belief, interest, values related to science and enjoyment of science amongst others. In addition, attitude is often used with terms such as interest, opinions, belief, enjoyment and other affective variables (Koballa & Glyn, 2007). This implies that the construct attitude towards science, consists of several sub-constructs.

According to Belge-Can and Boz (2012), the different sub-constructs of attitude contribute in varying degree to the attitude of learners which are developed in different contexts (Belge-Can & Boz, 2012). Thus, different sub-constructs are used to develop dimensionality of scales to measure the attitude construct (Belge-Can & Boz, 2012; Osborne et al., 2003). Many studies on attitude towards science have employed varying sub-constructs such as, interest and enjoyment of science (Kaya & Ebenezer, 2007), interest, enjoyment and perception of science (Anwer, Igbal & Harrison, 2012), interest, enjoyment, perception, scientific attitude (Fraser, 1981) to measure attitude towards science.

The various descriptions of attitude towards science have this characteristic in common; attitude is a feeling towards or against an object, science is the object and attitude can be measured for it (science). This indicates that there is a subjective feeling towards the object (science). Therefore, in this study, the sub-constructs employed in measuring attitude toward science are; enjoyment of science, interest in science or a science-related career and perception (value) of science. These three sub-constructs were selected from the eleven different sub-constructs highlighted by Osborne et al. (2003). In addition, they are represented in the Test of Science Related Attitude (TOSRA) questionnaire used in this study (Section 4.5.1).

Enjoyment of science is the pleasure and fulfillment that activities in science give to learners (Kaya & Ebenezer, 2007). Sammons, Sylva, Melhuish, Siraj-Blatchford, Taggart et al. (2012) referred to enjoyment of science as a positive view and confidence in one's ability in science activities. In this study, learners' engagement in leisure-time activities that involve science such as reading about science at leisure is termed enjoyment of science.

The dictionary meaning of interest indicates a feeling towards an object. It signifies a response of liking or preferring directed towards objects or an activity. In the literature, interest in science is described as curiosity, appreciation and engagement in science (Maharaj-Sharma, 2012; Osborne & Collins, 2000). Bevins, Brodie and Brodie (2005) define interest in science as likes and dislikes of science in comparison to other fields. Having an interest in science could lead to learners wanting to learn or engage more in science activities as well as possibly take up a science career (Hofstein & Mamlok-Naaman, 2011).

Perception of science is described as the awareness and the degree of understanding of the value of science in everyday life (Cummins & Asempapa, 2013; Kaya & Ebenezer, 2007). It also refers to learners' views about the complexity of science (Kaya & Ebenezer, 2007). Literature reported that students' positive perceptions of science stimulated a positive attitude and thus improved achievement in science (Kaya & Ebenezer, 2007; Maharaj-Sharma, 2012).

### 3.2.3 Studies on attitude towards science

A good attitude towards science is recognized as important for science achievement and to encourage interest in pursuing science or science-related careers (Knezek et al., 2013; Welch, 2010). Welch (2010) argues that one possible way to promote learners' long-term achievement in science is to reinforce the development of a positive attitude towards science. This is because a lack of positive feelings, enthusiasm or motivation towards the subject may lead to a decrease in engagement and participation in the subject. George (2000) shares a similar view, in his opinion a good attitude towards science is closely related to achievement in science.

Weinburgh (1995) in a meta-analysis of 18 studies linking cognitive and affective domains, found that attitude towards science (affective) and achievement in science (cognitive) correlate. He affirmed that learners who had higher scores in attitude also accomplished higher achievement in science, which shows that these two domains are related and that they should not be considered to the exclusion of the other. It is argued that a combination of the affective and cognitive domains position learners for success in science education (Koballa, 2007; Welch, 2010). This suggests that a positive attitude towards science (liking science) is considered an antecedent to achievement in science (doing well in science).

Pierre and Oughton (2007) also assert that attitude towards science does have an effect on the cognitive domain and thus translates into achievement. They indicate that the cognitive and affective domain of learning science complement and are dependent on each other. For example, it has been found that students' engagement (learning content and performing science activities and interest) in science has a favourable effect on their achievements in science (Noam & Shah, 2013; Hofstein & Mamlok-Naaman, 2011). To take this further, their achievement influences their likelihood of pursuing a science or science-related career later in life (Noam & Shah, 2013; Welch, 2010).

Some studies (Osborne et al., 2003; Osborne & Dillion, 2008), however, report no clear (or none) causal relationship between attitude towards science and achievement in science. Osborne et al. (2003) caution against generalizing the observed relationship between attitude towards science and achievement. They argue that learners could achieve in science without necessarily having a positive attitude towards it. They suggest that self-efficacy has been identified to be a better predictor of learners' achievement than attitude alone.

Many studies have shown that learners' attitudes toward science are worsening (Chang, Yeung & Cheng, 2009; George, 2006; Osborne et al., 2003). This negative shift in attitude towards science varies according to a range of factors. In their review, Osborne et al. (2003) explain that learners' attitude towards science drops significantly after the age of 14 (in the middle school), which has been attributed to factors such gender, teachers' effectiveness and the curriculum. Researchers in the field of science education find themselves challenged to devise educational strategies that can improve learners' attitudes towards science. One strategy that has been identified is the after-school science enrichment programme (ASEP) (Bevan, Michalchik, Bhanot et al., 2010; Knezek et al., 2013).

In the literature, various factors have been recognized as having an influence on learners' attitudes towards science. Most learners' belief that science is difficult affects their attitude towards science (Kihwele, 2014; Osborne et al., 2003). Kihwele (2014) explains that parents, siblings or peers have a habit of saying that science is difficult and only for the talented few; as a result, learners put less effort into learning science, and their resulting poor performance then confirms that science is difficult. This confirmation makes them develop a yet more negative attitude towards the subject.

Turner and Ireson (2010) inform us that teachers' moral and personal commitment to teaching science have an influence on the attitude of learners towards science. They affirm that the use of practical work and other interactive activities have an impact on learners' enjoyment of science activities. They further explain that planning novel and creative activities for learners could help improve their attitude, as learners are bored by just sitting, listening and writing in class. Yilmaz and Timur (2011) concur, emphasizing that science lessons incorporating experimental activities could enhance the development of a positive attitude towards science.

A similar view is expressed in Pampaka, Williams, Hutcheson, Wake, Black et al.'s (2012) report: that traditional teaching methods, which are mostly concerned with assessment and grades, may be a contributor to the decline in learners' attitudes. They mention that learners' attitudes are closely associated with the learning environment. They also found that the use of a variety of teaching strategies and learning activities is associated with the inculcation of a positive attitude towards science. In addition, Lyon (2006) reports that learners' attitudes are influenced by their perception of how the subject relates to the real world, while Bennet (2003) suggests that learners' experiences of different science environments determine their attitude towards science. Other studies on the attitudes of learners towards science provide evidence of the effect of a context-based approach in developing learners' attitude towards science (Bennett, Lubben & Hoggarth, 2006; Hofstein & Mamlok-Naaman, 2011).

After-school programmes recognize the development of the attitude of learners towards science as one of their outcomes (Falkenberg, McClure & McComb, 2006; Stakes & Mares, 2005). In their study, Stakes and Mares (2005) found that after-school programmes have a positive impact on learners' attitude towards science and mathematics as well as on their academic performance in these subjects. Many recent studies (Knezek et al., 2013; Nadelson & Callahan, 2011; Oliver & Venville, 2011; Welch, 2010; Welch & Hoffman, 2011) also report significant changes in learners' attitude towards science in ASEP. Knezek et al. (2013) argue that learners' attitudes towards science are shaped as they participate in different educational settings, and thus interventions on the different learning environments may positively influence their attitude.

Knezek et al.'s (2013) argument on how learners' attitude is shaped in different settings harmonizes with the constructivist-developmental perspective and situated learning theory that views disposition/attitude to be changeable as learners interact and participate in a CoP. The social influence of others in a learning environment also affects attitude. This is congruent with the theoretical framework informing this study.

## 3.3 After-school programmes

After-school programmes (ASP) started in the United State of America (USA) in the nineteenth century (Harpen, 2002). The aim of ASPs is to provide a safe, adult-supervised environment for young people while offering them activities and experience that promote academic, personal and social growth (Durlak & Weissberg, 2007; Harpen, 2002). ASP served as a relief for working parents who could not be with their children immediately after school. Parents could not risk the negative outcomes of leaving their children unsupervised in an undesirable neighbourhood for some hours after school (White, 2005), so ASPs were started to occupy children productively during these hours. White (2005) describes the ASP as "a critical first step in the process of changing not just how we educate our children, but how we come together, in partnership – school and community – to ensure success" (p. 8).

After-school programmes are viewed as a sub-category of broader out-of-school-time (OST) programmes, especially in the USA. They run during summer holidays, weekends and before school (Stott, 2014). In the literature, the terms ASP and OST are often used interchangeably to refer to developmental programmes occurring outside of formal school hours. But some literature has distinguished ASP from OST, claiming that after-school implies programmes that students attend after the school day, while out-of-school-time programmes refers to programmes that take place before school or during holidays (Schwartz & Noam, 2008). In this study the terms OST and ASP both refer to programmes before, after and during school holidays or summer.

Lauer, Akiba, Wilkerson et al. (2006) assert that out-of-school-time is the time in which school-aged children are engaged in some other activities not required by school attendance. This corresponds with Durlak and Weissberg's (2007) view that after-school programmes are rightly praised for a more informal structure, responsive to students' interest and passions. They explain that ASPs offer a mix of activities in promoting different aspects of young learners' development and targeting at-risk children. These activities range from basic aftercare, to purely academic enrichment programmes, social or recreational activities, and even a mixture of these (Durlak & Weissberg, 2007).

Although the ASP originally started with the aim of keeping young children safe, it is now varied in terms of goals and programmes. Some ASPs continue with the tradition of providing a safe environment for children to have fun, while some focus on providing tutoring and helping students with homework completion. Others focus on enrichment to develop skills and interest in activities such as science, art and craft (Krishnamurthi & Rennie, 2012). Educators and policy makers have thus placed increasing emphasis on ASPs as a means of improving academic achievement and providing opportunities for the academic enrichment of learners (Fashola, 1998).

The goal of most ASPs has subsequently evolved to providing an enriched learning experience that contributes to the whole development of learners. They are often intended for remedial purposes, to serve at-risk students or the less privileged population (Fashola, 1998; Schwartz & Noam, 2008). ASP/OST are now seen as involving intervention programmes intended to provide intellectual stimulation for learners, generating an enthusiasm that they often transfer to the more formal classroom environment (Stakes & Mares, 2005).

Weiss (cited in After-School Alliance, 2011, p. 1) affirms that, "linking school and after-school programmes is a powerful way to support learning and address achievement gap issues". Aligning the after-school programme with the school curriculum can offer additional help for struggling students in an exciting way and bridge the achievement gap. As a result, many ASPs have taken steps to align their programmes with that offered in the school to ensure the success of participants (After-School Alliance, 2011). It is also important to note that ASPs are not mandated for all students, but are usually voluntary and attended by highly motivated learners or learners with more motivated parents.

A common feature across various ASPs is an engaging, experiential learning approach in an informal environment that aims to be different from formal school (Schwartz & Noam, 2008). Such learning often takes place in places such as universities, community centres, rural areas, indoors or outdoors, and may serve learners from many different schools (*ibid*). An ASP may be operated by private individuals, community organizations, or use of teachers and/or community educators, and may be supported by grants, philanthropic gifts, federal and local governments, parents, municipal parks, recreation departments, or any combination of these (Krishnamurthi & Rennie, 2012).

Khanya Maths and Science Club (KMSC) is an after-school programme which is focused on promoting the academic development and achievement of middle and high school students in maths and science (Sewry et al., 2014). A review of after-school programmes that specifically revolve round strengthening the academic development and achievement of learners in science and mathematics is therefore important.

### 3.4 After-school science (enrichment) programmes

After-school Enrichment Programmes (ASEP) or Out-of-School-Time (OST) programmes in science evolved as a modification of after-school programmes (Bell, 2014; Bevan et al., 2010). They are referred to as intervention or enrichment programmes designed to promote the skills, interest and engagement of students in science (Dabney, Tai, Almarode, Miller-Friedmann, Sonnert et al., 2011; Hussar et al., 2008).

In the literature, these programmes are sometimes referred to as after-school science enrichment programmes (ASEP) or intervention programmes (Sneider, 2011). The terms informal science, after-school science, informal STEM, after-school science enrichment and science in out-of-school-time are often grouped together in the literature or used interchangeably to refer to science intervention/enrichment programmes occurring beyond the formal school setting and curriculum.

ASEP are described as informal science environments designed to offer opportunities for active engagement, negotiation and participation for students in respect of science (Honig & McDonald, 2005). ASEP are informal environments where learners meet to interact and develop the skills and attitudes needed for engagement in scientific activities (Bell, Lewenstein, Shouse & Feder, 2009; Stott, 2014). Laursen, Thiry, Archie and Crane (2013) affirm that ASEPs are informal science environments ideally located for learning science and increasing the access of underrepresented groups in the science field. They acknowledge that these informal science environments can offer learners a variety of opportunities and experiences outside the classroom that can help them develop a positive attitude towards science.

Similarly, Krishnamurthi, Ballard and Noam (2014) indicate that engaging learners in well-structured after-school programmes can present opportunities for authentic science experience and exposure to role models. This is echoed in words of Bell et al. (2009, p. 4) that informal science environments can give learners

> Experience, excitement, interest, and motivation to learn about phenomena in the natural and physical world … (and) think about themselves as science learners who develop identity as someone who knows about, uses, and sometimes contributes to science.

Bell et al. (2009) further argue that the very nature of a formal science classroom limits these opportunities as they are driven by a predetermined set of requirements and bound by constraints such as limited instructional time, pressure to prepare learners to perform well in content assessment, curriculum standard teaching/learning, and large class sizes.

Similarly, Noam and Shah (2013) mention that ASEP provides the setting to address the perceived disconnect of science instruction driven primarily by defined curricula. They assert that there are some qualities commonly associated with these informal science settings which are not present in the formal settings. In addition, they describe ASEP as having varying goals and structures with no centralized authority overseeing its operation, it allows for a flexible time and space for innovation in learning. Other authors (Albers, Smith, Caldwell, McCoy, Bottomley & Parry, 2008; Hussar et al., 2008; Sikes & Schwartz-Bloom, 2009) share a similar view that ASEPs were planned to enrich school science as well as provide avenues to strengthen the academic performance of learners through the infusion of exciting science activities and experience in a more relaxed environment.

Noam and Shah (2013) indicate that formal school and after-school settings often have complementary and overlapping goals. The advantages (impacts) that ASEP have over traditional school science in terms of using time more creatively and flexible teaching approaches have placed more demands on ASEP to provide quality science experiences for the learners. Notwithstanding, ASEP were never designed to replace the regular school curricula or instruction but rather to supplement regular school activities in a special and creative way (Matterson & Holman, 2012; Yohalem & Shouse, 2007).

The relaxed, interactive environment that encourages collaborative learning where learners engage in activities and discussion with peers has been identified as a major factor in improving learners' enjoyment of science (Turner & Ireson, 2010). Similarly, Noam and Shah (2013) argue that learners are more relaxed and enjoy participating in after-school programmes where there is no anxiety about tests compared with the school context. The social setting of ASEP provides an environment for both individual and collective learning experiences. Wenger's (1998) community of practice also emphasizes the value of the collective learning experience.

Krishnamurthi and Rennie (2012) confirm that the structure of the school curriculum is not adequate to motivate learners for life-long learning in science. Since the structure of the science classroom is not easy to change to accommodate all these outcomes, ASEP can be a perfect space to boost these outcomes. Graven (2013) concurs and points out that a key motive for after-school clubs is to shift learners' disposition from passive to active towards self, school, and better engagement with learning as they participate in various club activities.

Table 1 Summarizes the difference between the formal science classroom environment and informal science club environment as provided by Graven and Stott (2012).

**Table 1: Summary of Formal Classroom versus Informal Learning Environments**

| **Formal Classroom Environment** | **Informal Club Environment** |
|---|---|
| Participation is expected as part of formal schooling (in-school-time) | Voluntary participation during out-of-school-time |
| Less learners' choice over the activities they work on and engage with | More learners' choice over the activities that they work on or engage with |
| Curriculum and assessment standards as a prescriptive framework strongly influencing choice of contents and activities | Curriculum as contextual guide for what is nationally expected of learner but individual leaner proficiency guide contents and activities |
| Largely acquisition based and often driven by teaching for/to assessments | Participation based, where participants are active and engaged |
| Teacher led with whole class teacher learner interaction | Many interactions are learner led with few whole class mentor interactions and many one-to-one interactions between mentor and learner |
| Assessments tends to be summative and result in ranked performance | Assessment is formative and integrated and is used to guide individual learning experiences for the participants |
| Prescriptive, teacher controlled classroom rules within school rules | Negotiated norms which may differ from in school time rules |

(**Graven & Stott, 2012, p. 95**).

In South Africa, learners benefit from Saturday and Winter programmes sponsored by the government. The Department of Basic Education provides free tuition, transport and food for some of these programmes as a way of neutralizing economic differences among students (Erasmus, 2013). However, some parents prefer Saturday and Winter programmes run by universities, private schools or independent tutors (*ibid*).

Examples of ASEP include science clubs, summer camps, field trips, puzzles and academic competitions, practical investigations, gaming, simulations, weekend or Saturday clubs, science discovery programmes, vacation schools and Summer/Winter programmes, field trips, workshops, festivals. These programmes are often experienced in a science-rich environment like museums, zoos, cultural institutions, university science laboratories, science centres, schools and community centres (Laursen et al., 2013; Noam & Shah, 2013).

### 3.5 Impact of after-school science enrichment programmes (ASEP)

Albers et al. (2008) state that science clubs provide an experience that could spark students' interest in science and provide opportunities for reinforcing and enriching concepts introduced in the formal science classrooms. They further explain that clubs provide a space where learners are afforded an opportunity to interact freely and casually with teachers and their peers. The relaxed nature of activities in the club encourages, develops and exposes science abilities in learners that may not be revealed during formal classroom time (Albers et al., 2008). Learners are more attracted to club activities that they see as fun or play, with the added opportunity to express themselves and explore new ideas in the field (Graven, 2011; Knezek et al., 2013).

Graven (2011) reports that clubs provide learners with an opportunity to develop self-esteem and learn to work in cooperation with others while giving mutual support to one another. This resonates with the model of CoP (Wenger, 2000) that emphasized working in cooperation with other members in the community to gain competency.

Different activities and opportunities in ASEP are seen to bring about more understanding of the relevance of science, the depth and breadth of science and also develop a positive attitude towards science (Bell, 2014; Sneider, 2009). Bell (2014) points out that the context-based approach of ASEP provides avenues for developing scientific literacy, skills, understanding scientific concepts as well as promoting a positive attitude towards science. He adds that the school curriculum which narrowly focusses on assessment of science knowledge, is inadequate to develop science literacy and attitude towards science in learners. A similar view from Kuhlane (2011) is that engaging learners in various activities by using easily accessible resources enables their understanding of scientific concepts.

In the After-School Alliance's (2011) review of the outcomes of ASEP, it reported that outcomes can be divided into two main groups: (1) knowledge and understanding of scientific concepts, skills and processes and (2) change in attitude towards the science field, careers, values and improved behaviour and engagement in school work. Likewise, while various outcomes and impacts were surveyed in many studies, two broad aims/outcomes were identified in ASEP: improving learners' scores and achievement in science, or developing learners' affective areas such as attitude and confidence in science (After-School Alliance, 2011; Krishnamurthi et al., 2014; Noam & Shah, 2013). Notwithstanding, since many ASEPs do not include improved achievement as a direct goal, but focus more on developing a positive attitude towards science which they believe will subsequently translate naturally into improved achievement (see Section 3.2.3) (Krishnamurthi et al., 2014).

A growing number of studies show that ASEPs help learners to become scientifically engaged and develop a positive attitude towards science (Bevan et al., 2010; Oliver & Venville, 2011; Welch & Hoffman, 2011; Yohalem & Shouse, 2009). For instance, reports of learners participating in the For Inspiration & Recognition of Science and Technology (FIRST) club showed that participants have a greater appreciation for (and a more constructive approach towards) science (Welch & Hoffman, 2011). Studies on the evaluation of science attitude focused on measuring levels of interest in science and science careers, confidence in science, perception of science and sense of self as a science learner (Schwartz & Noam, 2008). These measures are included in the Test of Science Related Attitude questionnaire (TOSRA) (Appendix B) used in this study to assess learners' attitude towards science (Section 4.5.1).

Gibson and Chase (2002) conducted a study in order to examine the effect of a Summer science programme on middle school students. Their report indicates that the participants were more enthusiastic towards science after the programme. The study employed an inquiry-based approach in teaching science and learners reported that hands-on experience and the inquiry-based nature of the programme led to them enjoying science and increased their interest in science. According to Albers et al. (2008), when students are exposed to fun activities that are hands-on in mathematics and science, their enthusiasm for science grows and they realize that they are enjoyable subjects. This finding corresponds with Maselwa and Ngcoza's (2003) belief that learners do enjoy hands-on activities if they are carefully planned and help to explain some key scientific concepts.

