THE PROMOTION OF SCIENTIFIC LITERACY WITHIN A MUSEUM CONTEXT

by

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DECLARATION BY CANDIDATE

I, Nicolette Deidré Daniels, student number 208068940, hereby declare that this thesis, submitted for the qualification of *Magister Educationis* in the Faculty of Education at the Nelson Mandela Metropolitan University has not previously been submitted to this or any other university. I further declare that it is my own work and that, as far as is known, all material used has been recognized.

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Date: November 2010

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ABSTRACT

Currently South African museums are faced with the challenge of evaluating and transforming their roles and functions as a response to changing national educational needs. The purpose of this study was to investigate whether aspects of the integrated strategies approach to promoting scientific literacy can be successfully employed in a museum context. The approach was used as part of the education programmes at the Port Elizabeth Museum School (Bayworld) and mixed methods were used to gather qualitative and quantitative data on the teachers' ability to adopt the strategy. Data were also generated on the teachers' perceptions of teaching and learning, possible activities which supported the approach, and aspects of the strategy which the learners adopted most readily. The findings suggest that active engagement in the process resulted in effective adoption of the strategy by the teachers, improved attitudes towards science learning by both the teachers and children who participated in the process, and improved scientific literacy in both.

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CHAPTER ONE

INTRODUCTION AND OVERVIEW

1. INTRODUCTION

One of the objectives of the South African Department of Education (DoE, 2002) is to increase the conceptual knowledge of learners. This research targeted Grade six learners who regularly visit the Port Elizabeth Museum School's education programme. The rationale for the research strategy was prompted by the need to promote increased literacy for scientific inquiry and to prepare students for careers in science-related fields by nurturing the natural curiosity of children with a view to deploying it in the scientific field of reasoning (Department of Education, 2002). Whereas multifarious programmes have been designed and various approaches used to teach science in order to promote science literacy in schools, the training and support given to school based teachers in science literacy in South Africa is not adequate (Burger, 2008; Fleisch, 2008) and results of national and international testing reveal that much still needs to be done in such an endeavour (Christie, Butler & Potterton, 2007).

Institutions of learning and museums share a common goal since both are committed to lifelong learning (Bonner, 1985). There is ultimately a common denominator to all museums, irrespective of what their particular focus might be, as they acquire, preserve, research, communicate and exhibit the cultural and natural heritage of society for the purpose of education and entertainment - otherwise denoted as 'edutainment'1. Screven (2002: para. 1)

[1] 'Edutainment' is a neologism invented by Dr Chris Daniels in 1975. It espouses the philosophy of "education through entertainment". It advocates a blend of core communication theories and fundamental entertainment pedagogy to guide the program. A museum is ideally placed to be a hands-on experience that fulfills the criteria of "edutainment" where learners actively play in an environment while learning.

asserts that "…museums offer untapped potential for communicating social, cultural and scientific information, correcting misconceptions and improving attitudes and cognitive skills." A museum can be strategic in the re-training of teachers for science literacy in that they learn to (a) utilise it as a teaching resource where specimens and exhibits are integrated into the present curriculum; (b) provide the opportunity for learning by manipulating real objects in a stimulating setting thus enhancing and complementing conceptual learning in the classroom and (c) harness the potential to be the ideal setting for training programs that can benefit educators, schools and universities. Bonner (1985) cites Van Dorn who suggested that over time the education function of museums has grown considerably and bridges the gap between the roles of museums and universities.

Currently there is a relatively rich field of international literature in terms of informal education via museums (Bonner, 1985), including learning science beyond the classroom (Ramey-Gassert, 1997). But there is a paucity of South African research studies on museum delivery of the desired scientific literacy advocated by the South African Department of Education (DoE, 2002). As such, this study monitored and assessed the implementation and impact of specific aspects of an integrated strategies approach (Webb, 2007) to Natural Science teaching by the museum school teachers with a view to promoting scientific literacy.

2. SCIENTIFIC LITERACY: TOWARDS A WORKING DEFINITION

Fensham (2004) compiled a historical review of the ideas regarding scientific literacy and commented on what he thought science literacy for all might include and not include. Yore and Treagust (2006), however, feel that curricula which emphasise personal well-being, democratic well-being, socio-economic well-being and scientific well-being do not place sufficient emphasis on learners' cognitive tools and the communication abilities that are needed to be scientifically literate. They believe that the promotion of science literacy should empower people to be literate in reading, writing and talking science. Gee (2005) reiterates the point that no learning area represents academic language better than science because it challenges learners to use language orally and in print, as well as symbolically as in diagrams equations and analogies: skills that are at the heart of what is required for higher levels of school success. As such, this approach to scientific literacy is adopted in this study.

3. DESCRIPTION OF RESEARCH PROBLEM

As noted earlier, despite the discourse around the need to develop science centres, little has been said in the literature about the promotion of scientific literacy in South African museums. Currently there is a great deal of international research coming to the fore around developing scientific literacy in its fundamental sense (reading, writing and talking science) in order to develop scientific literacy in its derived sense, that is to say, making sense of scientific arguments, seeing the big picture and relating science to social issues (Yore & Treagust, 2006). Research into promoting scientific literacy in its fundamental sense has been initiated in the South African school context (Villanueva & Webb, 2008; Webb, Williams & Meiring, 2008) and this study is a natural progression from the primary pedagogical environment (the school) to a museum education context.

4. RESEARCH QUESTION

The primary question that guided this study is "Can aspects of the integrated strategies approach to promoting scientific literacy be successfully employed in a museum context?"

The sub-questions that served the fundamental research question are:

- Can the teachers in the Port Elizabeth Museum School at Bayworld adopt the scientific literacy strategy if provided with appropriate support?
- If the strategy is adopted by the participant museum school teachers, how does it impact on their current pedagogical paradigm with regard to the nature of teaching and learning towards scientific literacy?
- What is the nature of the types of activities that can be utilised to support the integrated strategies to promote scientific literacy in the museum education transaction?
- Which aspects of these strategies do learners visiting the museum adopt most readily?

5. RESEARCH DESIGN

The research design is based on the sub-questions outlined above. The approach to answering each of these sub-questions is described below.

5.1 Can the museum school teachers adopt the strategy?

In order to determine whether the museum school teachers at Bayworld could adopt the scientific literacy strategy required an intervention (professional development workshops and support) in order to introduce them to the strategy. It was indicative of the type of support that was provided (materials, ideas and activities). Once this was done the museum school teachers presented workshops to practice the approach on invited schoolchildren (Grade 6 learners). The abilities of the teachers to adopt and implement the strategies were monitored using the teacher artefacts (Appendix F) and scientific literacy classroom observation schedule (Appendix G). The teachers participated in a focus group interview (Appendix C) and completed a questionnaire (Appendix) B) after the intervention to determine how they viewed the workshops and their perceptions of the integrated strategies approach to promoting scientific literacy specifically in a museum context. Learners completed a questionnaire (Appendix H) in order to determine their perspectives of what happened during the contact session.

5.2 How does the involvement of the museum school teachers influence their view of the nature of teaching and learning to promote scientific literacy?

A pre- and post intervention strategy was implemented with the participating museum teachers who completed a personal written appraisal (Appendix A) and focus group interview (Appendix C) as to what they thought it meant to be scientifically literate: what schools can do to promote scientific literacy, and what museums can do to promote scientific

literacy prior to being introduced to the strategy. They were asked to reassess their perception of the learning strategy once the study was completed.

5.3 What type of museum activities can support this approach?

Possible activities to support the approach were brainstormed by the museum teachers and the effectiveness thereof was judged during the teaching sessions by using the scientific literacy classroom observation schedule (Appendix G), learner artefacts (Appendix F) and questionnaires (Appendices D and H) and explored during the museum teacher's focus group interview (Appendix C).

5.4 Which aspects of the strategy do the learners visiting the museum adopt most readily?

These were monitored and assessed during the teaching sessions by using the classroom observation schedule (Appendix G), what was said during the museum teachers' focus group interview (Appendix C), the participant learners' written artefacts (Appendix F) and by their questionnaires (Appendices D and H) . Specimens of the learner artefacts are appended as Appendix O.

6. RESEARCH METHODS

The research was conducted within an interpretivist paradigm and a form of triangulation was employed, namely, a mixed methods approach, where data was generated both qualitatively and quantitatively. Qualitative data was generated by the use of teachers' reflexive essays, focus group interview, teachers and learners questionnaires as well as lesson observations. Quantitative data was generated from the classroom observation schedules (Appendix G), and the teacher and learner artefacts (Appendix F).

7. DATA COLLECTION INSTRUMENTS

Data was generated using reflexive essays, questionnaires, classroom observation, written artefacts and interviews.

7.1 Reflexive Essays

The museum teachers wrote a pre- and post intervention reflexive essay on their understanding of scientific literacy and what schools and museums could do to promote scientific literacy (Appendix A).

7.2 Questionnaires

Separate semi-structured pre- and post intervention questionnaires were developed for the participating museum teachers (Appendix B) and learners (Appendix D and H).

7.3 Focus Group Interview

The museum teachers participated in a focus group interview to discuss their workshop experiences, views of the nature of teaching and learning for scientific literacy as well as their perceptions of adopting the integrated strategies approach (Appendix C).

7.4 Written artefacts

The validated Science Notebook Checklist (Appendix F) was used to assess teacher and learner artefacts (their personal science notebooks).

7.5 Classroom observation

The validated Inquiry-Based Science Observation Schedule (Appendix G) was used to assess teachers' abilities to implement the strategy and the aspects most readily adopted by the learners.

8. SAMPLE AND SETTING

8.1 Sample

The sample included five museum teachers at Bayworld in Port Elizabeth and two classes of Grade 6 learners taught by these educators during museum visits. The sample comprised 58 learners.

8.2 Setting

The research was conducted at the Port Elizabeth Museum School which is located in the museum at Bayworld, also known as the Port Elizabeth Museum. The school was established in 1942 and is registered with the Department of Education (Port Elizabeth District). The sample group of five museum teachers who participated in this study are staff members at the Port Elizabeth Museum School. Bayworld incorporates a natural history museum, oceanarium, snake park as well as a small historical house museum. The museum school has four teaching venues (classrooms) each with theme based exhibitions that include stuffed, dried, wet and live specimens. The exhibitions in the classrooms are changed quarterly to complement the education programme presentations. Learners spend time in the classrooms, galleries and around live animal exhibitions during their visits.

During the research process the museum teachers presented workshops for visiting learners in the classrooms and galleries of the museum using authentic museum specimens.

9. ETHICAL CONSIDERATIONS

Written permission was obtained from Bayworld management and the Eastern Cape Education Department to undertake this research (Appendices I and J). Informed consent was solicited from the participating teachers which included in loco parentis informed consent for

the learners who were brought to the museum. The research plan was submitted to the Nelson Mandela Metropolitan University Faculty of Education Human Ethics committee for approval.

10. OUTLINE OF THE STUDY

The research report consists of six chapters. Chapter one gives a general introduction and orientation of the study and focuses on issues of scientific literacy. In terms of background, the chapter touches on the status of science and literacy achievement in the South African context and the nature of education in museums. This chapter also states the research problem, why the study is conducted and briefly explains the methodology adopted in the study. Finally, there is a reference to ethical issues involved in the study in terms of permission and informed consent.

Chapter two provides a literature review and theoretical framework for this study focusing on issues of developing scientific literacy, the role that museums play and can play in developing scientific literacy, the expectations of the South African curriculum statements, and issues of teacher development.

Chapter three explains the methodology followed when collecting data, the rationale of the teacher perspective essay on scientific literacy, design of the interview protocols, using and evaluating learner science notebooks, as well as issues of the validity and reliability of the research process and procedures. This chapter is linked to the research questions and the literature review, so that the data collected can be used later in the discussion and recommendations of the study.

Chapter four focuses on the results obtained from the methodology used in chapter three and the methods of data analysis used. Chapter five presents a discussion of the results

obtained from the findings of the study in the light of the literature review in chapter two, while chapter six presents the conclusions drawn from the study, their implications, and the recommendations that flow from these findings, as well as recommendations for further research

CHAPTER TWO

LITERATURE REVIEW

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1. INTRODUCTION

This chapter focuses on the history, roles and functions of museums, education in museums, formal and informal science learning, challenges to museums, and the importance of being scientifically literate. Issues that link science, literacy, museums and science education are considered. The development of an 'integrated learning strategies approach' at the Nelson Mandela Metropolitan University (NMMU), which incorporates reading, discussion, the use of science notebooks and argumentation techniques in order to promote scientific literacy in schools, is described. Issues around stimuli towards framing investigable questions, the notion of authentic classroom discussion, designing an investigation, doing an authentic investigation using the 'science notebooks' approach, argumentation, extending the 'line of learning, and presenting findings, are also discussed. Finally, the purpose of this study is stated.

2. MUSEUMS

Various definitions of museums have been proffered in the past. A definition formulated by the International Committee of Museums (ICOM) in 1946 reads as follows:

> "Museums include all collections open to the public, of artistic, technical, scientific, historical or archaeological material, including zoos and botanical gardens, but excluding libraries, except in so far as they maintain permanent exhibition rooms"

International Committee of Museums, 1946, Article II, Section 2, para. 1

Over time, as museums developed and redefined their role and purpose, the definition was amended to include more specific functions. For example, in 1961 ICOM amended their definition to include the following:

> "ICOM shall recognize as a museum any permanent institution which conserves and displays for purposes of study, education and enjoyment, collections of objects of cultural or scientific significance"

International Committee of Museums, 1961, Articles 3 & 4

Hein (2005) suggests that there has been a paradigm shift from exclusivity to inclusivity in terms of the way in which museums function. Evidence of such a shift is reflected in the more recent definition adopted by ICOM at their 22nd General Assembly in Vienna, Austria on 27 August 2007, which states that:

> "A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment".