A study by Kaulinge (2013) on an after-school mathematics club showed that the club's learning activities helped the mathematical learning of the four learners in the case study. Schwartz and Noam (2008), also reported on a study of minority high school students participating in an after-school mathematics and science programme – the Gateway programme. They stated that participants had better scores in mathematics and science with higher graduation rates compared to the control group. The analysis of the impact of the clubs show statistically significant improvement in the mathematics and science achievement of learners in the programme.

Likewise, Klein and Bolus (2002) reported a significant improvement in mathematics scores between pre-test and post-test for students participating in an ASEP in Pennsylvania, New Jersey and Florida. They claimed that participants were more interested in mathematics and improved at a significant rate in mathematical skills. This has important implications for science as proficiency in mathematics is seen as a gatekeeper for many science related fields (Krishnamurthi et al., 2014).

The findings revealed above resonate with the findings of other research, for example, Oliver and Venville's (2011) case study with Australian High School learners participating in a Science Olympiad Summer Camp enrichment programme. They administered a survey to assess the influence of the Olympiad Summer Camp on learners' attitude towards science. The result of the pre- and post- camp responses suggests that more than 80% of participants developed a more positive attitude towards science as a result of the programme. Their findings showed that their attitude toward science increased significantly compared with non-participating learners of a similar age. They further explained that learners indicated that science at the enrichment programme was enjoyable and different from science at school; they referred to the nature of school science as restrictive, formulaic and lacking in relevance (Oliver & Venville, 2011).

A review of Broward County Saturday Science Programme by Falkenberg et al. (2006) revealed that most learners had improved on their academic performance and confidence in science. The aim of the programme was to increase science and mathematics skills of the underrepresented learners in the county. They indicated that learners in middle and higher schools were motivated to pursue a science and engineering major in college because of the programme. The programme also introduced the learners to new career opportunities by introducing them to role models in those careers. The findings of Falkenberg et al. concur with the report by Campbell and Acerbo-Bachmann (1998) on After-School Science Plus – an ASEP. They reported that learners participating in the After-School Science Plus acknowledged benefitting from engaging in science and developed constructive perceptions of science.

Similarly, Bevan et al. (2010) reported on the evaluation of LEAP (Learn, Explore and Play): science is fun. LEAP is an ASEP that provides learners aged 8-13 with science programmes that focus on conceptual learning and how science connects with their everyday lives. The participants reported that LEAP made science more interesting and influenced their attitude towards science. They also acknowledged that it improved their performance in science at school, helped them to know more about science in their environment and are considering science as a future career choice.

Using the Test of Science Related Attitude (TOSRA) questionnaire (Section 4.5.1), Welch (2010) explored the attitude of high school learners after participating in the First Robotic Competition (FRC). FRC is an after-school STEM programme designed to increase interest in pursuing STEM related fields (Welch, 2010). She affirmed that programmes that engage learners in authentic science related activities significantly improve their attitude towards science. Welch's study confirmed earlier findings about a good attitude correlating with high achievement in science as evidenced in the results of her study.

Little, Wimer and Weiss (2007) claim that learners participating in ASEP recorded improved achievement in test scores and grades, improved attitudes towards self and school, improved homework completion and increased engagement with learning. This corresponds with Albers et al.'s (2008) notion that a 'good' ASEP (2008) will develop interest and skill in participating learners that will stay with them for the rest of their lives. Erasmus (2013) adds that higher-level thinking can be developed in students through enrichment programmes.

In Albers et al.'s (2008) study, a good percentage of participants in the ASEP were more interested in studying mathematics, science and engineering after high school. This is because learners had developed a better perception about learning science and believed that they could get good grades in mathematics and science. Correspondingly, Hewana (2013), in his study of learners' mathematical learning disposition in an after-school maths club, reported that the expression of enjoyment of maths was a frequent feature in the maths club. Stott (2014) also mentions that OST clubs provide enabling spaces for improvement in learners as the club environments are free from several contextual constraints of the formal classroom.

Mentoring is identified as one of the benefits of ASEP which influences learners' attitude towards science (Ferreira, 2001; Noam & Shah, 2013). Ferreira (2001) asserts that female middle school science learners are influenced for the better after working with a female mentor in an ASEP. She reported that the scores of a post-test were higher than that of the pre-test on the attitude instrument used. In addition, the mentors' role in this programme improved performance and attitude of participants towards science. Other studies of ASEP for females show similar positive results (Harvard Family Research Project, 2003; Stakes & Mares, 2005).

According to Lave and Wenger (1991), in a CoP mentors (experts/teachers) demonstrate an attitude required by the community, which are then mastered by the apprentice (learner). Learners acquire the necessary attitude for participation in this community through progressive mentorship roles and also exercise expertise by demonstrating the appropriate attitude required (Honig & McDonald, 2005; Wenger, 1998). From this perspective, it could be argued that facilitators (mentors) in ASEP demonstrate an appropriate science oriented outlook, which is acquired, mastered and demonstrated by the apprentices (learners) as a CoP.

According to Kihwele (2014) and Sneider (2009), some learners perceive science as boring, impractical and disconnected from their world of reality. Also science education has been accused of being gender biased due to factors such as cultural depiction of science as masculine (Kihwele, 2014). Hall (2011) argued that females perceived science as a male domain, and the nature of science learning environment is seen as competitive and individualistic, excluding female participation. The science curriculum materials often illustrate science as primarily a male endeavour. This is inadvertently reducing the number of females interested in science, and their attitude towards science is generally more negative than the attitude of their male peers (Stakes & Mares, 2005; Waldron, 2006).

It is thus imperative to promote gender equality in science education through effective interventions. Many ASEP are designed to provide opportunities for girls to improve their outlook on science and to promote gender equity in the sciences (Stakes & Mares, 2005; Waldron, 2006). For example, the Family Tools and Technology Club was designed for boys and girls with the goal of increasing the number of girls interested in science, and maintaining their interest. The programme provides role models and engages girls in activities that would typically have been reserved for boys (Waldron, 2006).

This review of research shows that ASEPs have the potential to improve learners' attitude towards science, increase school attendance, improve learners' grades/test scores, and increase their scientific knowledge. Learners' participation in ASEPs has also been correlated with the likelihood of their pursuing a science or science-related career (Dabney et al., 2011).

The diversity of activities that fall under the umbrella of ASEP makes it difficult to identify those that are most effective. Nevertheless, there are studies that have identified the conditions or features required to deliver positive outcomes and effectiveness in ASEPs (Little et al., 2007). Section 3.6 discusses the features most likely to achieve positive outcomes in the ASEP.

In contrast to all the findings above, Stakes and Mares (2005) found no significant changes in the pre-test and post-test attitude measure of middle school learners after they had participated in an ASEP. A similar finding by Cole (2014) revealed a large decrease in positive attitude towards science among participants following enrichment programmes. Likewise, Waldron (2006) found that a science club intervention did not have a positive effect on females' attitude towards science. He surmises, from further findings, that factors beyond the enrichment programme (such as family background) appear to have more influence on attitude than the enrichment programme.

Furthermore, from a meta-analytic review of the effect of after-school programmes on the achievement of middle school students, Kidron and Lindsay (2014) report that out-of-school-time programmes do not have any significant effect on learners' achievement in mathematics and literacy. Correspondingly, the Gervitz Summer Academy Programme designed to improve the mathematics and science scores of middle school students showed no significant difference in the mathematics and science scores of participants' compared to the control group (Schwartz & Noam, 2008).

Also, some researchers have reported that there is no certainty that ASEP will improve learners' attitude toward science or achievement in science (Little et al., 2007; Stakes & Mares, 2005). Some studies note changes in science achievements but no evidence of positive impact in the affective domain, while some programmes designed to improve the affective domain have yielded inconclusive findings (Hussar et al., 2008; Schwartz & Noam, 2008; Stakes & Mares, 2005). Moreover, Krishnamurthi et al. (2014) argue that despite the fact that some programmes are successful in these outcomes, caution should be taken not to assume that all ASEP will be able to deliver on all the outcomes or to expect immediate success.

Another important finding is that learners who have been selected for ASEP or who voluntarily enroll in these programmes already have a high rating for science interest, placing a ceiling on possible change as stemming from their participation in the enrichment programmes (Dabney et al., 2011; Stakes & Mares, 2005). Many studies also failed to state whether interest is a precursor or a result of the ASEP (Dabney et al., 2011). Thus, comparison of the results from studies on ASEP could not provide a simple answer to the question about the impact of ASEP as there are variations in programmes studied, contents, context, goals and structures, as well as the research designs of the studies.

As highlighted in Section 3.3, factors or variables other than ASEP have been identified as influencing learners' attitudes towards science. These variables include family, school teachers, peers, gender, age, socio-economic status, religion, teaching methods, science curricula and the perceived difficulty of science (Osborne et al., 2003; Reddy et al., 2015; Papanastasiou & Papanastasiou, 2004; Stakes & Mares, 2005). When these factors have direct association with the learners, they may very likely reflexively influence their attitude towards science. For example, learners who have strong family encouragement, or well-educated parents with an interest in science, or a network of friends keen on science, might as a result develop a positive attitude towards science.

Given the potential benefits of after-school clubs, Graven (2011) cautions that clubs should not overshadow the formal school curricula. She emphasizes that there is nothing inherent in ASEPs that will enable the positive shaping of individual learners. However, ASEPs have the "potential for providing an enabling space" (p. 5) since they are less controlled by school curricula and rules. This suggests that the quality of activities in ASEP is very important in measuring its outcomes on learners. Studies are beginning to distinguish between the qualities and effectiveness of different ASEPs as not all programmes have shown positive outcomes (Granger, Durlak, Yohalem, & Reisner, 2007; Little et al., 2007). Studies suggest that factors such as programme quality and strategies utilized can produce different outcomes (Granger et al., 2007; Stakes & Mares, 2005). As a result, studies focusing on the quality and typical structure required for programmes to attain positive outcomes are most important.

### 3.6 Features associated with positive outcomes in ASEP

Evaluations of the quality of participants' experience and the impact of ASEPs have been challenged and many factors have been identified that affect their influence (Falkenberg et al., 2006). These challenges include;

- difficulty keeping track of participants over a long period of time for evaluation;
- developing appropriate tools for impact measurement; and
- determining whether changes in outcomes result from their participation in the after-school programme or as a result of other factors such as school and family (Falkenberg et al., 2006; Matterson & Holman, 2012).

It is thus worthwhile examining the conditions or features that are required to deliver positive outcomes in ASEP.

Krishnamurthi and Rennie (2012) suggest that to measure the effectiveness of ASEP, it is imperative to focus on the quality of the programmes and activities offered. They gave a summary of the quality features of ASEP which include: a relaxed environment with less adult control and punitive measures, considering the needs and interests of participants, not duplicating the formal school lessons or routines, offering activities that actively engage learners with peers. They argue that when these features are present, there is increased attendance, which is important as regular participation is necessary for achieving outcomes.

Using observational measures of quality, Granger et al. (2007) assert that ASEPs are most successful when they employ sequenced, active involvement, focused and explicit learning activities (SAFE). Programmes with these (SAFE) features have positive effects on every outcome while other programmes without these features showed no significant effect for the measured outcome (Granger et al., 2007). Similarly, Bevan et al. (2010) argue that ASEP programmes that have carefully chosen curricular topics that connects to the school curriculum do have the potential to achieve outcomes and facilitate transferability of attitude to the school and other science settings.

Using different terminology, Jones (2010) developed a model of academic motivation in science. The model specified that learners' attitude towards a particular field are influenced positively when they perceive that; they are e**M**powered, the content is **U**seful, they can be **S**uccessful, the content and instruction is **I**nteresting and the instructors **C**are about their success (MUSIC). These five components, when present in any context, could motivate and influence learners' feelings towards science (Jones, 2010).

Huang and Dietel (2011, p. 2) developed a model for effective high-quality after-school programmes. The five components of the model are;

1. Clear, well defined, curriculum aligned and practice specific **goals**;

2. Experienced well-educated **leadership** that sets high expectations and provides staff and students with adequate materials and resources;

3. Experienced, qualified **staff** with a positive relationship with each other and students;

4. Unique, innovative, structured and engaging **programme** with emphasis on making learning fun; and

5. Internal and external **evaluation** to identify programme strength and weaknesses for continuous programme improvement.

These five components, goal, leadership, staff, programme and evaluation work together to produce a high quality effective programme (Huang & Dietel, 2011).

In addition, positive outcomes in ASEPs are associated with regular attendance and quality experiences of learners in the programme (McLaughlin, 2000; Vandell, Reisner & Pierce, 2007). For example, in a narrative review of 27 studies of ASEPs provided by McComb and Scott-Little (2003), they focused their discussion on the conditions seen to favour positive outcomes. They found that learners attending the programme frequently benefited more than those not in regular attendance. Vandell et al. (2007) concur by affirming that elementary and middle school learners who attended ASEPs regularly demonstrated significant increases in test scores compared to their peers who were not regular attendees.

There appears to be a pattern of activities/programmes that indicate that ASEPs can positively impact learners' outcomes as suggested above. These hypotheses on the structure/effectiveness of ASEPs support Dewey's idea of developing disposition; to develop a specific type of disposition, a focus on how the entirety of the programme affects development of disposition is imperative (Nelsen, 2015).

### 3.7 Concluding remarks

In this chapter, the relationship between disposition, attitude and other related concepts such as beliefs, behaviour as well as definitions of these terms as used in this study were discussed. Also, studies on learners' attitude towards science and the different factors identified in the literature as influencing attitude towards science were detailed. Discussions about the nature of after-school programmes, more specifically ASEPs was presented. The potential benefits of ASEPs were also discussed. Lastly, an outline of different models for effectiveness and conditions to achieve positive outcomes in ASEP were enumerated. This chapter together with the earlier ones on the problem statement and the theoretical framework influenced the research methodology employed in this study which is discussed in the next chapter.

# CHAPTER FOUR: RESEARCH METHODOLOGY

## 4.1 Introduction

This chapter details the research design and the data collection process followed in conducting this study. It includes discussion of the research paradigm, methods, sampling, pilot study, data collection tools and procedures. The data analysis process, ethical issues before, during and after research, data analysis trustworthiness, including reliability and validity are also discussed.

The goal of this research was to explore the influence of learners' participation in an after-school science enrichment programme on their disposition towards science. To achieve this goal the following questions were explored;

- What is the nature of grade 7 learners' disposition towards science prior to participation in KMSC?
- In what ways do the grade 7 learners' dispositions towards science change over time as a result of participating in KMSC?
- What are the factors influencing the dispositions that grade 7 learners attending KMSC have towards science?

## 4.2 Research paradigm

Researchers have different beliefs about ways of conducting research. These beliefs are guided by some standard principles which can be referred to as paradigms. In the literature, a paradigm is also referred to as a 'world view' (Feilzer, 2010). According to Feilzer (2010), paradigms are ways of perceiving and experiencing the world. A paradigm gives an understanding of why and how a methodological approach is chosen in a study. Thus, the following discussion centres on the paradigm that best fits the focus of this study.

In order to answer the research questions (Section 1.8) posed in this study both quantitative and qualitative research approaches need to be considered. It would be inappropriate to position this study as either purely quantitative or purely qualitative. A third type of research design, which combines both quantitative and qualitative approaches, is known as mixed-methods research

(Feilzer, 2010). There are four commonly agreed-upon paradigms: positivism/post-positivism, constructivism, transformative and pragmatism (Feilzer, 2010; Tashakkori & Teddlie, 2008). Of these four paradigms, pragmatism is seen to be most compatible with mixed-methods research (Feilzer, 2010).

The aim of this study was to explore the influence of learners' participation in the KMSC on their disposition towards science. The constructivist-developmental perspective and the community of practice framework informing this study explain how an individual is influenced by participation in a particular context. The study draws on qualitative methods to examine factors influencing learners' disposition that are first identified through a quantitative approach.

The use of a quantitative approach alone would be inadequate to effectively accomplish the aim of this study. Employing both quantitative and qualitative approaches enabled a detailed description of learners' disposition prior to and after participation in the club to gain insight into what factors actually influenced their disposition towards science. The aim and theoretical frameworks informing this study support the use of mixed-methods, therefore the study adopts the pragmatic paradigm.

Pragmatism views the issues of truth and reality (positivism and constructivism) as inadequate and orients itself towards solving practical problems in the 'real world' (Hanson, 2008; Feilzer, 2010). In this sense, pragmatism side-steps the quantitative and qualitative divide and suggests that the most important issue is choosing the best research method which ultimately helps to find out what the researcher wants to know. It is aimed at investigating a particular question or phenomenon with the most appropriate research method (Feilzer, 2010).

### 4.3 Research methods

This study is a mixed-methods case study of an after-school maths and science club. Christensen, Johnson and Turner (2015, p. 392) define mixed-methods research as "a research approach in which quantitative and qualitative data or techniques are combined or mixed in a single research study". In other words, Harris and Brown (2010) suggest that a mixed-method approach enables the researcher to answer confirmatory or exploratory questions. A case study involves qualitative research in which a detailed description and account of a phenomenon within its real life context is given (Christensen et al., 2015; Denscombe, 2010). This should not be confused with a qualitative case study which employs only qualitative methods of data collection.

A mixed-methods approach allows multiple sources and methods of data collection and this can in turn ensure validation of data (Christensen et al., 2015). It provides the opportunity to investigate the after-school club in depth while describing learners' disposition towards science and their experiences within the real-life context (KMSC).

Yin (2009) enlightens that the research method employed must align with the nature of specific research questions (Section 4.2). Question 1 of the present study is about measurement of the nature of learners' disposition towards science prior to participation in the club. The quantitative data collection instrument used, allowed measurement and grading of learners' disposition using a pre-test questionnaire. Question 2 aims at observing how learners' disposition change over time as they participate in the club. The post-test result was compared with the pre-test to examine how the learners' disposition changed over the period under study. The data collected to answer research questions one and two are quantitative. Then, if there were changes, the purpose of question 3 is to look at the factors responsible for the change.

A qualitative approach was used to gain insight into research question three. Merriam (2009) informs us that qualitative methods explain how individuals construct meanings attributed to their experiences. Since the third research question sought to gain an understanding of the factors influencing learners' attitude towards science in the club, a qualitative approach to the question is considered appropriate. This was investigated through qualitative research instruments, which are: semi-structured interviews and the learners' journal entries. In addition to the main data collection tools highlighted above, the researcher kept an ongoing reflective journal and photographs of club activities.

Christensen et al. (2015) explain that mixed-methods design are constructed on: time order (concurrent or sequential) and paradigm emphasis (equal or dominant status). This study employed the quan ⟶ QUAL design (Christensen et al., 2015). This (quan ⟶ QUAL) design depicts that; a) it is mixed-methods which is primarily qualitative and b) it is sequential, with the quantitative phase preceding the qualitative phase (Christensen et al., 2015).

The sequential mixed-methods design sets the order for data collection strategy, in which the researcher seeks to elaborate or expand the findings of one method with another. For instance, this study design begins with the quantitative method involving a large sample to generalize a result to a population and is then followed by qualitative methods to collect detailed views of a few purposively selected individuals. In this study, quantitative data are collected and analyzed first, followed by the collection and analysis of the qualitative data. The qualitative analysis will provide a deeper understanding of and perhaps explanations for the disposition revealed by the quantitative tool, while contributing to trustworthiness through triangulation. In addition, the quantitative and qualitative findings are integrated for discussion which is an identified feature of mixed-methods research (Christensen et al., 2015).

### 4.4 Research site and sampling

According to Cohen, Manion and Morrison (2011), the tools used in research alone do not only determine the quality of the research, but also the appropriateness of the sampling technique and definition of the population on which the research will focus. This study was carried out in Grahamstown in the Eastern Cape Province of South Africa where the Khanya Maths and Science Club is located (Section 1.4).

The participants in this study were grade 7 learners attending the KMSC. Grade 7 learners are middle school aged learners.  Studies have indicated that attitude towards science typically declines as learners go through middle to high school (Hoftsein & Mamlok-Naaman, 2011). Thus, middle school (starting from grade 7) is seen as a crucial stage in learners' development as learners prepare for a fast changing future (Knezek et al., 2013). In addition, grade 7 learners fall into the senior phase of the General Education and Training (GET) band (South African context). Their experiences in this phase where science is a compulsory subject influences whether or not they choose science at the Further Education and Training (FET) level when it is optional. Lastly, the grade 7 learners group (together with grade 8) in the KMSC are mainly involved in different science activities with the aim of promoting their love for science (Section 1.4). Therefore this group was considered most appropriate for this study.

Forty-two grade 7 learners whose parents consented to their participation in the study completed the pre-test questionnaire which was administered prior to their participation in the KMSC. However, only thirty-one of those that completed the pre-test were available to complete the post-test after 16 weeks of participation in the club. Thus, the data for this study was analysed based on the learners that completed both the pre- and post-test.

Six learners were selected purposively for the semi-structured interview, four females and two males. This was based on their completion of the (pre-test and post-test) questionnaires, and their ability to express themselves proficiently. According to Christensen et al. (2015), purposive sampling is used when selected samples are information rich and could offer insight into the issues under investigation. Similarly, Cohen et al. (2011) alert us to the fact that the results in purposive sampling may not be generalizable. However, this is not the primary concern in such sampling, rather the concern is to acquire in-depth information from those who could provide it. Selection was also based on those learners who attended the club regularly. Attendance or participation is highlighted in the community of practice model and in the literature as an important factor for maximum impact on attitudinal change (see Section 3.6). The learners were also selected from the low and average attitude groups, which is based on their scores from the questionnaire. The profiles of sampled learners are shown in Table 2.

**Table 2: Profile of interview participants**

| Participants | Gender | Pre-test attitude score | Post-test attitude score | Pre-test attitude group | Post-test attitude group |
|---|---|---|---|---|---|
| Learner 1 (L1) | Female | 57 | 61 | Low | Low |
| Learner 2 (L2) | Female | 71 | 95 | Average | Average |
| Learner 3 (L3) | Female | 46 | 91 | Low | Average |
| Learner 4 (L4) | Male | 83 | 95 | Average | Average |
| Learner 5 (L5) | Male | 60 | 83 | Low | Average |
| Learner 6 (L6) | Female | 66 | 125 | Low | High |

The intended sample was envisaged to include three males and three females, however, it proved to be difficult to find male participants who were regular attendees with the criteria highlighted above. Therefore, the actual sample consisted of four females and two males.

### 4.5 Data collection techniques

Quantitative data was obtained using a questionnaire known as Test of Science Related Attitude (TOSRA). Questionnaires are self-reported data collection instruments used to measure participants' opinions about a topic (Christensen et al., 2015). Items in a questionnaire could be close ended, where respondents pick from responses provided by the researcher or open ended where respondents provide answers in their own word (*ibid*). The questionnaire used in this study (TOSRA) is a close ended questionnaire designed to measure learners' attitude towards science. This is detailed in Section 4.5.1.

Qualitative data sources were individual semi-structured interviews with learners using a prepared interview guide and their weekly journal entries. Christensen et al. (2015) describe an interview as a technique used to obtain more in-depth insight on participants' attitude, thoughts and actions in the form of verbal response.

The data collection tools employed are discussed below.

#### 4.5.1 Test of science related attitude (TOSRA) questionnaire

Barry Fraser (1981) developed the Test of Science-Related Attitude (TOSRA). TOSRA is a multidimensional instrument designed to examine middle and high school learners' general feelings towards science. The instrument was developed based on Kloper's table of classification of affective behaviours for scientific education (Fraser, 1981). TOSRA in its original form includes 70 items. Its modified form, TOSRA-2 divided the TOSRA into 35 questions each for pre-test and post-test (Ledbetter & Nix, 2002).

TOSRA is a five point Likert scale questionnaire, containing more focused scales to measure the sub-constructs of attitude towards science. These sub-scales are: enjoyment, perception of science, attitudes to scientific inquiry and interest in science among middle to high school learners (Fraser, 1981). These sub-scales are used in my description of learners' disposition as discussed earlier in section 3.2, making this instrument suitable for the study. One advantage of choosing TOSRA over other attitude tests is that it yields different scores for different sub-constructs of attitude as opposed to producing just one overall score for attitude (Jewell, 2012).

Previous studies using TOSRA showed that some scales of TOSRA overlap and can be used alone or merged into a single scale (Jewell, 2012). As a result, some studies used only some of the scales (Fraser, Aldridge & Adolphe, 2010) or a merger of some scales (Madu, 2010) to measure attitude as it related to their research. To accurately reflect the scope and purpose of this study, the TOSRA-2 pre-test and post-test consisting of 35 items each was modified by merging overlapping scales to adapt it meaningfully for this study (see Section 4.6). Hence, the TOSRA scales were renamed as follows; enjoyment of science, interest in science (leisure interest and career interest in science scales) and perception of science (social implication of science, normality of scientist and adoption of scientific attitude scales). The revised instrument offered allowance for examining the nature of learners' attitude based on their responses to each of the three sub-scales.

Some items in TOSRA-2 are reverse scored. Combinations of positively and negatively worded items in Likert scales are to reduce response biases (Fraser, 1981). The response format of TOSRA-2 items requires learners to express their degree of agreement with each statement on a five point Likert scale. The responses range from strongly agree (SA), agree (A), Not sure (NS), Disagree (D) and strongly disagree (SD). The questionnaire used in this study is shown as Appendix B.

TOSRA has been carefully developed, extensively used in different countries and has been shown to be highly reliable (Ali, Mohsin & Iqbal, 2013; Welch, 2010). For this study, the Cronbach alpha coefficient measured using SPSS version 22 was 0.89. Concerning the sub-scales; perception (0.86), interest (0.79) and enjoyment (0.81) had appropriate reliability for this study. The Cronbach alpha of .89 suggests that TOSRA-2 was reliable for the respondents in this study. The number of items, item numbers retained after piloting and reliability coefficient values of each sub-scales are shown in Appendix C.

### 4.5.2 Semi-structured interview

Semi-structured interviews provide the opportunity for flexible, open-ended questions that allow further probing of participants' responses for clarification (Harris & Brown, 2010). Individual semi-structured interviews were used in this study. According to Cohen et al. (2011), an individual interview is a two-way interaction between two people - the interviewer and interviewee, on a topic of mutual interest. The individual interview is considered suitable as opposed to the focus group interview, to avoid the phenomenon referred to as 'group think'. Groupthink in an interview discourages individuals with a different view from other members to voice their opinions (Cohen et al., 2011). Focus groups may also lead to non-participation/dominance by some members of the group and the introverts may be denied a voice (*ibid*). Individual interviews also seems suitable as there are different shifts in attitude of participants, giving the opportunity to probe participants based on their unique attitude change.

Furthermore, semi-structured interviews employ an interview guide with open-ended questions. An interview guide is a schedule of questions, which the interviewer intends to ask, relating to the research goals and are prepared in advance (Leedy & Ormrod, 2014). However, the interviewer is allowed flexibility in the interview process where he/she can probe and explore further issues raised by the interviewee (Cohen et al., 2011). The interview guide for this study was based on a literature review of similar studies, items of the TOSRA-2 questionnaire and learners' responses to the pre-test and post-test. The interview guide is shown as Appendix D. There was freedom to digress from the structured questions and explore further issues as raised by the learners.

### 4.5.3 Learners' journal entries

Journal entries have been employed in different studies on informal learning environments to capture participants' experiences in these settings (Olitsky, 2007). Journals are a recognized means of expression which provide an avenue for learners to identify and record their experience or belief about science/learning science (Towndrow, Ling & Venthan, 2008). Towndrow et al. (2008) assert that journal writing gives learners an opportunity to process their experiences and critically reflect on activities in which they are engaged. It provides an avenue for learners to give expression to their dissatisfaction or satisfaction about learning activities.

Despite the highlighted potentials of journal writing, inexperienced learners may have difficulty in knowing what to write or how to put their thoughts into writing (Towndrow et al., 2008). Thus there is a need to guide learners in writing journal entries. Participants in this study were engaged in journaling activity as an additional data collection tool. They were required to describe their weekly experiences and activities at the club. Due to the weakness of journal writing as described above, as well as to prompt learners in writing what was relevant to this study, guidelines were provided to direct some part of their reflection. The journal prompt is shown as Appendix E.

It was difficult to get some learners to write weekly journals about their experience and activities in the club. It was discovered through conversation with them that they could speak proficiently about their experience but faced challenges putting it in writing. Therefore, journal entries were done individually after weekly club activities where learners chatted about their experience and these were written down for them in their individual journals with the help of an assistant.

Table 3 shows the summary of the data gathering techniques.

**Table 3: Summary of data gathering techniques**

| | **Question 1** | **Question 2** | **Question 3** |
|---|---|---|---|
| **Collection method** | TOSRA-2 questionnaire (Pre-test) | TOSRA-2 questionnaire (Post-test) | Semi-structured interview |
| | Learners' journal entries | Learners' journal entries | Learners' journal entries |
| **Nature of data** | Largely quantitative | Largely quantitative | Qualitative |
| **Time of data collection** | Beginning of the club session | After 16 weeks of club participation | At the end of the year's club session (after the Post-test) |

### 4.6 Pilot study

According to Christensen et al. (2015), pilot testing must be done before an instrument is used in research. The main purpose of piloting is to obtain a more reliable instrument for use in the study. Cohen et al. (2011) confirm by indicating that pilot testing increases the reliability, validity and practicability of the study.

A pilot study of the TOSRA-2 questionnaire was carried out with 72 learners attending a township school in the Eastern Cape Province of the country. The purpose of this pilot was to verify if the test items of the questionnaire, the response format and instructions were clearly understood by the learners.

As a result of the pilot study, appropriate changes were made where gaps had been identified; some items were reworded for purposes of clarity and some identified repetitions of items in the sub-scales were removed. Some items on the TOSRA-2 were identified as not appropriate for the learners in both context and language such as; "public money spent on science in the last few years are/have been used wisely" was rephrased to "it is good to spend money on science". The modified version of TOSRA-2 was then adapted for this study.

A pilot of the interview guide was also carried out with four learners in the club. The result from the pilot allowed for the correction of ambiguous questions. The process also enabled a reflection on the process, and strategies for probing responses for the main study to be implemented. Consequently, the interview guide was modified to ask questions appropriate for the learners' age while avoiding leading questions. The interview guide was also rephrased and checked in accordance with suggestions from my supervisors to obtain a more reliable guide that would answer the research questions.

### 4.7 Data collection procedure

The modified version of TOSRA-2 (from the pilot study) were administered to forty-two grade 7 learners prior to their participation in the club activities. This was the pre-test. Participants' parents/guardians had given consent for their wards to be part of the study (see Section 4.10). Participants were given an explanation about how to respond to the questionnaire. They were also told that there is no wrong or right answer but that they should just indicate the degree of their agreement or disagreement with each item on the questionnaire. It took the learners 20-25 minutes to complete the questionnaire. The pre-test questionnaires were collected and analyzed. The pre-test revealed the nature of their disposition towards science prior to club participation in order to answer the first research question. It provided a baseline for monitoring changes in disposition as they engaged in science activities at the club.

Learners participated in journal entries after the weekly club activities. This was on-going throughout the study as discussed in Section 4.5.3 above. Learners' journal entries at the beginning and throughout the club session albeit scanty, also provided insights into answering the three research questions.

The post-test TOSRA-2 questionnaire was administered to 31 learners out of the 42 that completed the pre-test (Section 4.4) after a period of 16 weeks of their participation in the club. The same procedure was followed as with the pre-test. The post-test analysis was compared with the pre-test to examine the trend of change in their disposition towards science. This was specifically to answer research question 2. In addition, the observed difference in learners' feelings about science in their journal entries from what it was at the beginning of the club supported the post-test findings.

Semi-structured interviews (Section 4.5.2) focused on data collection to examine what factors influence the learners' disposition towards science. This primarily connects to research question 3. See Section 4.4 for the sampling of learners for the interview.

The interview was conducted in English at the club venue and was audio recorded with the consent of the participants. The audio-recording provided a detailed account of the interviews which could not be captured in the notes but were necessary for transcription in order to answer the research question accurately. While issues to be covered were selected in advance as in the interview guide, participants were also given the opportunity to express what they felt was important and relevant to the study.

## 4.8 Approach to data analysis

Data analysis is a process of reducing data which involves organizing, sifting, sorting, reviewing and reducing large amount of data to make sense of it (Cohen et al., 2011). This is done to provide answers to researcher's questions (*ibid*). As this was mixed-methods research, both quantitative and qualitative data were generated. The quantitative data were analysed to answer research questions 1 and 2 while the qualitative data were analysed to respond to question 3.

### 4.8.1 Approach to quantitative data analysis

The quantitative data were entered and analyzed using the Statistical Package for Social Science (IBM SPSS) version 22. Exploratory data analysis using frequency, percentages and cross-tabulation (Christensen et al., 2015; Cohen et al., 2011) were used to describe the data. Exploratory data analysis is usually descriptive, mostly concerned with reporting the data itself without making inferences (Cohen et al., 2011). It makes use of graphical presentation of data such as bar charts (Christensen et al., 2015; Cohen et al., 2011). Bar charts are pictorial, vertical, presentations of categorical variables/data (Cohen et al., 2011). In this study, the percentages for each frequency of learners' responses were represented using bar graphs. It represents learners' degree of agreement with items on the three sub-scales; perception, enjoyment and interest in science.

The paired sample *t*-test was also used to measure the difference between the pre-test and post-test. A paired sample *t*-test is used to find out statistically significant differences between the means of data measured at two different points in time (Cohen et al., 2011). Thus, the paired sample *t*-test was used to find out whether ultimately there were significant differences between the mean values of TOSRA-2 pre-test and post-test in answering research question 2.

In order to obtain the attitudinal scores of participants and group them according to their scores; positive items in the TOSRA-2 questionnaire were scored 5,4,3,2,1 for responses SA, A, NS, D, SD respectively. Also, negative items were scored 1, 2,3,4,5 for responses SA, A, NS, D, SD respectively. There were no items omitted for this study as it was ensured that learners responded to all items on the questionnaire. Items ratings in the same subscales are summed together (Fraser, 1981).

Learners' scores on the TOSRA-2 scale were used to categorize them into groups: low, average and high attitude. This was done using the class interval formula (Range of scores)/ No of groups). The total attitude scale measure range from 35 to 175 points [(175-35)/3] = 46 (class width), this was used to profile learners into three main attitude groups. Higher scores indicate a better attitude towards science (Fraser, 1981). The high scores of 175-129 were grouped as high attitude. The average scores (128-82) were grouped as average attitude and scores from 81 and below were the low attitude group. The grouping of learners offers analysis of how learners move within the groups in the course of participation in the science club.

The detailed picture of the trend on learners' responses are shown using bar charts. However, in discussion of the charts, the Likert scales are combined into three main categories; agree, disagree and not sure. This was done in order to ascertain the overall indication of agreement and disagreement with the sub-scales. According to Cohen et al. (2011), combining scales to form categories are useful in showing the general trends in data. These categories give a general picture of responses in the positive (agreement), negative (disagreement) and undecided (not sure).

### 4.8.2 Approach to qualitative data analysis

Qualitative data can be analysed by placing it into themes and categories (Merriam, 2009). Data generated from the interviews and learners' journal were analysed by identification of themes inductively. A deductive approach was also incorporated to check the identification of themes through prior theories and assumptions suggested in the literature/theoretical frameworks. Inductive analysis is primarily a form of pattern recognition within data where themes or concepts are derived through the reading and interpretation of raw data (Cohen et al., 2011). In this study, in addition to the inductive approach, the emerging themes were also identified from the literature and the features of a community of practice (Section 2.2.2).

After transcription, the analysis of interviews and journal entries was done in five stages; from data coding to providing meaning to data. The first stage involved reading through the transcripts and highlighting or marking statements (Appendix F). The marked statements were the key points identified in response to the questions asked and considered relevant to the research question. The transcripts were read through again paying special attention to the marked text to determine what they mean by comparing and contrasting them.

Secondly, the marked texts were assigned short word descriptions of what they denoted and assigned a code in order to easily categorize them in order to generate a theme. Connection between codes was checked during and after coding. Similar codes were collated to generate potential themes. Themes were built from comparing codes from each interview transcript and journal, then from the broad grouping of codes. Thus, in this process I looked for trends, similarities and contradictions. These generated ten preliminary themes (Table 6). Boyatzis (1998, p. 161) defines a theme as "a pattern in the information that at minimum describes and organizes the possible observation and at maximum interprets aspect of the phenomenon". Themes were also identified based on readings from the literature surrounding attitude towards science.

In the third stage, the preliminary themes were reviewed to reduce the overlap of themes and these were checked in relation to the literature and theoretical frameworks. Similar data were grouped under a specified theme to isolate meaning. Names or definitions for each theme were generated according to the emerged data and the research question. Four main themes were developed from the initial analysis. These themes were described with the help of supporting literature and the theoretical frameworks I employed (Table 7). However, single comments or data falling outside the broad theme were considered as important and used to enhance discussion rather than merely eliminating them as irrelevant.

The fourth stage involved representing these themes in an analytical memo where all the codes that fitted into each theme were organised. In the analytical memo, data were recorded across participants (the six interviewees) and across the data sources (interviews and journal entries) which allowed triangulation. This involved the selection of compelling extracts that related to each theme in order to answer the research question.

The fourth stage was followed by the interpretation of data – giving an explanatory account and providing meaning to the themes generated to answer the research question, primarily reporting the findings. Explanation and discussion were based on the emerged themes, again referencing the literature and frameworks. Excerpts from interviews were used to convey learners' opinions more effectively as well as to increase the internal reliability of the study. Findings from the qualitative analysis were examined with the results of the quantitative data available to support or refute the findings.

A summary of the qualitative analysis stages is represented in Figure 1.

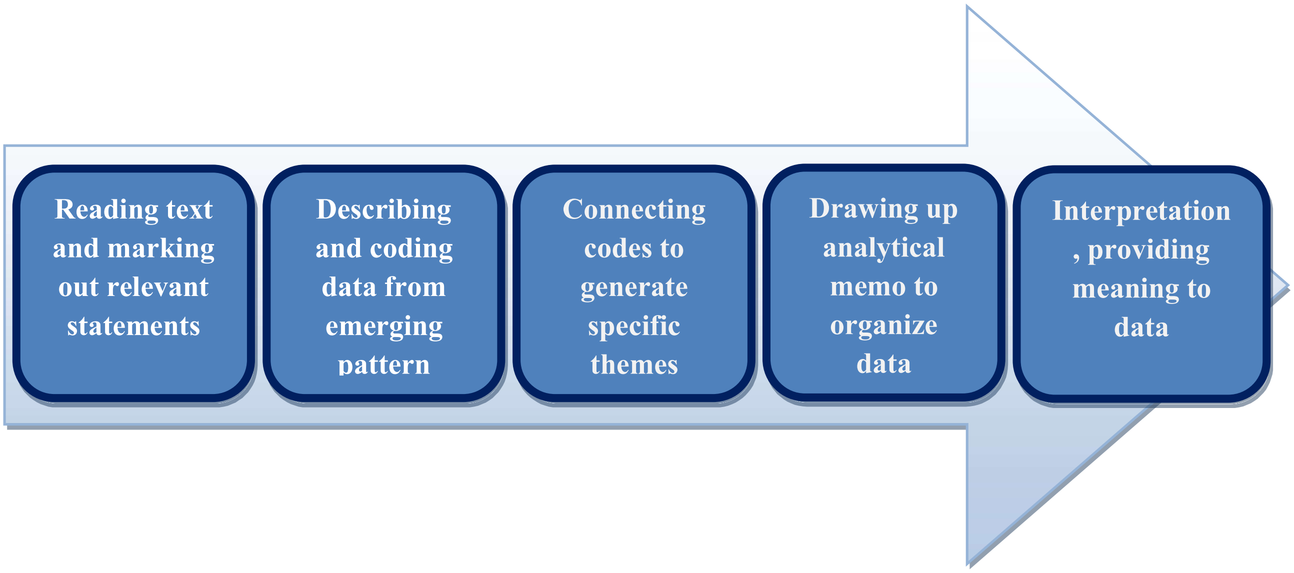


**Figure 1: Diagrammatic representation of stages of qualitative data analysis in this study**

### 4.9 Validity and trustworthiness

The use of multiple data sources contributes to reliability and trustworthiness of data as it is a reflection of ideas gleaned from different sources (Cohen et al., 2011). Lending support to this idea, Christensen et al. (2015) assert that triangulation is the use of multiple procedures and sources to corroborate information. This study employed triangulation through the use different methods of data collection namely, questionnaire, semi-structured interview and learners' journal entries as well as recording data across different participants to enhance the validity and trustworthiness of the data.

Data triangulation is also employed through agreement between responses of different learners to the same interview questions (Cohen et al., 2011). The quantitative analysis and transcripts generated from the audio recordings were compared and cross checked with a critical friend. This was done to reduce the risk of bias and to improve the assessment for the generality of the explanation. The low inference descriptor approach was used to increase internal reliability of the study (Christensen et al., 2015; Cohen et al., 2011) by using excerpts from interview and journal entries in the data analysis.

Validity involves the integrity, richness and scope of the data achieved through appropriate sampling, instrumentation and statistical treatment of data (Christensen et al., 2015). According to Mills (2011), validity is the means to ensure that the data we collect is believable, accurate and appropriate. The interview guide was piloted and checked with my supervisors to ensure its appropriateness. Interviews were audio-recorded to ensure that accurate verbatim responses justified each statement in the report. Direct quotes of respondents were used to enhance data corroboration and provide a rich/thick description to illustrate participants' experiences and meaning. This enhanced the credibility of the research (McMillan & Schumacher, 2001).

Efforts were made to reduce bias in the collection of data, analyzing and discussion of findings to achieve validity and trustworthiness. Cohen et al. (2011) argue that validity is seen as a matter of degree rather than an absolute state. This implies striving to maximize validity and minimize invalidity. They also suggest that to ensure validity, the meaning and inferences drawn from the data are important. The process of data analysis outlined in section 4.1.2 demonstrates how overarching themes were supported by excerpts from the raw data to ensure that data explanation could be linked directly to the words of the participants.

Denscombe (2010) suggests that providing an explicit account of methodological procedures contributes to validity as this enables researchers to assess if reputable procedures were followed. This is considered important as qualitative research is usually flexible and changing (Denscombe, 2010). An account of procedures, decisions taken and challenges taken during the research process were detailed. Stott (2014) offers that peer debriefing provides a logical, external evaluation of the research process. Fellow education researchers and supervisors played this role throughout the course of this study which involved fellow researchers posing questions about the procedures, meanings, interpretation and conclusion of the research.