This broader definition more clearly outlines the museum's functions and its responsibility to the community it serves. The ICOM definition is inclusive of the following as museums; aquaria, botanical gardens, science centres, zoological gardens, nature reserves, cultural centres and zoos.

The South African Museums Association (SAMA) defines museums as:

> "…dynamic and accountable public institutions which both shape and manifest the consciousness, identities and understanding of communities and individuals in relation to their natural, historical and cultural environments, through collection, documentation, conservation, research and education programmes that are responsive to the needs of society"
>
> South African Museum Association (2001, p. 1)

As such, it is evident that museums are not only institutions that acquire, maintain and preserve artefacts and collections in trust for society, but that they are expected to facilitate the exploration of these artefacts and collections for stimulation, learning and entertainment. In other words, they are expected to afford public access to these artefacts and collections through effective exhibitions, displays, research, education and entertainment programmes.

2.1 Museums and social contexts

Hein (2005) makes the point that, although museums have been in existence for centuries, they were in former times usually reserved for the educated elite and tended to exclude the general public. Notwithstanding such elitism, museum culture has spread to nearly every part of the world and Arinze (1999, p.1) states that "no matter how small the country is it would be very unlikely that it did not have a museum". The implication of this statement is that the notion of museums is global.

Hooper-Greenhill (1992) describes museums which have been in existence for the last 600 years, but notes that they have been transformed over time, largely due to the political, social and economic context that defines them. She points out that, although it is often assumed that they have always looked as they do today, displays restricted to glass cases which were previously the norm are the exception rather than the rule in modern

museums. Changing contexts challenge museums to evaluate what they display, how they display, how they engage the public and how they see their future potential. Hooper-Greenhill (1992) asserts that as museums confronted their value and respond within a particular context, new museums have been established in a variety of settings including factories, churches, private and public enterprises.

The first museum in South Africa was established in 1825 - the South African Museum in Cape Town (Brain & Erasmus, 1986). In 1855 this museum was re-established by Government Proclamation as an officially operational scientific institution. It was later renamed the Iziko Museum and is recognized as the oldest museum in the country. Later in the same year, the Albany Museum in Grahamstown was established. In 1856 the Port Elizabeth Museum (renamed Bayworld in 1999) was founded as the third oldest museum in the country. In 1884 King Williams Town was the third city in the Eastern Cape to establish a museum (Brain & Erasmus, 1986).

While it was possible for museums to justify their existence in the past as the protectors and displayers of social and scientific collections (Anderson, 1997), the dawn of South Africa's democracy in 1994 has exposed local museums to a time of challenge, change and transformation (Gore, 2005). A past Minister of Education, Prof Kadar Asmal, stated that museums and the heritage sector in South Africa have been associated with division in the past (Asmal, 2002). This division referred to is encapsulated by Gore as:

> "…from the 1950s, museums had begun to incorporate the history of settlement from Europe on a large scale, often displaying the triumph and superiority of white culture over black, and serving to give greater legitimacy to the prevailing system of apartheid".

Gore, (2005, p. 75)

More recently museums have attempted to transform both their exhibitions and collections to mirror the diverse and eclectic communities represented in the country. Asmal (2002) has also urged the museum sector to consider collaborating with other institutions, such as education and local communities, as museums are able to make a valuable contribution in shaping "public opinions and identities" (para. 11)[2] and to contribute together towards high quality education by using "our cultural and scientific heritage" (para. 5)[3]. However, while SAMA has a stated objective to promote cooperation among museums, government and the private sector, library and internet searches reveal that there is a paucity of literature on co-operation between museums, government and the private sector in South Africa.

2.2 Role and functions of museums

Lelliott (2009) refers to Falk and Dierking who note that there has been considerable international research done on the role of museums over the past 20 years. As noted earlier, museums used to focus predominantly on artefacts which limited their function to the technical work of collection and preservation. Consequently, they were viewed as places that simply housed, collected and preserved a variety of exhibits - dusty storerooms filled with mould-covered treasures (Ramsey, 1938). However, in the 20th century the role of museums has evolved from collectors, preservers and exhibitors of artefacts to that of valuable disseminators of knowledge, and Anderson (1997) believes that museum collections have been turned to good purpose through education.

All over the world museums relate stories of how the world and humanity has survived, and exhibit what both people and nature have created. In this way they embody the "cultural soul of the nation" and represent the "cultural conscience of the nation" (Arinze,

[2] No page numbers – online speech
[3] No page numbers – online speech

1999, p. 1). Over the years museums have been consistently challenged to move from being hallowed halls that showcase valuable objects, to progress with a view to engaging the public by adopting a greater social function. All museums, of natural history, science, fine art and history museums, promote learning, and each context has the potential to provide opportunities for different kinds of learning (Donald, 1991). As such they play an essential role in shaping public identity and opinions and strive to educate, denote and represent a society's responsibilities.

Transformation has been gradual and has happened in distinct stages. Donald (1991) outlines these changes in art and natural history museums. Fine art museums are highlighted as an example of where the changes are most evident. Originally fine art museums were quiet places which only art experts visited, but they have now incorporated guided tours where visitors view art works with a view to appreciating their aesthetic and historical value. Today visitors can participate in art workshops, create art and learn artistic techniques as well as the history of art. Donald (1991) further suggests that natural history museums have evolved from places where display cases were filled with stuffed animals, glass jars containing specimens and rare artefacts, to spaces where visitors can participate in a variety of activities on offer in the quest towards social engagement. Rennie & McClafferty (1995) also believe that the technological advancement of museums has led to the inclusion and increase in the number of interactive displays which have attracted growing numbers of visitors, particularly school groups. Increasingly, museums are realizing that by paying attention to their role as providers of informal learning, they are better able to evaluate the efficacy of exhibitions and simultaneously monitor responses as a means to increasing the learning potential and satisfaction of visitors.

2.3. Education in museums

All museums, of natural history, science, fine art or history, promote learning, and each context has the potential to provide opportunities for different kinds of learning (Donald, 1991). Museums often provide opportunities for learning experiences that are not available in the classroom (DeWitt & Hohenstein, 2010a), and education and learning has become a primary and explicit objective in many (Arinze, 1999; Tishman, 2005). Tishman, McKinney & Straughn (2007, p. 2,) emphasize that learning is not inactively acquiring knowledge but is "a dynamic process of meaning-making": a learning process of active engagement in a variety of contexts. DeWitt and Hohenstein (2010a, p. 454) refer to research based on the work of Vygotsky that suggests that learning is a "social process" whereby knowledge is acquired by communicating with others.