In addition to the above precautions, presenting the data at a symposium and colloquium provided opportunities for comments and suggestions by education researchers to enhance the quality of the study.

### 4.10 Ethical considerations

Ethical concerns stem from discussions about codes of professional conduct for researchers (Creswell, 2009). In other words, each stage in the research process raises ethical issues. Most qualitative research requires obtaining consent and cooperation from people or institution that are involved in the study or providing facilities for the study (Cohen et al., 2011).

Permission to conduct this research was given by the Department of Education Ethics Committee, Rhodes University. The KMSC coordinator also gave consent to the research site and participants. As the learners in the club are young children, I obtained informed parental consent written in both English and their home language. This was through signed letters explaining the research and the anticipated learners' involvement. A sample of the parental consent letter is included in Appendix A.

Learners were assigned identification numbers from 1-31 (in the quantitative phase) and 1-6 (in the qualitative phase). These numbers were used when referring to students in the reporting of the research to ensure anonymity. Learners were assured of confidentiality; that data was being used for research purposes only, data would be stored in a secure place and their responses would not be revealed to their teachers or parents. Participants were assured of voluntary participation in the study and they could withdraw anytime without prejudice.

Cohen et al. (2011) suggest that when interviewing children (participants are between ages of 12-14 years), it is important to establish trust with them and help them feel at ease. It is doubtful that children would share their experience with anyone with whom they have no interaction/relationship. I joined the club at the beginning of this study in order to interact directly with learners and participate in the club activities. By doing this, I was able to create trust and good relationships before the actual field work began. Participants were free to interact and share their experiences within the club. However, this might also be a limitation, as it is possible that participants made comments about club activities in order to satisfy me.

### 4.11 Concluding remarks

In this chapter, I described the study as situated in the pragmatic paradigm. The data collection methods used to respond to the research questions, research procedures, sampling and approach to data analysis were discussed. Finally, ways of ensuring a quality study and ethical issues were detailed. The next chapter presents the findings of the study.

# CHAPTER FIVE: DATA PRESENTATION, ANALYSIS AND DISCUSSION

## 5.1 Introduction

This chapter presents the data, its analysis and the discussion of the findings of this study. As explained in the previous chapter, quantitative data were derived from the TOSRA pre/post-test questionnaire while qualitative data were obtained from the semi-structured interviews and learners' journal entries. The results of both quantitative and qualitative data are thus presented in this chapter and then discussed in order to respond to the research questions.

## 5.2 Quantitative results

The quantitative data were analysed based on the thirty-one (31) learners that completed both the pre-test and post-test questionnaires. Data sets were analysed using frequency tables, percentages, means and the paired sample *t*-test. The trend in learners' responses are shown on bar charts derived from the frequency table. The Likert scales used in the TOSRA questionnaires were combined into three main categories; agree, disagree and not sure, to ascertain the overall indication of agreement and disagreement of the scales. According to Cohen et al. (2011), combining scales to form categories is useful in showing the general trends in data. These categories give an overall picture of responses in the positive (agreement), negative (disagreement) and undecided (not sure) categories.

### 5.2.1 Pre-test results (TOSRA prior to learners' participation in the KMSC)

Learners' responses to items assessing perception, interest, and enjoyment of science represented in the sub-scales of TOSRA (Appendix B) measuring the attitude of learners towards science are shown in Figures 2, 3, and 4 below.

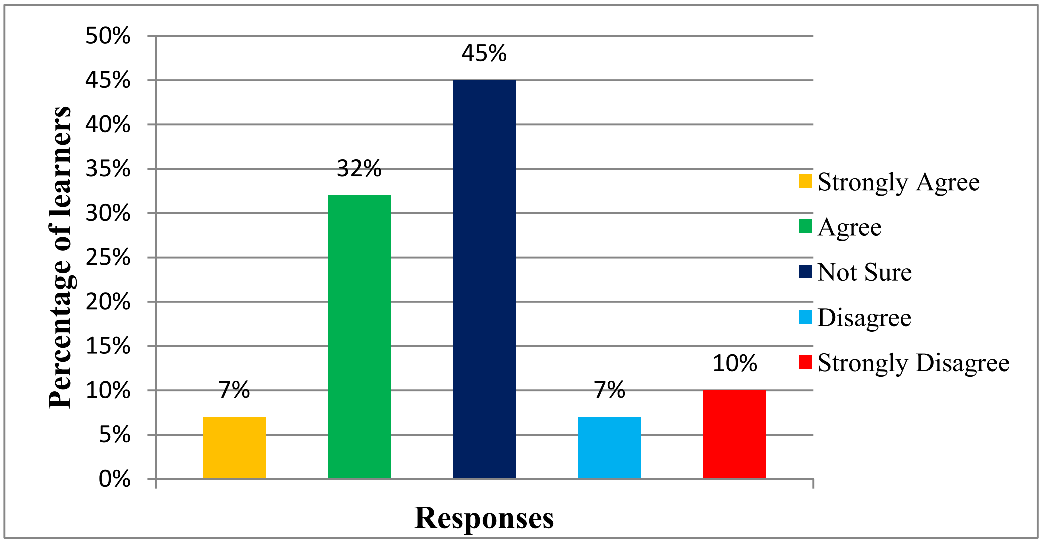


**Figure 2: Learners' responses to items assessing perception of science**

Figure 2 reveals that out of thirty-one learners surveyed, 39% had a positive perception of science, 45% were undecided while 17% had a negative perception of science.

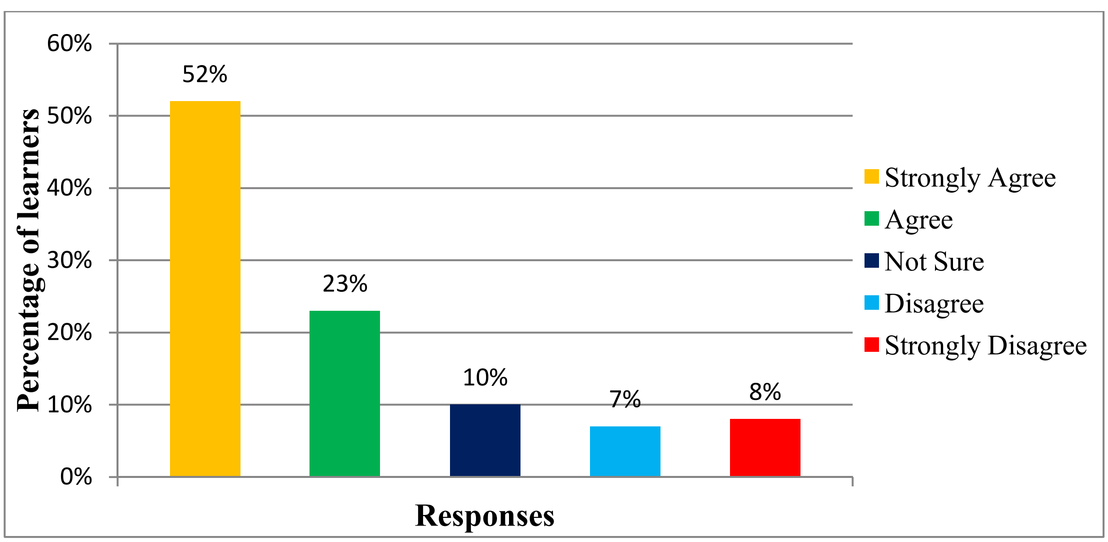


**Figure 3: Learners' responses to items assessing interest in science**

Figure 3 shows that 75% demonstrated/had an interest in science prior to their participation in the club. 10% are undecided while 15% do not have any interest in science. This shows that the majority of grade 7 learners attending the KMSC already had an interest in science prior to club participation.

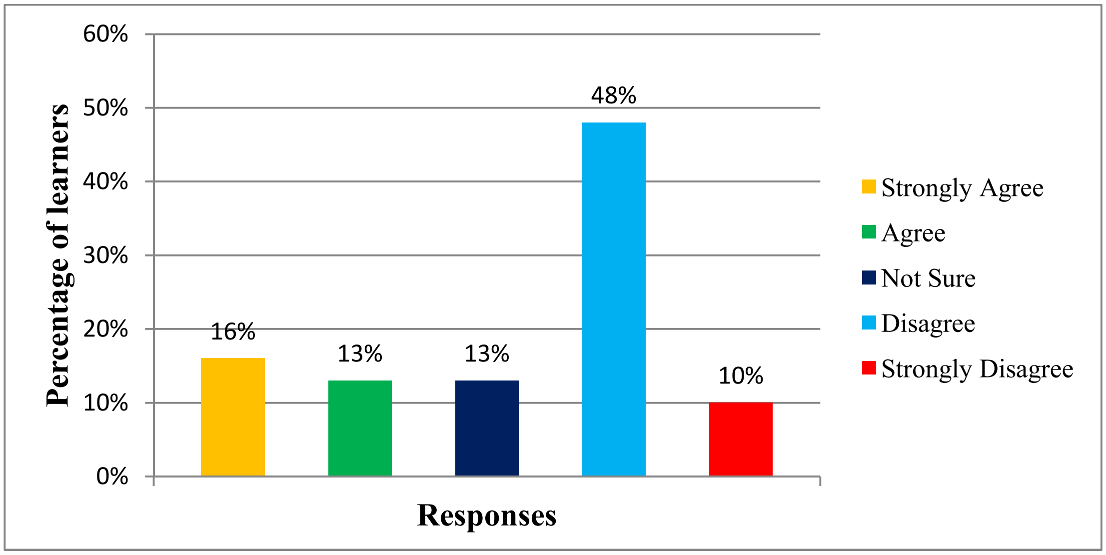


**Figure 4: Learners' responses to items assessing enjoyment of science**

Figure 4 show that 58% of learners disagreed in their response to items assessing enjoyment of science activities and lessons while 29% and 13% of learners are in agreement or not sure, respectively. This indicates that most learners did not enjoy science lessons and activities prior to their participation in the KMSC.

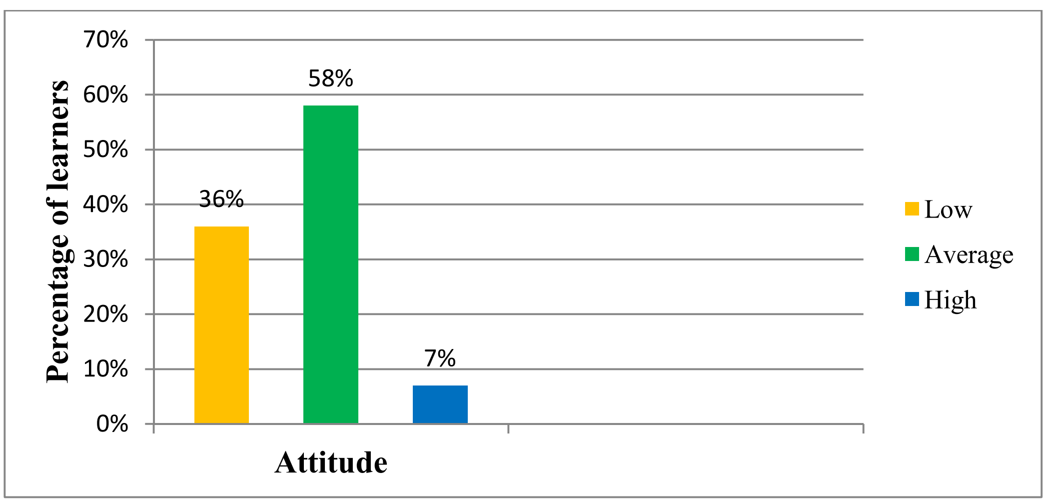


**Figure 5: Distribution of learners into attitude groups based on pre-test scores**

Learners were divided into three main groups based on their mean scores in the TOSRA scales using the class interval. Range of scores/Number of groups. The highest score was 97 and the lowest was 45. The low attitude group consisted of learners with scores from 45-62, the average group had scores from 63-80 and the high attitude from 81 to 97.

Figure 5 shows the distributions of learners in these three groups. 58% of the learners were in the average group while 36% were in the low and 7% were in the high group respectively.

### 5.2.2 Post-test results (TOSRA after 16 weeks of learners' participation in KMSC)

Figures 6, 7, 8, and 9 show the responses of learners to the three sub-constructs of attitude and their attitude groups in the post-test. Figures 10, 11, 12, 13 and Tables 4 and 5 show the comparison of pre-test results to the post-test results.

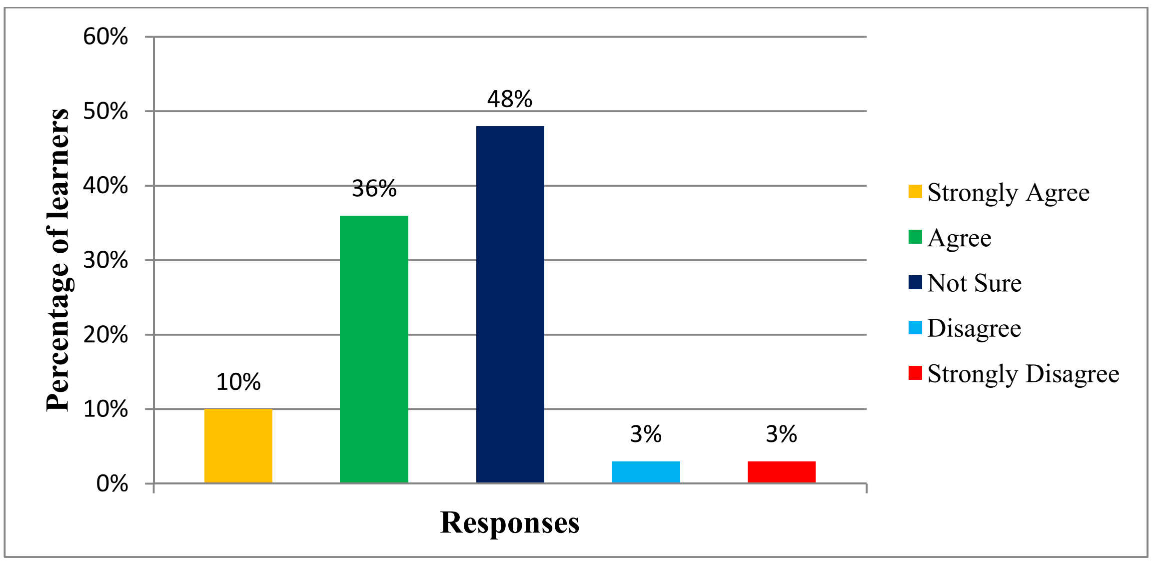


**Figure 6: Learners' responses to items assessing perception of science (post-test)**

After 16 weeks of participation, a total of 46% learners were in agreement with the items assessing their perception of science, 48% were undecided while 6% disagreed with items on positive perception of science.

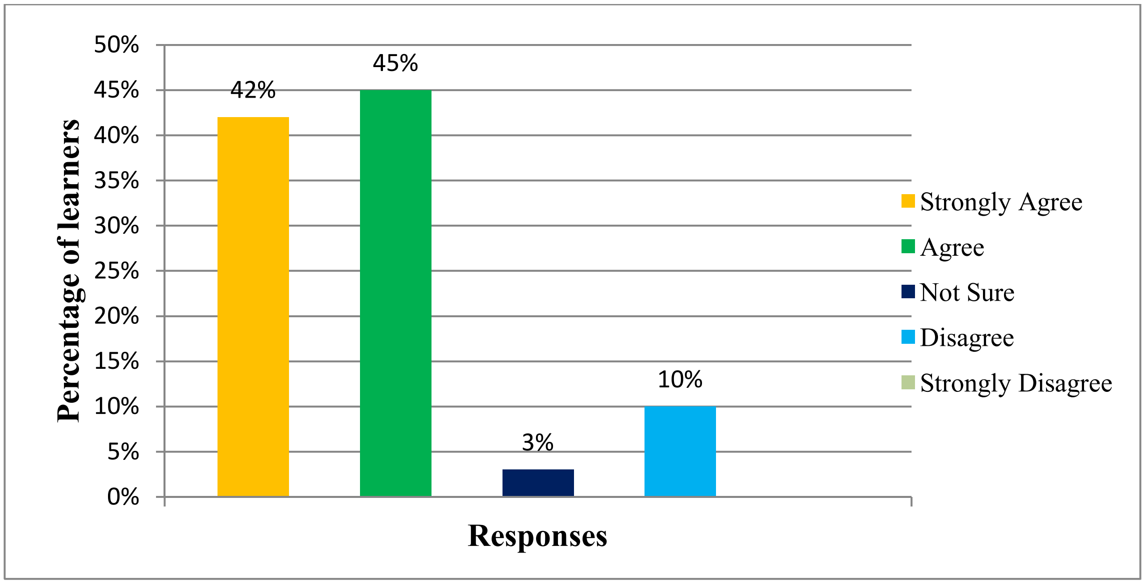


**Figure 7: Learners' responses to items assessing interest in science (post-test)**

From figure 7, at 16 weeks, 87% of learners were interested in science by agreeing with items assessing their interest in science, 3% were not sure while 10% disagreed. .

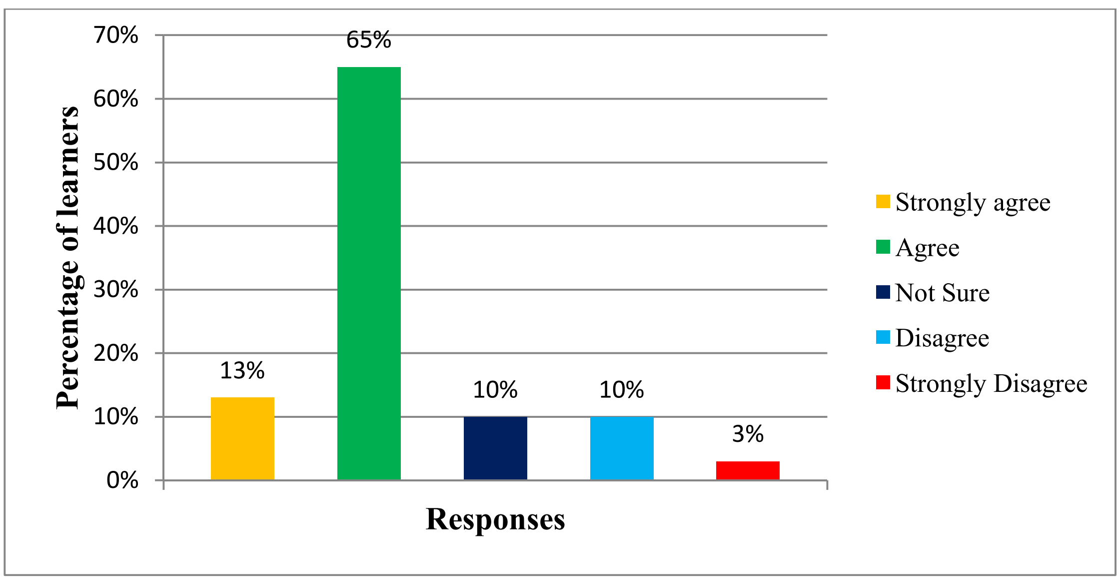


**Figure 8: Learners' responses to items assessing enjoyment of science (post-test)**

More than half (78%) of learners agreed with items assessing enjoyment of science at 16 weeks, 13% disagreed while 10% were undecided.

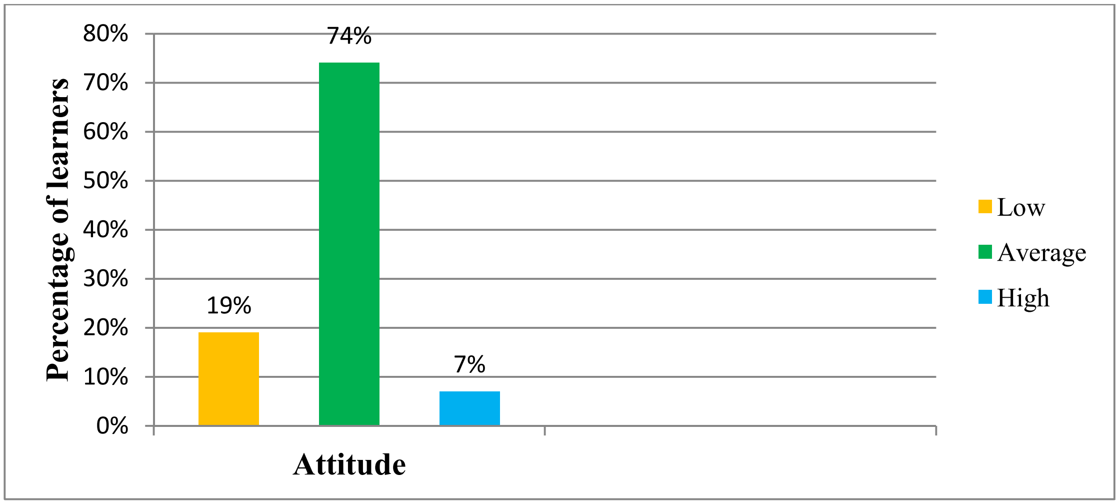


**Figure 9: Distribution of learners in the attitude group based on post-test scores**

Figure 9 shows that most of the learners (74%) had an average attitude towards science while 19% and 7% had low and high attitude towards science respectively.