While there are international sources on museum education in South Africa, library and internet searches in terms of museum education, teaching and learning science in local museums, promotion of scientific literacy in museums and the role of the South African National Curriculum in museums, yielded a paucity of data. Similarly, email contact with four natural history museums (Iziko Museum – Cape Town, National Museum – Bloemfontein, Albany Museum – Grahamstown and Natal Museum – Pietermaritzburg), one government organization (South African Agency for Science and Technology Advancement – SAASTA) and two zoos (Johanneburg Zoo and the National Zoological Gardens in Pretoria) yielded little information on these topics. The searches produced only one contact at a local university who recently published on science school visits in Gauteng, South Africa (Lelliott, 2009) and no other fruitful information, in-house publications, conference presentations or addresses on related topics.

2.4. Formal and informal science learning

Hofstein and Rosenfeld (1996) refer to Wellington who draws a distinction between formal and informal learning. Informal learning is outlined as learner led out-of-school activities as opposed to teacher led curriculum based activities within a classroom context. Ramey-Gassert (1997, p, 434) cites Resnick who elaborates on the differences between learning inside and outside of the school context as follows:

> "…in-school learning tends to be solitary, based on symbols and the abstract, and divorced from real-world experiences" whereas, in contrast, out-of-school learning "…involves the accomplishment of an intellectual or physical task by a group that is interacting using real elements, which allows learning to take on greater meaning".

Hofstein & Rosenfeld (1996), as well as Ramey-Gassert (1997), caution that the distinction between formal and informal learning is not as simplistic and clear cut as is often stated in literature. The question is whether or not formal learning can take place in informal settings and vice-versa. However, their definition suggests that informal learning experiences can take place in formal learning settings such as schools as well as informal learning settings such as museums. Learning in museums is referred to by Screven (2002, para. 1)4 as an opportunity to complement the formal education process that is motivated by "curiosity, discovery, and free exploration". Arinze (1999) suggests that museums have the advantage of possessing resources and information that can and should be used to enhance the school curriculum in various learning areas. Anderson (1997) suggests that as museums are resource rich environments they are ideally positioned to support both formal and informal learning.

Learning in a museum context may have a profound influence on the knowledge and understanding of learners as well as their beliefs, attitudes and motivation to learn. A major difference between learning in a classroom and learning in a museum is that the latter is a

[4] No page numbers – online article

stimulating environment that provides real encounters (Hofstein & Rosenfeld 1996; DeWitt & Osborne, 2007). Additionally, Chase (2002, p. 5) reasserts the fact that informal learning environments such as museums, science centres and zoos are unique because they "bring real things to people who might not have the chance to see those objects, organisms and ecosystems in their natural settings". These encounters provide opportunity for learners to manipulate authentic artefacts from collections and displays. Bell, van Zyl and Holleman (1989) acknowledge this unique learning experience provided by museums as having great potential in both formal and informal education. Learners can also engage with museum staff or specialists (DeWitt & Hohenstein, 2010a), most of whom are not available or readily accessible in the school setting. However Ramey-Gassert (1997) and DeWitt & Osborne, (2007) note that teachers rarely use museums as learning environments and postulate that this may be because they are not familiar with museums as educational resources, or are uncertain as to how to integrate museum resources with curriculum materials.

A survey of museum educators conducted by Wetterlund & Sayre (2003) provided evidence of the diverse nature of the duties performed by museum educators. Forty five key duties were identified. Some of the emergent factors from the survey include:

- Developing educational resources
- Participation in designing exhibitions
- Providing ongoing professional development for teachers
- Designing and presenting education programmes
- Involvement in education outreach programmes presented off-site

Needless to say, the duties are diverse, suggesting that museums should decide what type of education it wants to offer, as well as the value of this type of education.

Galla (2007) suggests that museums need to simultaneously remain dynamic and accountable public institutions that display and communicate an understanding of the historical, cultural and natural environments: producing knowledge and formulating strategies to connect communities to museums and their collections through conservation, research and education programmes. Fleming asserts that museums are:

> "…solely about learning" therefore the education function should be supported by all other functions including marketing, strategic planning, exhibitions, design, fundraising, collection, research and publications. Consequently, the education function should inform and shape all other museum functions, programmes and activities. By promoting learning, museums become agents of social change and engender 'social regeneration' because they influence the lives of people"
>
> (Fleming: 2005, p. 6)

Informal science learning in museums differs from formal science learning in that usually no learner assessment is required (Friedman, 1995). Museums do not approximate or constitute a school (Ramey-Gassert, 1997), but many have former school teachers in their education departments developing teaching resources which complement the school curriculum. DeWitt & Osborne (2007) believe that teachers do recognize the educational and motivational value of museum visits, and Gardner (1991) suggests that schools will do well to promote dynamism in their teaching activities by undertaking museum visits. However, Kisiel, Anderson and Zhang (cited in DeWitt & Osborne, 2007) stress the importance of linking the visit to the school curriculum if effective teaching and learning is to take place. In the South African context, Lelliott (2009) contends that there has been an increase in interest in the educational role of informal learning, which is evidenced by the establishment of more informal learning sites, including museums.

2.5 The challenge to museums

Storksdieck; Hannon and Randolph, referred to in DeWitt and Osborne (2007), highlight lack of finance, time and adequate synergy between the school curriculum and museum programmes as key challenges faced by museums. Further to this, Lemelin and Bencze (2004) argue that museum educators do not always have the time, expertise or resources to engage in research that focuses on the application of new learning theories. A particular challenge for South African museums is for them to respond to the changing needs of a developing and evolving education system (Department of Education, 2002). Museums occupy a favourable position to cultivate educational models in response to the unique needs of South Africa, and since they usually strive to deliver education programmes that complement what happens in schools, they are ideally placed to promote initiatives such as the integrated learning strategies approach to promoting scientific literacy (Webb, 2009), which underpins this study.

3. SCIENTIFIC LITERACY AND MUSEUMS

During the past two decades the education sector has had science literacy as its clarion call for the transformation of science education but this term has numerous interpretations (Webb, 2010; Pearson, Moje & Greenleaf, 2010). The new natural science curriculum in South Africa promotes scientific literacy and has three main learning outcomes namely, science investigations, developing science knowledge and science, society and the environment. An expectation of the last outcome is that learners are able "to demonstrate an understanding of the interrelationship between science, technology, society and the environment" (Department of Education, 2002, p.23), an area which fairly easily allows for the development of synergy between the school curriculum and museum programmes.

Science learning in museums is an area that has not been researched to any great degree in South Africa (Lelliott, 2009), but as museums in this country are in a transformation phase due to the agenda determined by a changing political landscape, the integration and promotion of scientific literacy through education programmes could possibly be one means of assisting the transformation of museums. This possibility provided the stimulus to explore a pedagogical framework for promoting scientific literacy that could enhance the transformation of educative approaches and help demystify both museums and science.