### 5.2.3 Comparison of TOSRA pre-test and post-test

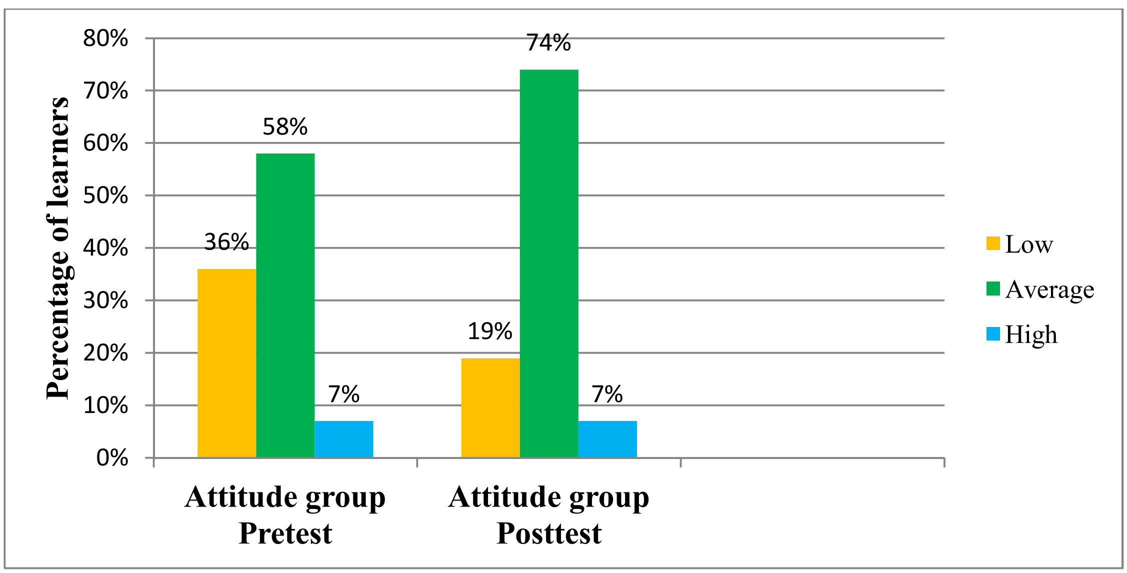


**Figure 10: Comparison of attitude group in the pre-test and post-test**

There are 17% fewer learners in the low attitude groups at the post-test compared with the pre-test. Learners in the average group increased by 16% in the post-test and the high attitude group remains the same as shown in figure 10.

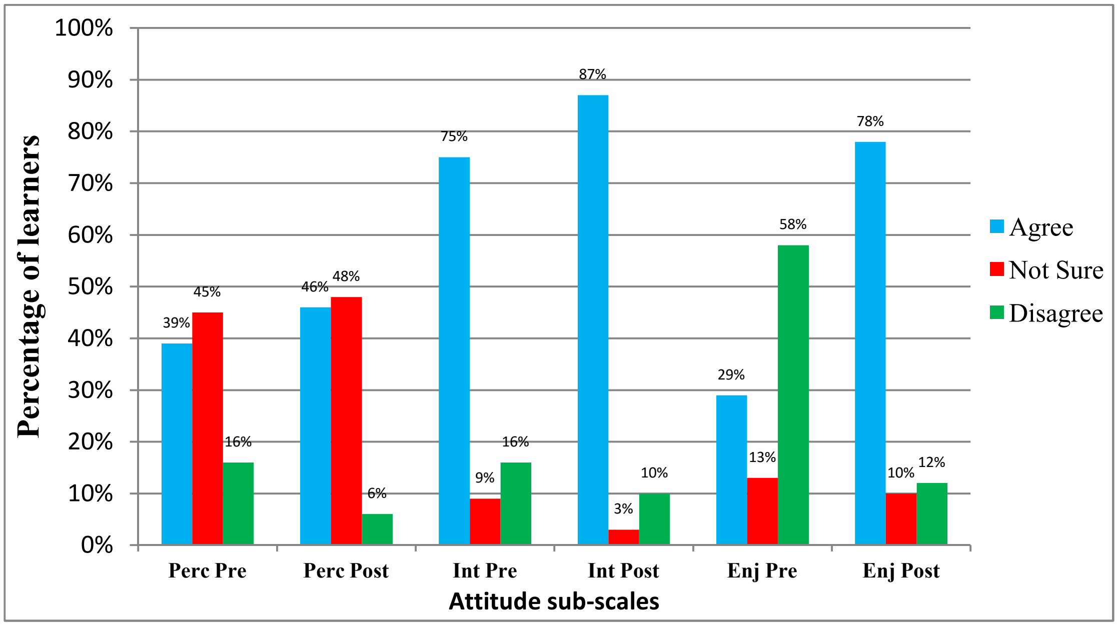


**Figure 11: Comparison of responses from pre-test and post-test**

Figure 11, represents the responses of learners to the pre-test and post-test for each of the three attitude subscales examined. The graph shows the combined categories depicting the overall indication of agreement and disagreement to the sub-scales.

**Table 4: Mean difference of attitude sub-scales (n = 31)**

**Paired samples test**

| | | Mean | Std. Deviation | t | df | sig (2-tailed) |
|---|---|---|---|---|---|---|
| Pair 1 | Perception pre-test | 22.5806 | 5.02510 | 3.343 | 30 | .002 |
| | Perception post-test | 26.6129 | 5.68435 | | | |
| Pair 2 | Interest pre-test | 26.1613 | 5.16460 | 5.446 | 30 | .000 |
| | Interest post-test | 32.1935 | 5.03600 | | | |
| Pair 3 | Enjoyment pre-test | 23.1290 | 6.44847 | 6.674 | 30 | .000 |
| | Enjoyment post-test | 30.3871 | 5.38936 | | | |

**Table 5: Mean difference in TOSRA-2 pre-test and post-test (n= 31)**

**Paired samples test**

| | | Mean | Std. Deviation | t | df | sig (2-tailed) |
|---|---|---|---|---|---|---|
| Pair 1 | Attitude pre-test | 71.8710 | 13.67173 | 6.881 | 30 | .000 |
| | Attitude post-test | 89.1935 | 12.19404 | | | |

The Paired sample *t*-test (Table 4) of the pre- and post-test scores (*n* = 31) shows a statistically significant difference. The significant value for perception, interest and enjoyment sub-scales are .002, .000 and .000 respectively. This indicates that there is a significant mean difference in these subscales with interest and enjoyment sub-scales having the highest significant values at 16 weeks. There is a significant difference (sig. 2 tailed ρ = .000) between the overall attitude mean of learners in the pre-test and post-test with mean difference of -17.3 (Table 5).

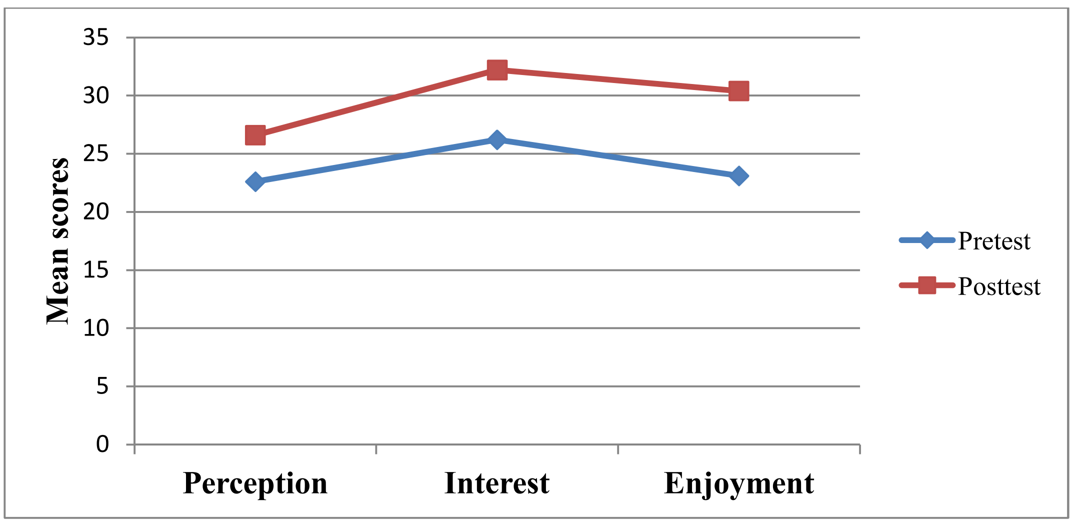


**Figure 12: Line graph showing means of learners' pre-test and post-test scores (*n*=31)**

The line graph in figure 12 shows the difference in the mean TOSRA scores pre-test and post-test according to the attitude subscales. The mean scores of the pre-test and post-test represented with a line graph (Figure 13) shows major divergence at the interest and enjoyment sub-scales. This shows that major shifts occurred in the interest and enjoyment sub-scales.

### 5.3. Discussion of quantitative results

The results are discussed in order of the research questions and how they have been presented. The quantitative results in Sections 5.2.1, 5.2.2 and 5.2.3 are discussed as findings to answer research questions 1 and 2 respectively.

#### 5.3.1 The nature of grade 7 learners' disposition towards science prior to their participation in KMSC

Based on the attitudinal class group, more than half (58%) of the learners had an average attitude towards science, while (36%) are in the group consisting of low attitude while a small percentage (6%) is in the high attitude group (Figure 5). According to Fraser (1981), higher scores in the TOSRA scales indicate a positive attitude towards science. It is deduced from figure 5, that learners in the average and high attitude group (64%) do have a positive attitude towards science while learners in the low group (36%) have a negative attitude towards science.

Interest in science has the highest overall positive response, enjoyment of science has the lowest and responses to perception of science are inconclusive (Figures 2, 3 & 4). These indicate that there is variability in the nature of grade 7 learners' attitude towards science prior to their participation in the club. Studies on various constructs of attitude towards science (Oliver & Venville, 2011; Welch, 2010) report similar findings concerning the variable nature of learners' attitude as described above.

Most learners disagreed or were not sure about science as a subject. This is indicated by their responses to items in the perception sub-scale (Figure 2). This is similar to the observation of Kaya and Ebenezer (2007) who report that generally learners who are not exposed to science activities that are related to their local environment or connected to their lives have a negative perception of science. It might be that these learners at KMSC could not perceive any connection between science and their immediate environment prior to their participation in the club activities.

Examination of the enjoyment sub-scale (Figure 4) indicates that most learners did not enjoy science lessons and activities prior to their participation in KMSC. This trend is similar to those observed in studies where Turner and Ireson (2010) posit that learners find science uninteresting when they are not engaged in creative or interactive science activities. So, it could be that these learners had never been exposed to science activities which elicited personal pleasure or fulfilment.

While comparing the three subscales/constructs of attitude studied, learners' interest in science (Figure 3) had the highest percentage of response in the affirmative (75%) compared to other sub-scales. This indicates that the majority of grade 7 learners attending KMSC did have an interest in science prior to club participation. This is similarly demonstrated in studies that found learners who voluntarily enrol in ASEPs show a high interest in science (Dabney et al., 2011; Stakes & Mares, 2005). The initial interest in science may be influenced by the science they do at school, family or scientist role models around them (Dabney et al., 2011). In addition, Hofstein and Mamlok-Naaman (2011) assert that learners who have an interest in science will want to learn or engage more in science activities. Thus, it could be presumed that learners attend KMSC in order to be involved in science activities.

The next section details the ways in which learners' attitude shifted over time as they participated in KMSC.

### 5.3.2 Change in disposition towards science over time for grade 7 learners participating in KMSC

The TOSRA post-test results show a change in attitude towards science when compared to the pre-test.

On the perception sub-scale, 39% of learners items agreed with items assessing their perception of science at the onset of the study compared to 46% at 16 weeks. There was no significant change in the proportion of learners who were not sure in their responses comparing before and after participation at KMSC (45% & 48% respectively), while those who disagreed decreased from 16% to 6% by the end of the study.

On the interest sub-scale, in the pre-test, 75% of the learners showed an interest in science, this percentage increased to 87% after participating in KMSC. Figure 11 shows a 12% increase of learners showing an interest in science and a 6% decrease in those who responded 'not sure'. The post-test results show a 10% decrease for those who disagreed.

In the enjoyment of science sub-scale, the pre-test revealed 29% of learners agreed with enjoyment of science, while the post-test result showed 78% agreed (Figure 8). This shows a 49% increase for learners who found science enjoyable after participating in KMSC. On the other hand, the percentage of learners that disagreed and were 'not sure' decreased by 46% and 3% respectively. It can therefore be assumed that KMSC enthused the learners about science.

The patterns that emerged from the post-test results revealed learners' attitude increased positively towards science when compared to the pre-test. There were major shifts in the interest and enjoyment sub-scales. Table 5 showed that the shifts in perception of science was not as great (the difference between pre- and post-tests) when compared to interest in science and enjoyment of science sub-scales. One possible reason might be that the club activities and experiences did not affect their perception of science when compared with the other sub-constructs. This result differs from findings of other studies such as Knezek et al. (2013); Welch (2010) where it was reported that learners' perceptions of science improved greatly after participating in an ASEP.

Nonetheless, the major shift in the interest and enjoyment sub-scales is in agreement with the findings of previous studies such as Oliver and Venville (2011) conducted in Australia. They reported an increase in enjoyment and interest in science as learners participated in Summer science camp. In addition, the overall mean scores of learners' attitude in the post-test increased compared to the pre-test, which indicates an affirmative attitude towards science (Fraser, 1981). The result indicates more learners shifted to having the positive attitude towards science group.

### 5.4 Qualitative results

Data from the semi-structured interviews and learners' journal entries were analysed for purposively selected participants. As described in Section 4.4 (methodology chapter), six learners who showed varied trends in attitude shifts, amongst other factors, were sampled for interview. All six participants' journal entries were collated and analysed together with the interview transcripts.

From the broad categories of data that emerged from the transcripts, I proceeded to pull together some of these categories by checking for similarities and contrasts. Ten preliminary themes emerged from the grouping (Table 6).

**Table 6: Generating preliminary themes from codes**

| Marked Text No | Description of marked text | Sub-themes | Code |
|---|---|---|---|
| 3, 4, 5, 12, 18 | Hands- on experience/ enjoyable activities/ experiment is interesting/ preference for hands-on activities/ science is fun | Hands-on experience | HOE |
| 8, 16, 23, 26 | Experiment facilitates understanding/ Variety of club activities/ enjoyment facilitates understanding/ learning new things | Variety of activities | VOA |
| 9, 19, 21 | no rote learning/simplicity/ understanding of concepts | No rote learning | NRL |
| 22, 24 | Clarity in concepts explanation/ Teachers' influence | Facilitators' attribute and influence | FAI |
| 6, 7 | Engaging activities/ collaborative learning | Engaging and collaborative learning experience | ECLE |
| 10, 11, 20, 25 | Positive atmosphere/ no test anxiety/ friendly environment/ no distraction | Positive learning atmosphere | PLA |
| 2,13 | Science is important/ usefulness of science | Usefulness of science | US |
| 14,15 | Want a career in science/positive perception of scientist | Perception of science | POS |
| 1, 17, | Learning about the environment/ Linking science to everyday life | Linking concepts to everyday life | LCE |
| 27 | Perceived difficulty | Perceived difficulty of science | PDS |

After a review of preliminary themes by grouping overlapping themes, checking for similarities and contradictions, four main themes emerged as representing the factors that influenced learners' attitude towards science in the club. The four themes are:

- Instructional characteristics;
- Facilitators/environmental characteristics;
- Making connections between science concepts and everyday life; and

- Perceived difficulty of science.

The four themes are described with supporting theory/literature as shown in Table 7. Words and phrases that were direct quotes from the transcripts were used in the narrative to give a sense of the learners' own words and allow interpretations concerning the research questions.

**Table 7: Themes and supporting theory/literature**

| Themes | Theory/literature |
|---|---|
| **Theme 1: Instructional characteristics** | |
| Hands-on experience<br>Variety of activities<br>No rote learning | (MUSIC) Jones (2010), Turner & Ireson (2010), (SAFE) Granger et al. (2007), Kuhlane (2011), Muselwa and Ngcoza (2003). |
| **Theme 2: Facilitators and environment's characteristics** | |
| Facilitators' attributes and influence<br>Engaging /collaborative learning experience<br>Positive learning atmosphere | (CoP) Wenger (1998), (MUSIC) Jones (2010), Noam & Shah (2013), Constructivist-developmental, Granger et al. (2007), Vygotsky (1978), Krishnamurthi & Rennie (2012). |
| **Theme 3: Making connections between science concepts and everyday life** | |
| Usefulness of science<br>Perception of science<br>Linking concepts to everyday life | Osborne et al. (2003), (MUSIC) Jones (2010), Lyon (2006). |
| **Theme 4: Perceived difficulty of science** | Hofstein & Mamlok-Naaman, (2011), Kaya & Ebenezer (2007), Luehmann (2009), Osborne et al., (2003) |

### 5.5 Factors influencing grade 7 learners' attending KMSC disposition towards science

The qualitative results are discussed with the view to answering research question 3 of this study. From the learners' journal entries and interview transcripts, four themes were identified as factors that influenced grade 7 learners' attitude towards science in KMSC (Table 6). These themes are described in table 6. Words and phrases that were direct quotes from the transcripts are included in the narrative of the learners' own voices in order to understand the interpretations relevant to the research questions.

### 5.5.1. Instructional characteristics

Participants enjoyed being actively involved in a variety of science activities while learning different scientific concepts. Learners explained that this experience influenced their understanding of science, and hence their interest and enjoyment of science. The following sample quotes describe what they perceived as most valued:

> "*When you do different things you enjoy it. Doing experiments makes it so interesting and I love it and we don't just copy notes, we do many things that I love to do, and I get to understand that science is not difficult*" (IL6).
>
> "*When you do experiments, you get to see things for yourself and understand. Science is interesting when we do lots of different things*" (IL3).

All six interviewees mentioned that they enjoyed engaging in hands-on activities at the club. Even those who perceived science as difficult and boring mentioned that they enjoyed the experimental aspect of it. An example is the following statement by one of the learners, "*I only like experiment we do in science because science is difficult when you don't do experiment and you don't understand*" (IL4). This finding is similar to the findings of Maselwa and Ngcoza (2003) who explain that learners felt practical activities minimised rote learning and facilitated science understanding. Hofstein and Mamlok-Naaman (2011) agree and assert that engaging learners in structured practical activities has the potential to enhance learners' meaningful learning and encouraged developing a positive attitude towards science.

In addition, the majority of the learners indicated that they found the various science activities at the club interesting, and not boring. They commented that they enjoyed the activities and were learning at the same time. They preferred the blend of interactive activities which were different from their previous experience of science as a subject which dealt with formulae, calculations, or note taking without any underlying understanding of the scientific content being taught. A learner pointed out that, "*We don't just copy notes, we do experiments and a lot of things and enjoy it, it's interesting"* (IL6). Another learner said, "*Science is interesting when we do lots of different things and not just reading and writing*" (L3). Learners complained about the nature of school science that involved too much note taking.

Learners disliked stereotypic activities such as sitting down, listening, writing notes and memorizing poorly understood scientific concepts. Instead, learners desired activities that engaged them as it influenced their enjoyment of science. The variety of activities in the club offered learners the opportunity to explore and facilitated their understanding of scientific concepts. It enabled them to find out how things work by themselves. A learner summarized how the club activity helped to understand the 'change in states of matter': *"I like the experiment we did on ice cream, we made ice cream from liquid nitrogen and now I understand solid, liquid and gas and how they change"* (L6J).

Learners believed that the various activities and 'do it yourself' experiences they had in the club made science simpler for them. Learners appreciated the feelings that they could discover things by themselves. They also remarked that engagement in practical activities minimised rote learning, thereby increasing their enjoyment of science and enhanced their ability to understand scientific concepts. One of them said, "*We have time to learn so many things and understand and not trying to remember stuff for test*" (IL1).

The insights from the statements above indicates that the blend of activities at the club influenced learners' disposition towards science by increasing their interest and enjoyment of scientific concepts. Kuhlane (2011) asserts that quality practical activities in science help learners to understand concepts which is supported by Yilmaz and Timur (2011) who report that science lessons that involve experimental activities enables the development of a positive attitude towards science.

### 5.5.2 Facilitators/environmental characteristics

The learners commented on the influence the facilitators (which they all referred to as teachers) had on their attitude towards science. They expressed that they loved science because of the attributes of the facilitators. They described the facilitators as being nice, helpful and patient at explaining things to them, often in a friendly way that endeared them to science. The following are some of their comments about the facilitators.

> *"I enjoy science by doing experiments and when teachers listen to you and explain what you don't understand very well"* (IL2).

> *"…the way the teachers explain things to you and you do experiments, you get to see things for yourself and understand"* (IL3).
>
> *"The teacher explain to you and they are very friendly and good … The teachers make you to understand"* (IL3).
>
> *"Especially the funny things and way of teaching makes me to enjoy it. I love the teachers because they are friendly, they want you to understand. I always enjoy science at the club*" (IL5).
>
> *"The way the teacher explains to you and this is why I like science"* (IL6).
>
> *"I had fun because of the different things we did and being helped by the teachers"* (L2J).

The learners described the attention and interaction from the facilitators as a major factor influencing their interest in science. Facilitators were reportedly approachable, giving clear explanations of concepts. They valued their interactions with facilitators who were willing to listen, explain and support them both academically and personally. They could express themselves freely, asking for help when necessary without the fear of being shut down.