4. IMPORTANCE OF SCIENTIFIC LITERACY

Over the past five decades consensus has been reached within the science education community that there is a need to focus on science literacy (Fensham, 2008). The framework within which this consensus initially developed emphasized scientific knowledge and applications, but more recently the need to focus more on the literacy aspects of science literacy has emerged (Norris & Phillips, 2003; Yore & Treagust, 2006). Concomitantly, the question that emerges is how the cognitive tools and communication abilities can be unlocked and developed to ensure the promotion of scientific literacy. The existent perception that a scientific formula, as represented by mathematical symbols, is the language of science is problematic. Whilst people may possess scientific knowledge, competency can only be manifested in the ability to read, write and explain in the science metaphor (Pearson et al., 2010). There is therefore a need to accentuate the role of language in the subject (Yore, Bisanz & Hand, 2003).

Moje, Duke, Lee, Spratley and Shoenbach (in Pearson, et al. 2010) purport that learners will leave schools disadvantaged and not able to use literacy tools for learning and reasoning if careful consideration is not given to their reading and writing in science. Pearson

et al. (2010) claims that through an emphasis on reading and writing in science learners are engaged by interpreting data, drawing conclusions, formulating arguments supported by evidence characteristics required to be good readers and writers. He emphasises that these skills are not only acquired through the emphasis on reading and writing but is improved and honed through the learner's engagement in science investigations.

Norris and Phillips (2003, p. 225) make the distinction between the "fundamental" and the "derived" sense of scientific literacy. Webb (2010) outlines the fundamental sense as something that requires learners to be competent in science language and thinking. The derived sense of science is understood as being able to make informed decisions on matters scientific and public. Krajcik and Sutherland (2010, p. 459) refer to scientific literacy as the ability to participate effectively in "decision-making as consumers, members of the electorate, and members of society". Further to these distinctions, Norris and Phillips (2003) provide a cogent argument for being able to read and write science as central to what it means to be scientifically literate. Yore (2000) also claims that the ability to read, write and talk science is characteristic of a scientifically literate person.

Fensham (2008) highlights that science literacy is for everyone and the school of thought that makes science literacy a key component to public education, while Yore and Treagust (2006) emphasise that there is a need for cognitive tools and communication abilities to be able to maintain and further develop children's' scientific literacy after they leave school.

5. SCIENCE AND LANGUAGE

South Africa has a multilingual context with 11 official languages. The national curriculum demands that "learners reach high levels of proficiency in at least two languages", of which one must be the home language (Department of Education, 2002, p. 20). The curriculum

further recommends that whenever possible the home language should ideally be used for learning and teaching, particularly in the Foundation Phase, namely Reception Grade to Grade Three. Webb (2010) points out that while this is the policy, South African parents and teachers prefer English as the medium of instruction because it is viewed as the international language as well as the language of commerce and social mobility. The consequence of this preference is that the home language is usually replaced by a second language as a medium of instruction, which often results in the teacher doing all the talking with very little comprehension by the learners (Setati, Adler, Reed & Bapoo, 2002).

The South African science curriculum promotes scientific literacy via the development and use of science process skills in a variety of settings, development and application of scientific knowledge and understanding, and appreciation of the relationships between science, society and the environment (Department of Education, 2002). Colvill and Pattie (2002) state that the challenge for science teachers is to adapt the way they teach if their learners are to acquire these skills. There is a need to seek equilibrium between good citizens and lifelong learning, based on the tenets of science. Yore and Treagust (2006) suggest that as scientists mostly use the spoken and written word as opposed to purely mathematical symbols in order to construct, describe and denote scientific claims, this presupposes linguistic proficiency in the language of science for understanding the mechanics of the interaction and interdependence between science and the environment.

Pearson et al. (2010) suggests that one way to develop linguistic proficiency in the language of science is to engage in an integrated science/literacy teaching method. They argue that integrated science/literacy teaching depends on a balance between the use of good science texts and investigations that are theory and praxis (practice). They note that learners are often passive and rely on the teachers for their science knowledge when they are not engaged in science learning (Pearson et al, 2010). Integration of science investigations and

literacy practices provide an opportunity to promote teaching strategies that develop learners' basic literacy skills and stimulate their interest in the world around them (Krajcik & Sutherland, 2010).

As noted earlier, South African research into the use of science notebooks (Villanueva & Webb, 2008), discussion (Webb, 2007) and argumentation (Webb, Williams & Meiring, 2008) has resulted in the development of a local integrated teaching strategy to promote scientific literacy (Webb, 2010). The integrated teaching strategy aims to integrate "reading to learn science and learning to read for science, exploratory talk toward investigable questions, planning and doing an investigation, and scaffolding writing to learn science, argumentation, and critical thinking" (Webb, 2010, p. 449).

6. MUSEUMS AND LEARNING SCIENCE

Braund & Reiss (2006, p. 1373-1374) describes learning science at school as "boring, irrelevant, and outdated; designed only to educate a minority of future scientists" as opposed to learning science in a museum that is "exciting, challenging and uplifting". Xanthoudaki, (1998) believes that museums have the potential to provide a synergistic relationship between their educational activities and the school curriculum when they respond to the requirements and concerns of teachers. The School-Museum Integrated Learning Experiences in Science (SMILES) model was developed by Jeanette Griffin to facilitate integration between school and museum learning (DeWitt & Osborne, 2007). The guiding principles of the SMILES model is to improve learning experiences in museums through self directed learning in addition to teaching and learning strategies relevant to the informal setting.

Museums are places of learning where children can develop their understanding of science and can play an important role in supporting teachers to develop their teaching strategies (DeWitt & Osborne, 2007). Given adequate support, teachers could potentially

engage more meaningfully with their learners and in turn encourage them to work together more productively (DeWitt & Osborne 2007). However, persuading teachers to use museums as science teaching resources and developing their teaching strategies is a challenge as Cox-Petersen & Pfaffinger, as well as Griffin and Symington (cited in DeWitt & Osborne, 2007), point out that despite teachers' awareness of the unique education experiences provided by museums, learning in such contexts is often not exploited. Nevertheless, Haden (2010) asserts that there is immense potential to improve the scientific literacy of the large numbers of children who visit museums.

Although Friedman (1995, p. 6) notes that museum science learning experiences are usually entertaining, exciting and hands-on, Webb (2010) suggests that hands-on activities, although necessary, are not adequate to promote scientific literacy. What are needed are "minds-on" activities including planning, reading, writing, discussion and argumentation (Webb, 2010, p. 448). Such activities form part of the integrated learning strategies approach to promote scientific literacy that was used in this study.

7. UPTAKE OF TEACHER CONTINUOUS PROFESSIONAL DEVELOPMENT

The problem of poor uptake and implementation of continuous professional development programmes (CPD) by teachers is recognised both nationally and internationally (for example Steadman, Eraut, Fielding & Horton, 1995; Taylor & Vinjevold, 1999; Adler & Reed, 2002). What one considers what teachers say about the impact of INSET experience on their classroom repertoire compared to what they do; it is apparent that certain outcomes are more likely to achieve concrete developments in the classroom than others. This finding prompted Harland and Kinder (1997) to develop a tentative sequence or hierarchy of outcomes (Figure 2.1).