One interviewee explained the positive influence her facilitator's patience and help with schoolwork had on his interest in science. *"But here the teachers help you, they helped me with my school work and because of that I like doing more science"* (IL4). The facilitators' qualities enhanced learners' enjoyment of science. This finding supports the literature that indicates that a teacher's personality is a very important variable in the shaping of learners' attitude towards science. George (2006) agrees that teachers' attributes are one of the major factors that influences students' attitudes towards science. When teachers show an interest in learners and support them, instructions are given with a motivating attitude and have an impact on learners' interest in the subject. In agreement, (Anwer et al., 2012; Osborne et al., 2003; Turner & Ireson, 2010) point out that the interaction between a teacher and a learner is important for effective learning and in determining learners' attitude towards science. According to Turner and Ireson (2010), a supportive and encouraging teacher enhances students' interest in science.

Furthermore, learners tend to enjoy the informal and relaxed environment of the club. They expressed how working together and communicating with their friends and facilitators increased their understanding and enjoyment of science. Some learners expressed their preference for science learned without the anxiety of any examination or test at the club. They explained that they are not pressed to memorize things to pass exams or tests, which enhanced their enjoyment of the activity as it gave them the opportunity to learn at their own pace. The following examples of statements from learners highlight how collaborative learning and the club setting influenced their attitude towards science.

> *"You work things out with your friends and we all love it and when you don't understand sometimes, your friends can explain to you and you will understand .....so we relaxed very well to learn. Science is interesting when I do lots of experiments and work with my friends"* (IL1).
>
> *"Here we are free and nobody is shouting at you. I also like working with my friends. Everybody is friendly and they make you to understand very well"* (IL2).
>
> *"You are not even afraid of test so we are very free and enjoy science here"* (IL3).
>
> *"I always enjoy science at the club because it is not difficult because the teacher and your friends explain to you. There is nobody disturbing you in the club and we can pay attention to what we are doing… you feel comfortable around your friends and explain things to each other. It makes it more fun"* (IL5).
>
> *"It's fun and we work together with our friends and you are not shy to ask questions from them because they will not laugh at you… I enjoy what we do here"* (L6).

The CoP framework (Wenger, 1998) and Vygotsky (1978) suggest that social interaction is an important component of the learning process where significant interactions occur while working with peers. Clearly, the learners enjoyed the opportunity to participate in what they perceived to be interesting to them while working alongside peers. They enjoyed the cooperative learning experienced in the club. Interactions between learners and between learners and the club facilitators encouraged learners to become active participants in their learning and this in turn had a positive impact on their attitude towards science. This is most likely the reason why the percentage of agreement to enjoyment and interest in science in the post-test increased substantially.

According to Noam and Shah (2013), learners are more relaxed and enjoy participating in after-school programmes where there is no anxiety about tests compared with the school context. Similarly an interactive environment that encourages collaborative learning where learners engage in activities and discussion with peers has been identified to improve learners' enjoyment of science lessons (Turner & Ireson, 2010).

I argue that the setting of the club provided an opportunity for both individual and collective learning experiences as emphasized by Wenger's (1998) community of practice as the club could be described as a community in which learners interacted with teachers and peers, through which they also learned more while having fun with science. According to Vygotsky (1978), collaboration is a key term in a social learning environment where learners have the potential of achieving above what they achieve on their own.

The informal club environment influenced learners' enjoyment of science as indicated in their responses. This finding coheres with other studies as highlighted by Bennet et al. (2006) on the effect of context on learning science. Learners emphasized that they are more comfortable in the club where there was no anxiety about tests compared with the school context. They focus more on learning for understanding than memorizing for testing. This corresponds with the views of Tytler (2010) who argues that the structure and characteristics of formal school science does not adequately meet the needs of science learners. Cooperative learning should be encouraged by getting learners to work in groups during activities which increases their participation and understanding, with the resulting improvement in their attitude towards science.

### 5.5.3 Making connection between science concepts and everyday life

Learners are enthusiastic about activities in the club, which they could relate to their everyday lives. Learners explained that they developed an interest in science because they discovered that science was useful and they could see the link between science concepts and their surroundings. They also explicated that presentations and examples used in the club highlighting the usefulness of science helped them to understand the concept. In addition, learners could draw associations between scientific concepts and real life contexts. It was clear from their responses that when there are connections between science and their everyday lives, they understood the practicability thereby improving their attitude towards science. The following statements reflect learners' responses about how science relates to their everyday lives.

> "*It makes you to know so many things about our environment… we learn pollution and how dangerous it is and how to prevent different bad thing in our environment. We learn about bad chemicals and green chemistry…..how we can keep our environment safe from bad chemicals"* (L6).
>
> *"…we did it ourselves and understand how the foams and some walls are made. The one I made I took it home and saw the same thing under our chair. So I know science is very useful to know things around us" (L5).*
>
> *"I know why oxygen will make the fire to burn and how carbon dioxide will …blow it out... I know oxygen and carbon.... carbon dioxide is very useful in life"* (L4).
>
> "*Experiment makes me to know how it is in real life*" (L5J).

These statements revealed that learners enjoyed and are interested in environmental issues and events that affect their lives. The findings indicated that learners had a significant change in their awareness of environmental issues. For example, most of the learners enthusiastically commented on activities or presentations they had on oxygen and carbon dioxide, green chemistry, polyol, pollution, *etcetera*. Learners stated that they had achieved a better understanding of the value of science from these activities. Their remarks suggest that recognition and application of concepts in an everyday situation does have an effect on their interest in and value of science.

As suggested by Hofstein and Mamlok-Naaman (2011), when learners find science content relevant to their daily lives and their immediate environment, there is an increased potential of developing a positive attitude towards the subject. Kuhlane (2011) suggests that science activities that involve the link between scientific ideas and the environment or everyday knowledge increases learners' understanding of concepts and level of engagement. She further argues that teachers must connect science with learners' everyday life experience so that learners see its usefulness. This suggests that where possible, giving relevant examples from learners' everyday life in explaining scientific concepts would assist in learners' understanding. Explaining the practical application of concepts would help learners to see the 'big picture' of science and its relevance.

From the findings, it also appeared that most of the interviewees appreciated the importance of science for their future careers. One interviewee put it this way: "*I love science and when I grow* *up, I want to be a scientist so that I can see different things and help people and the world like the scientist"* (L6).

Similarly, Lyons (2006) affirms that learners' attitude towards science is influenced by their perception of how it is related to the outside world and its use in the future. Other studies such as Bennet et al.'s (2006) suggest that a context-based approach leads to a greater appreciation of the relevance of science to everyday life and a consequent increase in learners' understanding of science content. This finding resonates with that of Luehmann and Markowitz's (2007) study that reported that learners described specific concepts and processes which they learned during OST enrichment activity; these increased their understanding and view about science and as a result they considered career options in science.

### 5.5.4. Perceived difficulty of science

Prior to their participation in the club, most of the learners perceived science as a difficult subject. They expressed their frustration and negative feelings associated with some concepts in science which they found to be challenging. They felt that science required a high level of intelligence since it involves lot of calculations, uses difficult language that they do not understand and may have to memorize. To express their perception of science as a difficult subject, learners made statements such as:

> "*Science is difficult because you do lots of calculation and you may not understand some things*" (IL4).
>
> "*Science is difficult and sometimes boring*" (LJ5).
>
> "*I don't like science, science is difficult*" (LJ4).

Phrases such as '*I don't like science*', '*science is boring*', '*I don't wanna do science*', '*it's difficult*' were used to express their attitude towards science in the first two weeks of their participation at the club (Appendix I). These phrases show that learners do demonstrate a negative attitude towards science when they perceived it as a difficult subject (Kaya & Ebenezer, 2007; Kihwele, 2014).

According to Kihwele (2014), learners' environment and the people around them play a role in shaping their perception of science. Some learners are made to believe that science is difficult even before they study it and this notion could lead to less effort and poor science achievement. Their belief is then confirmed and they consequently develop a negative attitude towards it.

The perceived difficulty of science might be a reason why learners' responses to the TOSRA pre-test and post-test on perception of science appeared inconclusive despite their participation in the club. Learners agreeing with items on positive perception of science marginally increased by 7% in the post-test and those that responded 'not sure' increased by 3% in the post-test. Learners in this study stated that they would not like to take up science careers because they perceived science as difficult. One of the learners said, "*I don't want to be a scientist ... because I think science is not very simple and I don't want difficult things*" (IL4). This is consistent with Kaya and Ebenezer (2007) and Kihwele's (2014) findings that learners who perceive science as 'too hard' are unlikely to consider further study and career options related to it. Learners are more committed to science when they have a positive perception about it and want to take more science courses and continue reading about science (Hofstein & Mamlok-Naaman, 2011).

Learners proffered that difficulty in science emanated from learning scientific concepts without any supporting experiments or activities they considered as interesting. They shared a sense of accomplishment and pleasure when they were finally able to understand some concepts through engaging in a variety of activities at the club. For an example,

> "*Science is difficult but when you learn it and understand it is very interesting*" (IL6).
>
> "*It is just too difficult, but I like it most when we do experiments with my friends and you guys explain to us how to do things*" (IL4).
>
> "*I only like experiment we do in science because science is difficult when you don't do experiment and you don't understand*" (IL5).

The statements above revealed that though some learners had the preconceived notion that science is difficult, the instructional style and activities in the club seemed to diffuse this notion. There is a relationship between perceived difficulty of science and instructional characteristics. For example, learners' perceived science as difficult because they lacked understanding of some concepts, which resulted in the need for memorization. However, they expressed that the science activities they engaged in at the KMSC and the clarity in the explanations helped them to gain understanding. As suggested by the CoP framework, learners deepen their knowledge about the subject of concern as they interact regularly in a community of practice. Interactions, activities and learning is emphasized by Wenger which influences members' ways of being in communities of practice.

Looking at the four factors that emerged from the data, there are relationships between them. The facilitators or environmental characteristic had an effect on the instructional characteristics and the instructional characteristics had an effect on learners making connections between concepts and everyday life.

### 5.6 Additional findings

The four main themes identified concerned understanding science. Learners stated the influence of hands-on activities, facilitators/environmental characteristics, making connections between science and real life as having a real effect on how they understand science. A reasonable assumption is that ease of understanding scientific concepts may be the foundation for developing a shift in attitude towards science.

One the other hand, the assumption holds that learners who perceived science as a difficult subject expressed a negative attitude to it. The main reason given was that they lacked understanding of some concepts and they had to resort to rote learning. Though many of the learners did not mention explicitly that understanding concepts influenced their attitude, it could be deduced from their responses that lack of understanding promoted a negative attitude towards science.

Hofstein and Mamlok-Naaman (2011) suggest that properly designed and structured practical science activities with relevant content will improve learners' understanding of concepts and the nature of science. In agreement with this finding, Anwer et al. (2012) found that learners develop a positive attitude towards science when they can understand, learn and have more time for various science activities. Thus, it could be argued that learners' understanding of scientific concepts and the nature of science is central to the four main themes identified as factors influencing their attitude towards science.

The relationship between formal school science and the informal club science seems to be dichotomised by learners who could not make connections between science at school and the club. They seemed to view science within these contexts as separate and not connected. They indicated their attitude towards science when connected to the club science but separated it from school science. For example, learners said:

> "*It is only here that I like science, we do experiments, we don't do that at school so I don't like science at school. But here it is fine*" (IL2).
>
> "*Science at school is not the same. We do different things at school, we don't do experiment we just write notes and stuffs and it's not interesting*" (IL1),
>
> *"Not the same. We learn different things but I like the one here. Science at school is difficult and different" (IL6).*

The statement above shows that learners had difficulty connecting activities at the club with their science classrooms. They described their typical science classroom activities as not being engaging and as 'just sitting down, listening, writing notes'. For this reason, learners portrayed school science as difficult and uninteresting compared to science in the club which they described as enjoyable. They also differentiated between the science content taught at the club and in their schools. Because of this, some learners viewed science in these two environments as unrelated. According to Luehmann (2009), ASEP activities should map closely with formal school content and activities in order to garner full potential and encourage transferability. She explains that learners benefit in unique ways when there is collaboration between science classroom contents/activities and ASEP activities.

Likewise, Bevan et al. (2010) inform that ASEPs that have carefully chosen curricular topics that connect to the school curriculum, using experienced/qualified staff provide opportunity for learners to connect learning and attitude in the two settings. They argue that a lack of collaboration of activities and content across the formal and informal settings can create barriers in transferability of learning or skills acquisition. The notion of Bevan et al. (2010) on transferability resonates with Huang and Dietel's (2011) model for effective ASEP. Huang and Dietel (2011) suggest that ASEP must employ the services of experienced and qualified staff who could make intentional effort at connecting the school curriculum with the activities in ASEP to ensure effective outcomes.

Conclusively, the qualitative results revealed reasonable evidence supporting Jones' (MUSIC) model (Section 3.7) in developing positive attitude towards science. He specifies that learners' attitudes are influenced in any context; when they are engaged in the learning activities, content/instruction is very useful and interesting and instructors care about their success. As shown in this study, these five components were reflected in the learners' responses in describing what influenced their attitude towards science in the club.

### 5.7 Concluding remarks

This chapter began with presentation of quantitative and qualitative results from the three data gathering tools used. From the quantitative pre-test results, it was clear that the majority of the learners had an interest in science prior to their participation in the club, many of them did not enjoy science lessons and activities and many were undecided about their positive perception of science. The post-test results revealed how their attitude changed over time with enjoyment and interest showing a significant progressive change and the positive perception of science remained inconclusive. Four main themes emerged from the semi-structured interviews and journal entries analysis: instructional characteristics, facilitators/environmental characteristics, making connections between science and everyday life and perceived difficulty of science. These themes illuminated which factors they experienced in the club influenced their attitude towards science. The themes that emerged were further discussed in support or contrast to the literature reviewed. In the next chapter the conclusions drawn from this study, some recommendations and limitations are presented.

# CHAPTER SIX: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

## 6.1 Introduction

Studies have shown that a positive disposition towards science has the potentia to improve learners' achievement and increase their engagement in science education (Belge-Can & Boz, 2012; Knezek et al., 2013). Research also shows that after-school science enrichment programmes can be effective in strengthening learners' positive disposition towards science (Bevan et al., 2010, Turner & Ireson, 2010). The purpose of this study was to explore the influence of an after-school science enrichment programme (KMSC) on learners' disposition towards science.

I employed a framework of constructivist-developmental and situated learning theory, specifically drawing from the CoP framework (Wenger, 1998). A mixed-method approach was used to explore how grade 7 learners' experience of an ASEP influenced their disposition towards science after 16 weeks of participation.

## 6.2 Summary of findings

The data collected was analysed in order to answer the three main research questions.

**Research question 1: What is the nature of grade 7 learners' dispositions towards science prior to participation in KMSC?**

In response to research question one, the results presented in Chapter 5 (Section 5.2.1) revealed the learners' attitude towards science prior to their participation in KMSC in terms of the three sub-scales examined. The results indicated that many of the learners were not sure or had a negative perception of science. They did not understand the relationship between science and everyday life. This may be due to their inability to link science concepts with their environment. Most learners nevertheless displayed a high level of interest in science prior to their participation in the club. It could be that their interest in science was in fact responsible for their voluntary participation in the club. Reasons for this initial interest may include the influence of family, teachers, media or peers. Another finding is that the majority of the learners do not derive pleasure or fulfilment from science lessons and activities. The literature makes it clear that learners have a negative attitude towards science when they do not enjoy it. They perceive that science is boring and full of difficult tasks.

**Research question 2: In what ways do the grade 7 learners' dispositions towards science change over time as a result of participating in KMSC?**

In response to the second research question, the findings indicated that there were variable shifts in learners' attitudes towards science (Section 5.2.2). Learners' perceptions of science, their enjoyment of, and interest in science shifted significantly after a period of time. These were clearly influenced by their participation in the club.

One advantage of this study is that the different sub-constructs of attitude towards science are defined and measured with a multidimensional tool (TOSRA). Some studies on attitude have been criticised for a lack of clarity in the sub-constructs or terms being measured (Anwer et al., 2012; Osborne et al., 2003). This study examined specific sub-constructs concerning attitude towards science. This served to demonstrate that learners' perception of science was robust/persistent, as there was no significant change in the proportion of learners who were not sure in their responses comparing before and after participation at KMSC though statistically, there was significant difference between pre- and post-tests. However, this was disputed by the qualitative findings.

**Research question 3: What are the factors influencing the dispositions that grade 7 learners attending KMSC have towards science?**

The qualitative results (Section 5.4) revealed that learners' attitudes towards science are influenced by the following aspects of the club: instructional characteristics, facilitators, environmental characteristics, making connections between science concepts and everyday life, and the perceived difficulty of science. Consistently, the learners' reflections contained very few negative comments about their experience in the club. After reviewing the factors I recognised that most learners' desire ideal instructional methods, ideal teachers and an ideal classroom. They believe that when these desires are met, their attitude towards science will be influenced positively. These factors, albeit different, are closely related. For example, the characteristics of the teacher can affect the instructional style, and the learning environment the teacher creates may influence the understanding of learners. As revealed in this study, the key to a positive shift in attitude towards science is providing a positive learning experience. This suggests that the overall factor influencing learners' attitude towards science is the educational experience provided by the 'teacher' in a positive learning environment.

Learners in this study expressed a preference for practical, hands-on activities, as alluded to by Maselwa and Ngcoza (2003). They believed that this made science more interesting and easier to understand. Learners desire a variety of science activities which include clear explanations and examples. Appropriate instructional methods involving depth rather than breadth should be encouraged in science classrooms, as this was perceived to facilitate understanding as opposed to rote learning. Hands-on experience is a distinctive feature of science education and it is often regarded as important in improving learners' attitudes towards science (Ledbetter & Nix, 2002). However, engaging in just any hands-on activity does not mean that learning will take place, so teachers should focus not only on the activity but also on the learning taking place.

According to the results of the qualitative analysis, the club setting supported learners being active in the learning process, and this potentially played a role in influencing their attitude positively. They wanted a relaxed, interactive classroom, to break the monotonous routine of formal classrooms. They felt that learning with their peers brought life to learning, in contrast to just sitting and writing. Learners emphasized that learning in groups increases their understanding of scientific concepts and improves their attitude towards science. Cooperative learning should be encouraged in science classrooms as it makes the learners active participants in their learning, and more motivated to take it seriously. Evidently, this may constitute a challenge for a teacher in a formal science classroom which is syllabus-driven. Such a teacher is (necessarily) goal directed and may dismiss creative activities other than those prescribed by the syllabus.

A learning environment could be varied appropriately, for example, by going to the science laboratory, taking field trips or learning through nature, all of which learners might find enjoyable. In addition to variety, learners desire a devoted, patient and understanding teacher who motivates them and brings reality to the classroom. The results clearly indicated that learners are interested and enjoy science more if it is demonstrably applicable and relevant to their daily lives and immediate environment. Learners also identified the quality experience provided by the club facilitators as a factor influencing their enjoyment of science. They appreciated the facilitators' patience in their effort to make science interesting and understandable. Many of the learners enjoyed interacting with their teachers because it gave them a voice and encouraged them to realise that they are free to express even confused ideas.

The opportunity to participate in an ASEP is not by itself sufficient to develop and transfer learners' attitudes towards science to the formal science classroom, as predicted in the literature. This study emphasizes the importance of carefully designed ASEP activities to provide learners with opportunities to connect science at the ASEP with science at school. This will aid in the transfer of the disposition developed in the ASEP to the formal science classroom. The constructivist-development perspective (Section 2.2) suggests that attitudes acquired are transferred in related settings the same way as knowledge and skills. Therefore, the transfer of an acquired shift in disposition is difficult if learners view the ASEP and the formal science classroom as unrelated.

This study corroborates what the literature recommends for achieving effective outcomes in ASEP (Section 3.6) and contributes to the growing body of literature on features for quality outcomes in ASEP. The study makes a theoretical contribution to science education research, particularly with regard to how the emergence of a CoP framework provides useful information for planning club activities and analysing learners' evolving disposition. As such, this study contributes to the existing body of research on ASEP regarding what specific features or characteristics influence learners' disposition towards science and benefits them in ASEP.

### 6.3 Recommendations

The current research has generated further research possibilities. Most particularly, it would be interesting to carry out further research on the relationship between learners' attitudes towards science and their learning at school, as the literature tends to argue that there is a correlation between learners' attitudes towards science and their formal learning/achievement in science. Participants made a clear distinction between the two environments – the formal science classroom and the informal science club environment, so it would be useful to see how their attitude fared in the school setting.

It is equally important to look at how gender interacts with attitude. Gender issues were not assessed nor considered in this study. A longitudinal study of influence of the ASEP on middle school learners as they progress to high school is recommended. This is to investigate if learners' positive attitude towards science will fade after middle school, as some studies have claimed (George, 2006; Osborne, et al., 2003). Furthermore, the findings have implications for the structure of ASEPs regarding what encourages the transferability of attitude or skills in related settings. One could examine the extent to which an ASEP is structured to connect to the formal school curriculum as a potential factor in transferability.

Regarding the adoption or incorporation of the essential factors in ASEP that influence learners' attitudes, it is understandable that the structure of the formal school curriculum and the limited time for instruction might not be able to accommodate all the factors successfully. The reality is that the structure of the formal science classroom is not easy to change, so an ongoing ASEP can be an ideal space to put these factors into practice. Nevertheless, some effort to incorporate these factors in formal science instruction must be made. Teachers could enrich their science classes with activities that will engage learners in the classroom, using different methods and accommodating innovations in science education. It is believed that in this way learners' attitudes towards science can be improved. Teachers and the education system need to create a way of implementing such factors in the formal classroom. It is also recommended that science teachers be allowed to teach their own speciality, which might strengthen their confidence to offer stimulating learning experiences.

### 6.4 Limitations of the study

The limitations identified in this study are similar to those of other studies using the same approach or design to explore certain characteristics of a defined population. This includes the fact that the findings of this case study are not typically generalizable to all learners (due to the small number of participants involved), nor to all types of ASEP. The findings could thus be taken further through research that focuses on a larger sample of participants. Additionally, the results and findings cannot be generalised to other learning contexts. However, since KMSC possesses some characteristics typical of South African learning contexts, the results and discussions could be useful in providing insights into teaching and learning practices in similar contexts. Furthermore, the findings of the study can be generative, which would be the extent to which other studies might generate similar findings in other ASEP environments using the same research design.

The fact that I was participating in the club activities was both a strength and a limitation. It was a strength in the sense that it helped in establishing a relationship with learners and encouraged them to feel at ease during the interviews, as suggested by Cohen et al. (2011) (Section 4.5.2). On the other hand, it was a limitation in that it is possible that some learners could have made statements during the interviews just to satisfy me because they perceived me as one of the facilitators. Because of this, the validity of the data from these learners could be debatable.

Another limitation was that during the interviews and even journal entries, English was used even though *isiXhosa* is the mother tongue of the majority of the interviewees. Thus, some might have not expressed themselves as they would have if proceedings had been in *isiXhosa*. Nonetheless, this was considered in the sampling (Section 4.4) so as to lessen the effect of this consideration on the validity of the data. In addition, it was observed that learners experienced difficulty with writing in English in their journals, which made their journal entries very few before an alternative was provided (Section 4.5.3). This study was not investigating the language or writing problems encountered by learners in science *per se*, but since such problems came up, they could provide an area for future research.

### 6.5 Reflection and conclusion

In light of the limitations alluded to above, KMSC is an ASEP with its own intrinsic factors influencing learners' attitudes towards science, which do not necessarily becomes generalizable to other ASEPs. If this study were to be conducted again, an attempt would be made to include more than one ASEP in the same geographical location so as to compare findings.

Retrospectively, my participation in the club might have influenced learners' responses to myself as interviewer. An alternative would be to recruit a research assistant to interview and interact with the learners. The research assistant should be someone proficient in the learners' preferred language, which would help to mitigate language barriers. Learners might use the language in which they are most proficient in their journal entries.

Overall, the research process introduced me to many new ideas to which I had to adjust, including the language, vocabulary and writing style associated with research. Sometimes it was difficult wading through the unfamiliar concepts, but I learned to re-read and rework ideas until I understood them. The research design course, the colloquium and contact sessions with supervisors and colleagues were helpful in the whole process.

I believe my writing and critical skills have improved tremendously. I have learned how to sift through the myriad of data collected. More importantly, I have learned from this study that there are things we should not overlook as teachers in the teaching and learning process in our classrooms. For example, the study has revealed that the development of learners' attitudes is influenced by the teachers who frame and encourage it, and provided me with insights to take into my future work with learners. The research experience has made me focus on the importance of paying attention not only to the fact that learners' conceptual understanding is linked to their participation in variety of instructional activities, but also to the way in which they participate in these activities.

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## Appendix A

## LETTER TO THE PARENT AND CONSENT FORM

Dear Parent,

My name is Esther Agunbiade and I am doing a master's degree in Science Education at the Education Department, Rhodes University. You are being requested to give permission for your child to take part in a research study on "exploring the impact of after-school science enrichment programme on learners' dispositions towards science: A case study of Khanya Maths and Science Club". The focus of the study seeks in particular, to look at how Khanya Maths and Science Club influences learners' dispositions towards science as a result of participation in the club.

If you agree that your child may be one of the participants in the study, she or he will be interviewed (audio- recorded) and also complete a pretest and posttest questionnaire on attitudes towards science. There is no foreseeable risk involved in participating in this research. Pretest and posttest scores will be confidential and results will not include individual learners' names.

Kindly be informed that participation in this study is voluntary. If you do not want your child to be in this study, he/she does not have to participate. Also, participants are free to withdraw at any time if they so wish. A decision not to participate in the study will not have any effect on participating in the Khanya Maths and Science Club.

If you have any question about the research, please feel free to contact me at 07333463684, queenesther4throne@yahoo.com or Dr. K. Ngcoza at k.ngcoza@ru.ac.za, Mr K. Jawahar at k.jawahar@ru.ac.za and Mrs J. Sewry at j.sewry@ru.ac.za.

Thank you for taking time to read this letter.
If you agree for your child to participate in this research, please complete the consent form below.

Yours sincerely,
Esther Agunbiade

I ……………………………………………………………………. (full name of parent/guardian), the father/mother/guardian of ……………………………………………… (full name of child) hereby confirm that I understand the content of this document and the nature of the research, and I consent to my child participating in the research study.
I also understand that my child is at liberty to withdraw from participating at any time without any disadvantage.

**Parent's/Guardian's name……………………………………………………………………………**
**Parent's/Guardian's signature……………………..……………………………………………………**
**Date………………………….**

# INCWADI MVUMELWANO

Mzali obekekileyo,

Igama lam ndingu Esther Agunbiade. Ndenza izifundo ze-masters kwihlelo lweNzululwazi kwezeMfundo kwiSebe lweMfundo eRhodes University. Ngembeko nokuzithoba, ndicela imvume yakho ukuba umntwana wakho abe yinxalenye yabantwana abayakuthi bathathe inxaxheba kwizifundo zam ezijolise ekuphandeni ukuba ingaba ukuthatha inxaxheba kwabo kwi 'Khanya Maths and Science Club' kunegalelo kusinina kwizifundo zabo zeNzululwazi.

Ukuba uyavuma ukuba umntwana wakho athathe inxaxheba kolu phando, uyakuthi ke ubuzwe imibuzo malunga ne 'Khanya Maths and Science Club', abhale novavanyo ekuqaleni kwezifundo nasekuyeni kokuphela konyaka ukuzama ukuqonda ukuba umahluko ukhona kusinina. Akukho nto ke inobungozi ukuthatha inxaxheba kolu phando. Iziphumo zovavanyo ziyakuba semfihlakalweni yaye aziyikubanawo amagama abantwana.

Qonda kananjalo ukuba ukuthatha inxaxheba kolu phando kuxhomekeke emzalini womntwana nasemntwaneni, ukuba ayiyominqweno yakho ukuba umntwana wakho athathe inxaxheba, akunyanzelekenga ukuba athathe inxaxheba. Kananjalo, ukuba umntwana wakho uyafuna ukuyeka nangona ebeseqalile ukuthatha inxaxheba kolu phando, uvumelekile ukwenza oko. Okubalulekileyo kukuba ukungathathi nxaxheba kolu phando, akuthethi ukuba umntwana wakho akavumelakanga ukuba athathe inxaxheba kwi 'Khanya Maths and Science Club'.

Ukuba unento ofuna ukuyiqonda malunga nolu phando, ungaqhagamishelana nam kulenombolo 07333463684 (queenesther4throne@yahoo.com) okanye uDr. K. Ngcoza (k.ngcoza@ru.ac.za), uMr K. Jawahar (k.jawahar@ru.ac.za) no Mrs J. Sewry (j.sewry@ru.ac.za).

Ndenza ongazenzisiyo umbulelo ngokuthatha ithuba lokuba ufunde le mbalelwano. Ukuba uyavuma ukuba umntwaba wakho athathe inxaxheba kolu phando, ndicela ukuba uzalise esi siqendu semvumelwano singasezantsi.

Ozithobileyo,
Agunbiade Esther

Mna …………………………………………. (igama elizeleyo lomzali), utata/umama/umgcini ka ……………………………………… (igama elizeleyo lomntwana) ndiyaqinisekisa ukuba ndiyawazi umongo nomxholo walencwadi mvumelwano kananjalo nohlobo lophando. Ngoko ke ndiyavuma ukuba umntwana wam angayinxalenye yolu phando. Ndiyaqonda kananjalo ukuba umntwana wam unakho ukungaqhubekeki ukuthatha inxaxheba koluphando nasekubeni ebeseqalile ukuyithatha, kodwa ndiyakuthembisa ukuba loo nto ayikumbeka makhiwiniba.

**Igama lomzali/umntu ojongene nomntwana……………………………………………………………**
**Ushicelelo lomzali/umntu ojongene nomntwana ……………………..……………………………..**
**Umhla…………………………………………………**

**Appendix B**

# WHAT DO YOU THINK ABOUT SCIENCE?

This survey is completely confidential and your participation is voluntary.

Gender: Male _____ Female _____ Student Name: ___________________________ Grade_________

**Please choose how you feel about each statement by circling the best response. This is NOT a test.**

| | ITEMS | RESPONSE | | | | |
|---|---|---|---|---|---|---|
| 1 | Science can help make the world a better place | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 2 | Scientists spend their free time in the laboratories | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 3 | I would rather find out why something happens by doing an experiment than by being told how it works | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 4 | I find it interesting to hear about new ideas in science | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 5 | Science lessons are fun | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 6 | I would like to belong to a science club | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 7 | I would like a job as a scientist | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 8 | It is good to spend money on science | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 9 | Scientists are as healthy as other people | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 10 | Doing experiments help me learn as much as finding out information from teachers | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 11 | It is good to learn new methods of doing science experiments | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 12 | I dislike science lessons | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 13 | I enjoy watching science programs on TV | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 14 | I would like to work with people who make discoveries in science | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 15 | Doing science projects is not a waste | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 16 | Scientists are friendly like other people. | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |

| | | | | | | |
|---|---|---|---|---|---|---|
| 17 | It is good to do experiments to find out about things | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 18 | I enjoy reading about new things in science that change my ideas | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 19 | Schools should do more practical science lessons each week | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 20 | I would like to be given a science book or a piece of scientific equipment as a present | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 21 | I would like a job in a science laboratory | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 22 | Scientific discoveries are doing more harm than good | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 23 | Scientists like sports as much as other people do. | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 24 | To answer a science question, I would think it over before asking for help | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 25 | It is good to repeat an experiment to check if results are correct | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 26 | Science lessons are useful for learning about everyday life | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 27 | I dislike reading books about science in my free time | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 28 | Working in a science laboratory would be interesting | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 29 | Building science laboratories is good for the society | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 30 | Scientists are less friendly than other people | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 31 | I enjoy scientific experiments because I learn from them | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 32 | Finding out about new things in science is not important | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 33 | Science is one of the most interesting school subjects | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 34 | I would like to do science experiments at home | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |
| 35 | I would not like to be a scientist because it requires too much education | Strongly Agree | Agree | Not Sure | Disagree | Strongly Disagree |

**Adapted from Fraser (1981)**

## Appendix C

### Items and reliability coefficient of TOSRA-2 sub-scales

| TOSRA-2 sub-scales | No of items | Serial number of statements | Reliability coefficients |
|---|---|---|---|
| Perception of science | 12 | 1,2,9,15,16,22,23,26,29,30,32,35 | 0.86 |
| Interest in science | 12 | 3,4,8,11,14,18,21,24,25,28,31,33 | 0.79 |
| Enjoyment of science | 11 | 5,6,7,10,12,13,17,19,20,27,34 | 0.81 |

## Appendix D

## Semi-Structured Interview Guide

1. Why do you keep coming to the club?
2. Is science important? If yes/no, why?
3. Is science helping our society and environment? If yes/No, How or why
4. Do you like/enjoy science lessons and activities? If yes/No, Why?
5. Describe the science at the club? Is it same with science at school?
6. Is the club helping you with science at school
7. What do you like/dislike about the club?
8. What do you think will make science interesting and enjoyable?
9. Is anything hindering your attendance at the club?
10. Would you like to be a scientist?
11. Do you watch science programmes on TV?
12. Do you read new things about science?
13. Why do you think some of your friends are not attending to the club

## Appendix E

## Journal prompt

The science we did at the club today is about …………………………………………

What I learned from science activities of today ……………………………………….

What I do not like about like about science activities today……………………………

What I like about science activities today ………………………………………………

My experience at the club today …………………………………………………………

## Appendix F

## Transcripts of interviews and initial coding of data

### Learner 1 (IL1)

| Interview transcripts | Initial description | Assigned No |
|---|---|---|
| I: Why do you keep coming to the club?<br>L: because I like what we are doing here and I learn more new things.<br>I: You learn more new things? Like what?<br>L: I learn different things about our environment. | Learning about the environment | 1 |
| I: what do you think about science?<br>L: science is important and it's fun. | science is important | 2 |
| I: Ummh… can you explain more?<br>L: emm…… because everything we learn about science we can see it around us.<br>I: ok. So is science helping our society?<br>L: yes..<br>I: can you tell me how?<br>L: because we learn about different chemicals and green chemistry and ….how we can keep our environment safe from bad chemicals. | Learning about environment | 1 |
| I: Do you like or enjoy science lessons and activities?<br>L: yeees<br>I: why?<br>L: I like science because it makes us know so many things that we don't know especially when we do experiment we learn a lot of things. | Hands-on experience | 3 |
| I: can you describe science at the club?<br>L: it's fun<br>I: it's fun? How?<br>L: because when you do different things you enjoy it. Doing experiments makes it so interesting and I love it and we don't just copy notes, we do many things that I love to do, and I get to understand that science is not difficult. | Enjoyable activities<br>Experiment is interesting<br>Engaging activities | 4<br>5<br><br>6 |
| I: ok. is it same with science at school?<br>L: not the same. We do different things at school, we don't do experiment we just write notes and stuffs and it's not interesting.<br>I: why is it not interesting?<br>L: because it' not like here where we do experiments and | Collaborative learning | 7 |

| | | |
|---|---|---|
| …. You work things out with your friends and we all love it and when you don't understand sometimes, your friends can explain to you and you will understand. | Experiment facilitates understanding | 8 |
| I: ok. is the club helping you with science at school?<br>L: yes it is helping because I understand what we learn here and when my teacher is teaching us at school I easily know what we are learning.<br>I: can you tell me more?<br>L: eem….. here at the club you learn and see examples of some things you learn before and you now understand and I don't have to memorize things but we learn about things in our surroundings. We have time to learn so many things and understand and not trying to remember stuff for test ..so we relaxed very well to learn. | No rote learning<br>Positive atmosphere<br>No test anxiety | 9<br>10<br>11 |
| I: ok. What do you like or dislike about the science activities at the club?<br>L: I don't dislike anything<br>I: then ..what do you like?<br>L: I like everything, I like going to the lab and playing with the computers. | Preference for hands-on activities | 12 |
| The club makes me to think very well and learn things about my environment. Like, when we learn about green chemistry, I understand it very well and I know of some things that are dangerous in our environment. | Learning about environment | 1 |
| I: do you watch science programmes on TV?<br>L: sometimes<br>I: why sometimes?<br>L: because …. I don't know.. I only watch when I see the programme.<br>I: so when you see any science programme, you would like to watch?<br>L: yes…because I know I will learn from it. | Usefulness of science | 13 |
| I: do you read books or new things about science?<br>L: I don't have books to read, I read only my school books.<br>I: but if you have one, would you like to read?<br>L: yes I will, because I may learn some new things there<br>I: ok. What do you think will make science interesting and enjoyable for you?<br>L: science is interesting when I do lots of experiments and work with my friends. | Hands-on experience<br>Collaborative learning | 3<br>7 |
| I: is that all?<br>L: arrr… doing experiments and not just writing what you don't understand. | Hands- on experience<br>Engaging activities | 3<br>6 |
| I: would you like to be a scientist?<br>L: yes I will. | Want a career in | 14 |

| | | |
|---|---|---|
| I: Why?<br>L: because I found out that science is fun and very interesting and as a scientist I will be working in the laboratory to make different things. | science<br>Positive perception of scientists | 15 |

**Learner 2 (IL2)**

| Interview transcripts | Initial description | Assigned No |
|---|---|---|
| I: Why do you keep coming to the club?<br>L: I am coming to the club to learn some things I cannot learn at school<br>I: things like what?<br>L: different things we learn here like I have never used a thermometer before, but here I used it to know the temperature of some reactions | Variety of club activities | 16 |
| I: ok. what do you think about science?<br>L: science can be very interesting when you do a lot of stuffs like experiment, knowing about reactions. | Preference for hands-on activities | 12 |
| I: tell me more?<br>L: you know science makes you to know many things and how they are produced. We learn about the earth and just everything you wanna know. | Linking science to everyday life | 17 |
| I: ok. So is science important?<br>L: yes it is<br>I: why?<br>L: because science makes you to understand everything around you and how to make them good and use them. | Linking science to everyday life | 17 |
| I: Do you like or enjoy science lessons and activities?<br>L: yes I like science and enjoy doing science experiments.<br>I: why?<br>L: because it's fun and you learn different things. Science is interesting when you don't have to memorize stuff and calculate but you learn about things in the surrounding. | Varieties of club activities<br>No rote learning<br>Learning about environment | 16<br>9<br>1 |
| I: can you describe science at the club?<br>L: we do a lot of experiments. we do experiments like polyol, making ice cream, foams, we learn more things, You know… experiment make me to like science because you don't do calculations and difficult things. At school we don't do these types of things. | Hands- on experience<br>Preference for hands-on activities<br>Simplicity | 3<br>12<br>19 |
| I: what do you mean at school you don't do these types of things?<br>L: because at school we are not allowed to use these | | |

| | | |
|---|---|---|
| chemicals and make different things but here we are free and nobody is shouting at you. I also like working with my friends.<br>I: u mean it's not same with science at school?<br>L: no. At school you we don't do experiments we just learn and write and do exams. School is different.<br>I: ok, so, is the club activities helping you with science at school?<br>L: yes<br>I: how?<br>L: what we learn here makes you to understand better about science. Because you are not just writing, we know different things so when we are learning it at school I already know it and it is not difficult for me.<br>I: ok. What do you like or dislike about the science activities at the club?<br>L: I like everything at the club. Everybody is friendly and they make you to understand very well.<br>I: what do you dislike?<br>L: I don't dislike anything<br>I: do you watch science programmes on TV?<br>L: yes<br>I: why?<br>L: because ….emm…it will make you to know more about things around you.<br>I: is that important?<br>L: yes. because I know I will learn from it and know how things are.<br>I: do you read books or new things about science?<br>L: yes. But only the school books.<br>I: ok. What do you think will make science interesting and enjoyable for you?<br>L: I enjoy science by doing experiments and when teachers listen to you and explain what you don't understand very well.<br>I: any other thing?<br>L: umm…also going to the laboratory and doing everything together with my friends.<br>I: so u like working together with friends?<br>L: yes it makes it fun<br>I: would you like to be a scientist?<br>L: yes I like to be a scientist.<br>I: Why?<br>L: because scientist makes the world better by doing different things in our environment. | Positive atmosphere<br>Collaborative learning<br><br>Engaging activities<br><br>Friendly environment<br>Understanding concepts<br><br>Learning about environment<br><br>Science is important<br><br>Preference for hands-on activities<br>Clarity in explanation<br><br>Collaborative learning<br><br>Want a career in science<br><br>Positive perception of scientist | 10<br>7<br><br>6<br><br>20<br>21<br><br>1<br><br>2<br><br>12<br><br>22<br><br>7<br><br>14<br><br>15 |