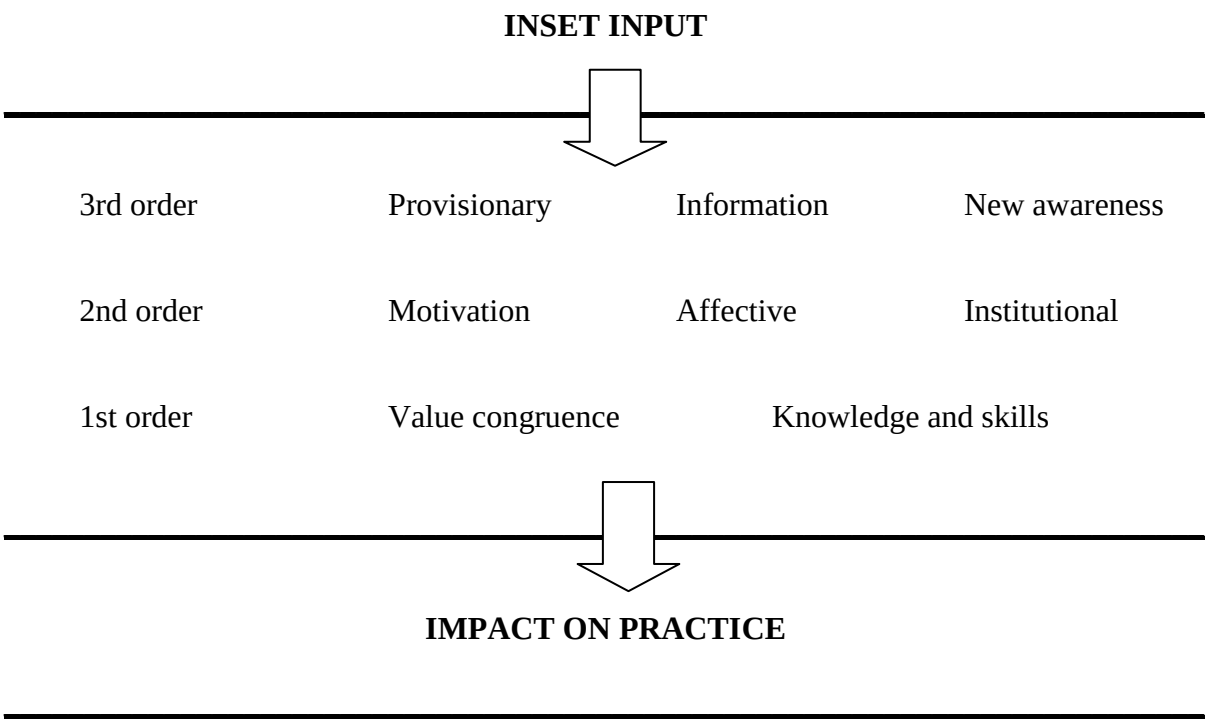

Figure 2.1: An ordering of INSET outcomes (Harland & Kinder 1997)

Material and provisionary (third order) outcomes, i.e. the physical resources which result from participation in INSET activities (worksheets, equipment, handbooks, etc.) can have a positive and substantial influence on teachers' classroom practice (Fullan & Stiegelbauer, 1991). However, provisionary outcomes can be achieved without resulting in better classroom practice (Harland & Kinder, 1997). Informational outcomes are defined as the state of being briefed or aware of background facts and news about curriculum and management developments, including their implication for practice. While new awareness is a perceptual or conceptual shift from previous assumptions of what constitutes the appropriate content and delivery of a particular curriculum area. For example, in primary science this may be a shift from teachers believing that science is about 'chemical equations and test-tubes' to feeling that it is about 'children investigating', as in the case of this

scientific literacy intervention. However, research corroborates teachers' own assertions that changed awareness is no guarantee of changed practice (Harland & Kinder, 1997).

Affective outcomes are the emotional experience in any learning situation. Motivational and attitudinal outcomes refer to enhanced enthusiasm and motivation to implement the ideas received during INSET experiences, e.g. a teacher may feel inspired by what they see and attempt to emulate it. The benefits of institutional outcomes such as consensus, shared meanings, collaboration and mutual support when attempting curriculum innovation in the classroom, are also fairly well established in the research literature (Harland & Kinder, 1997).

Knowledge and skills outcomes are the development of deeper levels of understanding, critical reflexivity and theoretical rationales, with regard to both curriculum content and pedagogy (e.g. the management of investigations). The outcome of value congruence refer to the personalised versions of curriculum and classroom management, which informs a practitioner's teaching, and how far these 'individuated codes of practice' come to coincide with the INSET providers messages about 'best practice'. Value congruence is a crucial factor in influencing the extent of subsequent classroom implementation (Harland &Kinder, 1997). The notion of value congruence approximates Fullan's (1993) key effects of the change process, i.e. the alteration of beliefs, pedagogical approaches and theories underlying particular new policies or paradigms.

Harland and Kinder's (1997) research suggests no regular pattern of linear progression through the nine outcomes and the most evidence would allow was a ranking of the INSET effects into the hierarchy shown in figure 2.1. In this research study attention was given to providing for as many of the outcomes as was possible and appropriate, and cognisance was taken of the difficulties of CPD uptake amongst teachers, as noted above.

8. INTEGRATED LEARNING STRATEGIES APPROACH

The scientific literacy strategy used in this study focused on the role of reading, writing, talking and doing science to promote scientific literacy. Lind (2001) suggests that scientists know the best way to learn science is to do science. This way of learning can best be accomplished with children by examining natural phenomena over time. Children learn and discover through asking and answering questions, doing investigations, and by applying problem-solving skills.