**Learner 3 (IL3)**

| Interview transcripts | Initial description | Assigned No |
|---|---|---|
| I: Why do you keep coming to the club?<br>L: I am here to get help with science because I am struggling with science at school.<br>I: and are you getting the help you need? | | |
| L: yes. It is helping me now and school work is not so difficult for me. | Simplicity | 19 |
| I: what do you think about science?<br>L: Science is important and we learn more about science in the club. Science is kind of like difficult but when you learn it and enjoy it you know it. | Science is important<br>Enjoyment facilitates understanding | 2<br>23 |
| I: ok. can you explain?<br>L: you know the way the teachers explain things to you and you do experiments, you get to see things for yourself and understand. But when you are just writing you may not understand. | Clarity in explanation<br>Hands-on experience<br>Engaging activities<br>Understanding of concepts | 22<br>3<br>6<br>21 |
| I: you said science is important, what do you mean by that?<br>L: science is important .... because... it tells you everything about the earth. Different things we use and if they are good or not. Science also help to produce the things we use like soap, bleach and other things. | Usefulness of science | 13 |
| I: Do you like or enjoy science activities?<br>L: yes I like science activities<br>I: why? | | |
| L: because I enjoy science, especially when I am doing experiments and we mix things together to get different things. You know how scientist work and how things are produced. So... experiment makes you to like science because you don't do calculations and other difficult things | Preference for hands-on activities<br>Positive perception of scientist<br>Simplicity | 12<br>15<br>6 |
| I: can you describe science at the club?<br>L: we do lots of interesting things in the club, solving maths and doing experiments in science. I enjoy going to the lab to make that foam thing and know about……is it…e..mm gas? | Varieties of activities<br>Hands-on experience | 16<br>3 |
| I: you mean oxygen or carbon dioxide gas?<br>L: yes..the carbon dioxide, blowing the balloon with carbon dioxide from mixing two chemicals. | Usefulness of science | 13 |
| I: is the club helping you with science at school?<br>L: yes. because what we learn here we may learn it after two weeks at school and then I will understand because we | | |

| | | |
|---|---|---|
| have done it here. It helped me with my school work and because of that I like doing more science. | Understanding of concepts | 22 |
| I: ok. What do you like or dislike about the science activities at the club?<br>L: everything is fine.<br>I: everything like what? | | |
| L: I like everything, the teacher explain to you and they are very friendly and good. And everybody is listening nobody is disturbing you. The teachers make you to understand and there is no exam you will fail. The teachers don't just talk and rush you. You are not even afraid of test so we are very free and enjoy science here | Clarity in explanation<br>Friendly environment<br>Teacher's influence<br>No distraction<br>No test anxiety<br>Positive atmosphere | 22<br>20<br>24<br>25<br>11<br>10 |
| I: umm…do you watch science programmes on TV or read books about science?<br>L: yes.<br>I: why? | | |
| L: because I want to become a scientist and learn about so many things in science. | Want a career in science | 14 |
| I: Why do you want to be a scientist? | | |
| L: because everything is about science and doing experiments in the laboratory makes me know and enjoy how scientists are. I like working like scientist because it is interesting. | Hands-on experience<br>Experiment is interesting<br>Positive perception of scientist | 3<br>5<br>15 |
| I: ok. What do you think will make science interesting and enjoyable for you? | | |
| L: science is interesting when we do lots of different things and not just reading and writing but working in the lab and using the computers. | Varieties of activities<br>Preference for hands-on activities | 16<br>12 |
| I: what again? | | |
| L: doing some nice stuff, experiments and nobody is rushing you. | Engaging activities<br>Positive atmosphere | 6<br>10 |

**Learner 4 (IL4)**

| Interview transcripts | Initial description | Assigned No |
|---|---|---|
| I: Why do you keep coming to the club? | | |
| L: I want to know more about maths and science. | | |
| I: why do you want to learn more about science? | | |
| L: because I think science is good and when you know more of it …….you……. | Science is important | 2 |
| I: what do you think about science? | | |
| L: science is very difficult and not simple. | Perceived difficulty | 27 |
| I: why do you think it is difficult? | | |
| L: science is difficult because you do lots of calculation and you may not understand some things. | Perceived difficulty | 27 |
| I: tell me more | | |
| L: the teacher tells you a lot of things you don't understand and you just write them down. I don't like science. | | |
| I: so you don't like science because you don't understand or why? | | |
| L: it is just too difficult, but I like it most when we do experiments with my friends and you guys explain to us how to do things. | Perceived difficulty<br>Experiment facilitates understanding<br>Collaborative learning | 27<br>8<br><br>7 |
| I: you mean when you do experiments you understand and that makes you like science? | | |
| L: yes. it is only here that I like science, we do experiments, we don't do that at school so I don't like science at school. But here it is fine. | | |
| I: so you like or enjoy science activities here and not at school? | | |
| L: yes. because here, we all do everything together and you friends explain how to do things to you and I understand why we are learning those things. | Collaborative learning<br><br>Usefulness of science | 7<br><br>13 |
| I: you see why you are learning those things? How? | | |
| L: yes, when we learn about oxygen and ………..emmm.. | | |
| I: carbon dioxide? | | |
| L: yes, carbondioxide, I know why oxygen will make the fire to burn and how carbondioxide will …blow it out. | Linking science to everyday life | 17 |
| I: how is that important? | | |
| L: because…. I know oxygen and carbon.... carbondioxide is very useful in life. | usefulness of science | 13 |
| I: ok. can you describe science at the club? | | |
| L: it is very interesting especially making different things. | Science is fun | 18 |
| I: tell me more? | | |
| L: we make different things that are very useful here. So you see how things you see around you are made. We learn how to make plastics and…. foam and…….. ice | Hands-on experience<br><br>Linking science to | 3<br><br>17 |

| | | |
|---|---|---|
| cream. | everyday life | |
| I: ok. Now that you enjoy science at the club, is it helping you with science at school?<br>L: not everything. Because science we do at school is different from here. The school is very difficult and you don’t understand. But here the teachers help you, they helped me with my school work and because of that I like doing more science. | Teachers’ influence | 24 |
| I: ok. So is it helping you with school work or not?<br>L: only the things we learn here when we learn at school I understand it.<br>I: ok. What do you like or dislike about the science activities at the club? | | |
| L: science here is very interesting and I love it here. I don’t dislike anything, everything is fun. | Science is fun | 18 |
| I: everything? | | |
| L: yes. the club is cool. I only like experiment we do in science because science is difficult when you don’t do experiment and you don’t understand. | Preference for hands-on activities<br>Experiment facilitates understanding | 12<br>8 |
| I: do you watch science programmes on TV or read about science?<br>L: not every time<br>I: why not every time?<br>L: um…. nothing.<br>I: ok. What do you think will make science interesting and enjoyable for you? | | |
| L: we should explain very well to understand and do experiment to show how things are. | Clarity in explanation<br>Experiment facilitates understanding | 22<br>8 |
| I: do you mean when you understand and do experiments and understands, you enjoy science?<br>L: yes.<br>I: would you like to be a scientist?<br>L: no I don’t want to be a scientist.<br>I: Why?<br>L: because I think science is not very simple and I don’t want difficult things.<br>I: but you said if you do experiments and you understand, so why won’t you like to be a scientist?<br>L: because the science exams we do at school is difficult and I am still struggling. | | |

**Learner 5 (IL5)**

| Interview transcripts | Initial description | Assigned No |
|---|---|---|
| I: Why do you keep coming to the club?<br>L: because I like science here.<br>I: you like science here? Why?<br>L: I really do enjoy the science here ma'am. I learn different things, especially the funny things and way of teaching makes me to enjoy it. | Science is fun<br>Teachers' influence | 18<br>24 |
| I: what do you think about science?<br>L: science is.. makes me to know more about natural things so it is very important. I enjoy science and learning about the natural things in the environment. | Learning about environment<br>Science is important<br>Enjoyable activities | 1<br>2<br>4 |
| I: you said you enjoy science?<br>L: yes ma'am<br>I: why?<br>L: Science is very interesting because it teaches us how to use chemical to make different things. Almost everything about our environment is about science. | Science is fun<br>Usefulness of science | 18<br>13 |
| I: can you tell about science at the club?<br>L: science at the club is very interesting and I love it. The things we do are from our environment and how things are made so it is interesting. | Learning about environment<br>Hands-on experience | 1<br>3 |
| I: tell me more<br>L: I like the experiment we did on ice cream, we also did experiment on gas and how it helps fire to burn. We learn a lot of things here. | Variety of activities<br>Linking science to everyday life | 16<br>17 |
| I: is it same with science at school?<br>L: not the same. The science here is richer and different from the one at school, here we are allowed to go to lab and use chemicals. We see the real thing how they are not just about remembering stuff at school. | Engaging activities<br>No rote learning | 6<br>9 |
| I: ok. is the club helping you with science at school?<br>L: Science here is helping me at school. The science here is much better, science at school is simpler and very boring but here it makes me to think very well and work hard and I even know a lot of stuff here because we do experiments on them. | Hands-on experience<br>Experiment facilitates understanding | 3<br>8 |
| I: ok. What do you like or dislike about the science activities at the club?<br>L: I love everything<br>I: like what?<br>L: I love going to the lab. I love the teachers because they are friendly, they want you to understand. I always enjoy science at the club because it is not difficult | Teachers' influence<br>Clarity in explanation | 24<br>22 |

| | | |
|---|---|---|
| because the teacher and your friends explain to you. There is nobody disturbing you in the club and we can pay attention to what we are doing<br>I: why do you love working together with your friends?<br>L: because …..you feel comfortable around your friends and explain things to each other. It makes it more fun.<br>I: do you read or watch science programmes?<br>L:yes ma'am.<br>I: why do you watch or read?<br>L: because you get to learn new things.<br>I: that's fine. What do you think will make science interesting and enjoyable for you?<br>L: aaa…mm..doing experiment to see how things are like the experiment we did on poly…..<br>I: polyol?<br>L: yes polyol… we did it ourselves and understand how the foams and some walls are made. The one I made I took it home and saw the same thing under our chair. So I know science is very useful to know things around us.<br>I: would you like to be a scientist?<br>L: I am not sure.<br>I: Why?<br>L: I don't have a reason now. | Collaborative learning<br>No distraction<br>Friendly environment<br>Learning new things<br>Hands-on experience<br>Linking science to everyday life<br>Usefulness of science | 25<br>7<br>20<br>26<br>3<br>17<br>13 |

**Learner 6 (IL6)**

| Interview transcripts | Initial description | Assigned no |
|---|---|---|
| I: Why do you keep coming to the club?<br>L: to learn things I don't know because I am struggling at school with science.<br>I: you are struggling with science at school? Is the club now helping you?<br>L: yes it is helping me because I like a lot of things we are doing here.<br>I: what do you think about science?<br>L: science is difficult but when you learn it and understand it is very interesting because you will see a lot of things around you about science.<br>I: ok. Is science is important?<br>L: yes..it is<br>I: can you tell me why?<br>L: because it makes you to know so many things about our | Understanding of concepts<br>Science is fun<br>Linking science to everyday life<br>Learning about | 21<br>18<br>17<br>1 |

| | | |
|---|---|---|
| environment. we learn pollution and how dangerous it is and how to prevent different bad thing in our environment. We learn about bad chemicals and green chemistry…..how we can keep our environment safe from bad chemicals. | environment<br>Linking science to everyday life<br>Usefulness of science | <br>17<br><br>13 |
| I: ummh. Ok. Do you like or enjoy science lessons and activities?<br>L: yes<br>I: why?<br>L: I like science but I am not very good at it that is why I am coming to the club.<br>I: and since you've been coming to the club, it is helping you?<br>L: yes it is.<br>I: tell me how? | | |
| L: Experiment make you to like science because you don't do calculations and difficult things and what I learn here is easy to understand and remember at school. | Hands-on experience<br>Enjoyable activities | 3<br>4 |
| I: can you describe science at the club?<br>L: it's fun and we work together with our friends and you are not shy to ask questions from them because they will not laugh at you. So I like the club because I enjoy what we do here. | simplicity<br>Understanding of concepts<br>Science is fun<br>Collaborative learning<br>Enjoyable activities | 19<br>21<br><br>18<br>7<br>4 |
| I: you said it's fun? How?<br>L: because when you do different things you enjoy it. Doing experiments makes it so interesting and I love it. We don't just copy notes, we do experiments and a lot of things and enjoy it, it' s interesting and I get to understand that science is not difficult | <br>Variety of activities<br>Experiment is interesting<br>Engaging activities | <br>16<br>5<br><br>6 |
| I: ok. is it same with science at school?<br>L: not the same. We learn different things but I like the one here. Science at school is difficult and different. The teachers listen and don't rush you, they help us and I like the scientist that presents things to us. I would like to be like them. | Enjoyment facilitates understanding<br>Teachers' influence<br>Positive atmosphere<br>Want a career in science | 23<br><br>24<br>10<br>14 |
| I: so, is the club helping you with science at school?<br>L: yes it is helping me.<br>I: can you tell me how?<br>L: here at the club I can understand very well because the things we do are not difficult. | <br><br><br>Understanding of concepts | <br><br><br>21 |
| I: ok. What do you like or dislike about the science activities at the club? | Simplicity | 6 |
| L: I like it when we do experiments, it's fun, we learn new things and enjoy the class and …the teacher don't shout at you at the club, they are patient to explain things and help you to understand | Preference for hands-on activities<br>Learning new things<br>Teachers' influence | 12<br><br>26<br>24 |

| | | |
|---|---|---|
| I: ok. What do you dislike?<br>L: nothing.<br>I: ok. What do you think will make science interesting and enjoyable for you?<br>L: I like experiment in science because I enjoy it. | Experiment is interesting | 5 |
| I: and what again?<br>L: I just know that I understand science now maybe because the way the teacher explains to you and this is why I like science. | Teachers' influence | 24 |
| I: you like science because of what?<br>L: because the teacher explains very well to you to understand and the experiments is very interesting | Experiment is interesting | 5 |
| I: why is experiment interesting?<br>L: experiment is interesting .....because.....eerr... it tells you what you don't know | Experiment facilitates understanding | 8 |
| I: umm…ok. would you like to be a scientist?<br>L: yes<br>I: Why?<br>L: Because I love science and when I grow up, I want to be a scientist so that I can see different things and help people and the world like the scientist. | Positive perception of scientist | 14 |

## Appendix G

### Learners' journal entries from February to September 2015

| | February 2015 | May 2015 | September, 2015 |
|---|---|---|---|
| Learner 1 (LJ1) | Science is difficult and you have to learn many things | I enjoy everything we do here because we learn more about science | It's getting boring here |
| Learner 2 (LJ2) | I like experiment on ice cream. I like experiment in science | This science is kind of boring, I would've preferred doing maths | I enjoy science, especially when I am doing experiments and we mix things together to get different things. |
| Learner 3 (LJ3) | - | I enjoy science at the club because it is not difficult and we work together to do things | I had fun because of the different things we did and being helped by the teachers |
| Learner 4 (LJ4) | I don't like science | It is making me to think. A lot of what we do required thinking | Doing science is lovely |
| Learner 5 (LJ5) | I like the experiment we did on ice cream, we made ice cream from liquid nitrogen and now I understand solid, liquid and gas and how they change | I love science because it helps us learn how to keep our environment safe from bad chemicals and we learn so many things about science in our surrounding like green chemistry | I enjoyed today's lesson because it was fun and easy for me |
| Learner 6 (LJ6) | Science is difficult and sometimes boring | Working in the laboratory makes me know and enjoy how scientists are. I like working like scientist because it is interesting | I like science because I understand and enjoy the different things we are doing here like experiment and working on computers |

## Appendix H

## Analytical Memo

This memo was drawn from both interviews and journal entries of learners. The excerpts are examples of statements that relates to the themes identified.

**Theme 1: Instructional characteristics**

| Sub-theme | Excerpts | Source |
|---|---|---|
| Hands-on experience | I like science because it makes us know so many things that we don't know especially when we do experiment we learn a lot of things | IL1 |
| | I enjoy science by doing experiments | IL2 |
| | I enjoy science, especially when I am doing experiments and we mix things together to get different things. | IL3 |
| | I only like experiment we do in science because science is difficult when you don't do experiment and you don't understand. | IL4 |
| | doing experiment to see how things are, I like the experiment | IL5 |
| | I like experiment in science because I enjoy it. | IL6 |
| | I like experiment on ice cream. I like doing experiment in science | LJ3 |
| | Working in the laboratory makes me know and enjoy how scientists are. I like working like scientist because it is interesting | LJ5 |
| | I enjoy science, especially when I am doing experiments and we mix things together to get different things. | LJ6 |
| | it's fun and you learn different things. different things we learn here like I have never used a thermometer before, but here I used it to know the temperature of some reactions. science can be very interesting when you do a lot of stuffs | IL2 |
| Variety of activities | science is interesting when we do lots of different things and not just reading and writing but working in the lab and using the computers. | IL3 |
| | when you do different things you enjoy it. Doing experiments makes it so interesting and I love it. We don't just copy notes, we do experiments and a lot of things and enjoy it | IL6 |
| | I had fun because of the different things we did and being helped by the teachers | LJ3 |

| | | |
|---|---|---|
| | I like science because I understand and enjoy the different things we are doing here like experiment and working on computers. Experiment makes me to know how it is in real life | LJ5 |
| No rote learning | I don't have to memorize things but we learn about things in our surroundings. We have time to learn so many things and understand | IL1 |
| | we don't just copy notes, we do many things that I love to do, and I get to understand that science is not difficult. | IL1 |
| | they make you to understand very well. | IL2 |
| | We see the real thing how they are not just about remembering stuff at school. | IL5 |
| | what I learn here is easy to understand and remember at school. | IL6 |

**Theme 2: Facilitators and environment's characteristics**

| Sub-theme | Excerpts | Source |
|---|---|---|
| Facilitators attributes and influence | Teachers listen to you and explain what you don't understand very well | IL2 |
| | The teacher explain to you and they are very friendly and good. The way the teachers explain things to you … you get to see things for yourself and understand | IL3 |
| | But here the teachers help you, they helped me with my school work and because of that I like doing more science. | IL4 |
| | I really do enjoy the science here ma'am. I learn different things, especially the funny things and way of teaching makes me to enjoy it. I love the teachers because they are friendly, they want you to understand. | IL5 |
| | the teacher don't shout at you at the club, they are patient to explain things and help you to understand | IL6 |
| | The teachers listen and don't rush you, they help us and I like the scientist that presents things to us. I would like to be like them. | IL6 |
| | I had fun because of the different things we did and being helped by the teachers | LJ2 |
| Engaging and collaborative learning experience | | |
| | science is interesting when I do lots of experiments and work with my friends. | IL1 |
| | I also like working with my friends. | IL2 |
| | I like it most when we do experiments with my friends | IL4 |
| | because here, we all do everything together and you | IL4 |

| | | |
|---|---|---|
| | friends explain how to do things to you and I understand why we are learning those things. | |
| | I always enjoy science at the club because it is not difficult because the teacher and your friends explain to you. | IL5 |
| | it's fun and we work together with our friends and you are not shy to ask questions from them because they will not laugh at you. | IL6 |
| | I enjoy science at the club because it is not difficult and we work together to do things | LJ2 |
| Positive learning atmosphere | We have time to learn so many things and understand and not trying to remember stuff for test ..so we relaxed very well to learn. | IL1 |
| | we are free and nobody is shouting at you. Everybody is friendly and they make you to understand very well | IL2 |
| | everybody is listening nobody is disturbing you. You are not even afraid of test so we are very free and enjoy science here | IL3 |
| | There is nobody disturbing you in the club and we can pay attention to what we are doing. You feel comfortable around your friends and explain things to each other. It makes it more fun. | IL5 |

**Theme 3: Making connections between science concepts and everyday life**

| Sub-theme | Excerpts | Source |
|---|---|---|
| Usefulness of science | science is important and it's fun. | IL1 |
| | science is important .... because... it tells you everything about the earth. Different things we use and if they are good or not. Science also help to produce the things we use like soap, bleach and other things. | IL3 |
| | I know oxygen and carbon.... carbondioxide is very useful in life. | IL4 |
| | Science is very interesting because it teaches us how to use chemical to make different things. Almost everything about our environment is about science | IL5 |
| | polyol… we did it ourselves and understand how the foams and some walls are made. The one I made I took it home and saw the same thing under our chair. So I know science is very useful to know things around us | IL5 |
| | polyol… we did it ourselves and understand how the foams and some walls are made. The one I made I took it home and saw the same thing under our chair. So I | IL6 |

| | | |
|---|---|---|
| | know science is very useful to know things around us | |
| | I found out that science is fun and very interesting and as a scientist I will be working in the laboratory to make different things. | IL1 |
| | I like to be a scientist… because scientist makes the world better by doing different things in our environment. | IL2 |
| | everything is about science and doing experiments in the laboratory makes me know and enjoy how scientists are. I like working like scientist because it is interesting. | IL3 |
| | I like the scientist that presents things to us. I would like to be like them. | IL6 |
| | when I grow up, I want to be a scientist so that I can see different things and help people and the world like the scientist. | IL6 |
| Perception of science | The club makes me to think very well and learn things about my environment. Like, when we learn about green chemistry, I understand it very well and I know of some things that are dangerous in our environment. | IL1 |
| | science makes you to understand everything around you and how to make them good and use them. | IL2 |
| | we make different things that are very useful here. So you see how things you see around you are made. We learn how to make plastics and…. foam and…….. ice cream. | IL4 |
| | science is.. makes me to know more about natural things so it is very important. I enjoy science and learning about the natural things in the environment. | IL5 |
| | science at the club is very interesting and I love it. The things we do are from our environment and how things are made so it is interesting. I like the experiment we did on ice cream, we also did experiment on gas and how it helps fire to burn. We learn a lot of things here. | IL5 |
| Linking concepts to everyday life | because it makes you to know so many things about our environment. we learn pollution and how dangerous it is and how to prevent different bad thing in our environment. We learn about bad chemicals and green chemistry…..how we can keep our environment safe from bad chemicals. | IL6 |
| | I like science because I understand and enjoy the different things we are doing here like experiment and working on computers. Experiment makes me to know | LJ5 |

| | | |
|---|---|---|
| | how it in real life | |
| | I like the experiment we did on ice cream, we made ice cream from liquid nitrogen and now I understand solid, liquid and gas and how they change. | LJ6 |

**Theme 4: Perceived difficulty of science**

| Sub-theme | Excerpts | Source |
|---|---|---|
| Science is difficult | Science is kind of like difficult but when you learn it and enjoy it you know it | IL3 |
| | science is difficult because you do lots of calculation and you may not understand some things. | IL4 |
| | it is just too difficult, but I like it most when we do experiments with my friends and you guys explain to us how to do things. I think science is not very simple and I don't want difficult things. | IL4 |
| | science is difficult but when you learn it and understand it is very interesting | IL6 |
| | Science is difficult and sometimes boring | LJ5 |
| | I don't like science. Science is difficult | LJ4 |