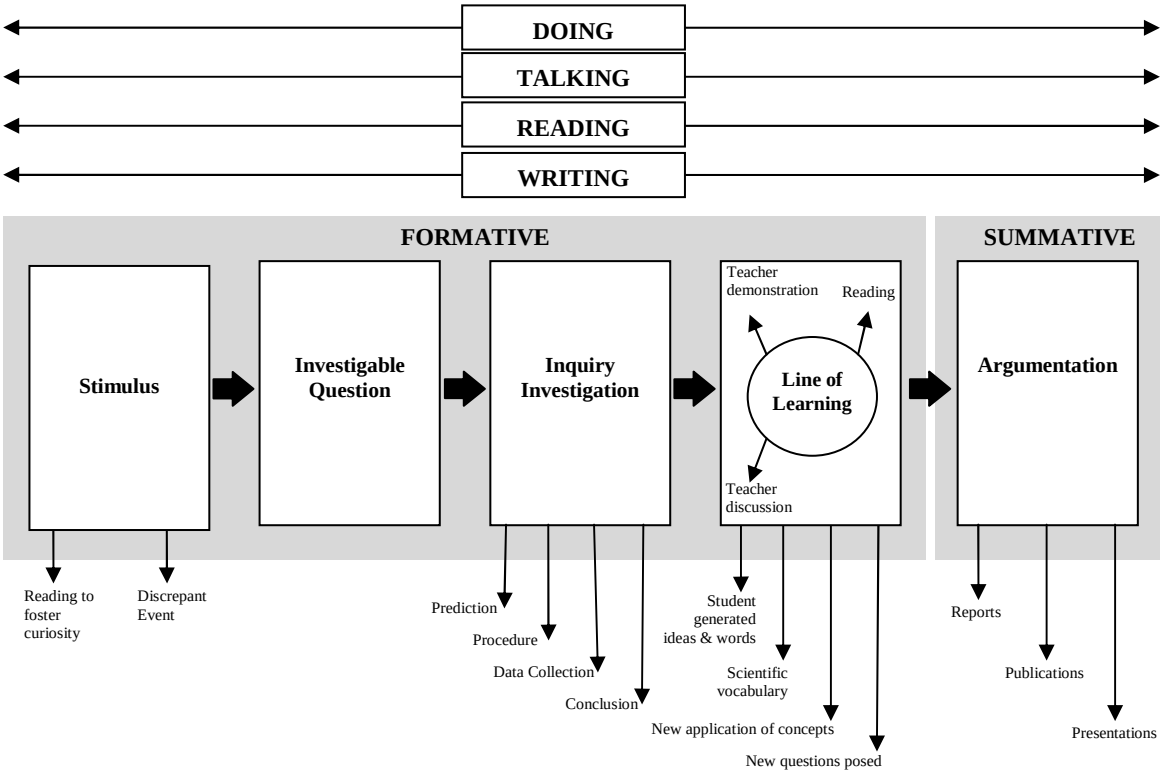

Figure 2.2: An integrated strategy for promoting teaching and learning towards scientific literacy (Webb, 2009)

In this study an approach was used that emulates what scientist do, namely read, talk, formulate a question, plan and do investigations, argue and present their findings, as depicted in Figure 2.1 (Webb, 2009).

8.1 Stimuli towards discussion

According to Xanthoudaki, Tirelli, Cerutti & Calcagnini (2007) discovery and learning commences when something happens that prompts observation, discussion, description, explanation and investigation. The aforementioned activities are set in motion by an object, phenomenon, discrepant event or questions (Millar, 1994; Lind, 2001).

Part of the first investigation in this study was the presentation to participant learners a slide depicting a bug walking on water (which to many is a 'discrepant event'). It was used at the first workshop to stimulate discussion around surface tension. A story with the title "Fish have ears?" was used at the second workshop to stimulate discussion around fish otoliths (fish ear bones). After reading the story at the start of the second workshop the learners were introduced to one of the resident marine biologists of Bayworld (Port Elizabeth Museum) and spent time questioning and discussing his work, research, interests and qualifications. The premise for doing this was that meeting a practising scientist and hearing what he did would highlight the reading, talking, doing and writing aspects of science. The stimulation for discussion for the third workshop was a presentation on the research done in the museum in terms of bottlenose dolphins. This species can often be seen in Algoa Bay (on which Port Elizabeth is situated), and a number of adult and juvenile dolphins, which are considered by many as the premium attraction for the institution, have been resident in the Bayworld Oceanarium for 48 years. The distinct purpose of these activities was to stimulate interest and challenge perceptions in order for the learners want to generate investigable and researchable questions (Webb, 2007).

8.2 Authentic discussion

Webb (2009, 2010) claims that 'discrepant events' and reading to learn science can play an important role in promoting exploratory talk which facilitates the planning and

execution of an investigation. The stimulation that is provided should have the potential to encourage and guide the learners to discuss, share and find out together; build on their prior skills, knowledge and experiences, and extend their scientific knowledge base (Hein, 1991). DeWitt and Hohenstein (2010b, p. 43) refer to suggestions that learning is a "social process" whereby knowledge is acquired by communicating with others. Yore and Treagust (2006) suggest that discussion makes learners more purposeful, engaged, detailed and directed, which results in higher retention of what they have discovered and learned. In order to do this teachers should be competent and comfortable enough to promote authentic discussion, i.e. discussion that has a clear purpose and enables progress towards a defined goal, which has been shown to improve the problem solving abilities of learners (Yore & Treagust, 2006).

As noted earlier, for the purposes of this study the museum school teachers and learners were provided with authentic museum specimens of otoliths and dolphin skull collections. These were specimens that they would normally only have seen displayed in glass cases, slides and pictures. Information relevant to the individual specimens was provided on the packaging or specimen container. The intention was to use the specimens to direct their discussions, make it more purposeful, and provide opportunities for the generation of investigable questions.

8.3 Planning an investigation

According to the national curriculum (Department of Education, 2002) investigations provide the opportunity for learners to practice their reading, writing, discussion, argumentation and presentation skills. Learners should be afforded opportunities to formulate and ask questions, test hypotheses, and depict data graphically. Further to this they should engage in data analysis, work in teams, solve problems, communicate findings and draw conclusions both orally and in writing. The focus of genuine investigations is on

developing cognitive abilities such as reasoning with data, constructing arguments and making coherent explanations (Orad, de Groot & Bavli, 2007). As noted earlier, hands on activities should be minds on, engage the learners, and provide them with something to think about and do within a challenging context (Hein, 1991). Webb (2007) claims that both cognitive and procedural aspects play essential complementary roles in investigations because the validity of the findings depends on the understanding about the science being investigated (cognitive) and the processes used (procedure).

In this study the museum school teachers and participating learners respectively were required to engage cognitively. The purpose was the acquisition of information with a view to solving a problem successfully and procedurally, i.e. they had to do what scientists do in order to learn how to carry out an authentic investigation (Webb, 2007). Discussions about the procedures to follow in conducting an investigation were discussed step by step and implemented at all three workshops. Manipulation of the collection specimens, observations and discussions raised questions which each group recorded. The questions that were raised were separated by the participants into researchable and investigable questions. Each group selected one investigable question that they focused on then formulated a prediction, planned and conducted their investigation. This entailed a step by step recording of what they planned to do such as listing the equipment needed to do the investigation, identifying what they would record, how they might represent their data, extend their line of learning and present their findings to their peers. These ideas were outlined on a poster that was permanently displayed in the workshop venue to remind participants of the procedures to be followed.

8.4 Doing an investigation – the 'science notebook' approach

Learning Outcome one, scientific investigations, of the South African national curriculum (Department of Education, 2002) requires learners to investigate and solve

problems using science process skills. For Paris, Yambor & Wai-Ling Packard (1998) investigations stimulate the natural curiosity of learners by exposing them to a learner centred learning environments. They assert that the manipulation and use of scientific artefacts encourages discovery and exploration. Furthermore learning is guided by the learner's interest and knowledge setting the pace for their learning.

Norris and Phillips (2003) note that talking and doing science are not sufficient activities to enhance science learning, but should be supported by writing. Similarly, Yore and Treagust (2006, p. 308) believe that different types of recorded representations enhance theoretical understanding, develop communication and can make difficult concepts easier to understand. The 'science notebook approach' is a formalized 'writing-to-learn science' approach that models the way scientists do science that encourages learners to document activities (Nesbit, Hargrove, Harrelson, & Maxey, 2003). As such, this approach was adopted in this study. Science notebooks are primarily used to learn science, but are also used develop writing skills (Nesbit, et al., 2003). The science notebook process provides an opportunity to write down the question being investigated, make predictions, record the findings of the investigation, and provide explanations of these findings. Each step that was planned, what was done and what was found out is recorded in the science notebook. Students are encouraged to make drawings, mind maps and notes as they conducted an investigation. The prescribed six headings of such a notebook include date, time, questions, prediction, procedure (including the collection of data), conclusion and line of learning.

The procedure and collection of data steps require the meticulous recording of the investigation in order to teach the learners to be accurate, detailed and clear. The data collected can be depicted by the use of diagrams, charts, labelled drawings or written descriptions. A conclusion, i.e. what was found out in the investigation, is recorded. The line

of learning is then drawn because from this point nothing more can be gained from the particular investigation that has been carried out. Beyond this 'line of learning' the experimental findings can be supplemented by further research using books, the internet, interviewing experts, etc.

8.5 Extending the line of learning

Once the line of learning has been delineated learners have the opportunity to consider the additional questions raised during the investigation as well as the researchable questions formulated at the beginning of the investigation. As noted above, the line of learning is then extended by using other sources of information, such as further reading, experts, teacher and peer information and the internet. In this way many of the researchable questions that have been identified can be answered and incorporated into the learners' presentation of their findings (and provide warrants and backings for their arguments) and the assimilation of new information. Incidentally, their vocabulary of science is acquired by way of recording their learning in their science notebooks.

During this study learners had the opportunity to access additional information online from the worldwide web. Notwithstanding, the support of the museum teachers was important to ensure that they were able to understand and process the information. They discussed their findings as a group before they were recorded in writing.

8.6 Argumentation

According to Shakespeare (2003), using argumentation in the context of school science investigations motivates learners through the cognitive conflict that arises between their own views and the views of others. This happens when learners come to the classroom with preconceived ideas and concepts. Lawson (2003) describes the shock that occurs when

learners experience the dissonance between their ideas and those of others; causing alarm that is triggered by the need to validate their ideas and arguments. Argumentation is the process whereby learners make claims about certain findings (results) and provide evidence to justify their claims (Osborne, Erduran, Simon & Monk, 2001). Shakespeare (2003) notes that argumentation should not be viewed in a negative light, but as a valued and necessary social interaction with peers to substantiate and share beliefs. Webb (2007) emphasizes that this is not a new theory but is based on the work of Toulmin (1958) who sowed the seed for the development of this theory of argumentation as we know it today.

The Toulmin model incorporates the following components: data (facts to support their claims), claims (provisional explanations whose merits are to be confirmed), warrants (reasons, rules or principles used to defend, justify or validate the connections between the data and the claim) and backings (assumption, ideas, notions, hypothesis statements given to justify the warrants). Osborne, et al. (2001) later simplified Toulmin's version to be more suited to the promotion of scientific understanding and conceptual change within an educational context and only included data, claims and warrants.

Shakespeare (2003) emphasises the role of the teacher as being essential in ensuring that learners come to logical conclusions during argumentation. Webb, Williams & Meiring (2008) further highlight that the teacher should make sure that learners never leave the classroom with the wrong idea and that the views of others should not just be accepted but always be supported by scientific evidence which is accepted as largely objective. They point out that the challenge for teachers is to educate learners and ensure that a satisfactory resolution is reached. Although teachers may have many solutions to a problem or answers to a question, the most credible and acceptable answer should always be sought. The primary

objective of argumentation is for the learners to convince others of the accuracy and validity of a particular claim.

According to Osborne et al. (2001) argumentation writing frames are tools that enable learners to make their perceptions of connections in the investigation clear. On these argumentation frames learners plan and organize their discussions as well as how they would convince their peers that their ideas are correct. The five headings on the argumentation writing frame include the following:

- My idea is (hypothesis) is…
- My reasons are…
- Arguments against my idea may be …
- I would convince or persuade someone with … and
- The evidence I would use to convince them is …

Shakespeare (2003) points out that when learners use this frame it assists them in preparing arguments and assist increased understanding about what they have learned. Additionally they will ask questions whereby they discover that there are several views but not many answers and that not all arguments are equally credible (Shakespeare, 2003). In this study the argumentation writing frame was not used due to time constraints and the emphasis was placed upon the investigation and the use of science notebooks. Argumentation has been expounded to outline the significance thereof within the integrated strategies approach. However because of time constrains, the museum teachers and learner workshops did not focus on this aspect of the strategy during this study.

8.7 Presentation

Once scientists have gathered data they make claims, warrants, backings and present their findings to peers (Webb, 2007). DeWitt & Hohenstein (2010a) refer to Chi, de Leeuw, Chiu, and La Vancher, as well as Pine and Messer, who claim that opportunities to explain ones thoughts and understandings to others are linked to greater learning. Making evidence available orally or in writing for others to peruse and interrogate is important and serves to allow children to present the explanation, answer or solution to the problem. The role of the teacher is to educate the learners to understand that the data they collect, the way they present and argue their findings, are important in constructing meaningful understandings.

In this study, once the investigations were completed and the learners drew their line of learning, the groups discussed their investigations using their science notebooks to formulate a presentation for the class. Osborne et al. (2001) claim that the opportunity to verbalize or represent what they are thinking, enables the learners to defend their beliefs to others and perhaps change their own thinking. Furthermore they stress that teaching students' acceptable ways of arguing is essential whilst simultaneously acknowledging that it is by no means an easy process. A simplified model (i.e., without the argumentation stage) was used in this study to provide learners with the opportunity to make connections between their investigable question, what they did, and what they found out by preparing a presentation for the class. Each group nominated a representative to present their findings and learners from the other groups were encouraged by the teacher to ask the presenting group questions relevant to the investigation.

9. PURPOSE OF THIS STUDY

This study investigated whether the museum teachers could be trained to implement a simplified integrated learning strategy successfully in the museum context and to determine

which aspects of the strategy were most readily adopted by visiting learners. The rationale for doing this was because, although museums are synonymous with education, study and enjoyment, the challenge is to adapt their roles and functions to respond to the demands of changing times, in this case the promotion of scientific literacy. By incorporating new teaching strategies in their education programmes museums can adapt their roles and functions and respond more effectively to their purpose. Providing learners the opportunity to actively engage by moving beyond the glass display through access to artefacts in the museum context should allow learning to take on greater meaning (Ramey-Gassert, 1997, Tishman, et al., 2007).

There is consensus amongst Screven (2002), Arinze (1999), Anderson (1997), Hofstein & Rosenfeld (1996), Chase (2002) and Bell et al. (1989) that museums have an advantage due to their rich resource base that allows for the handling of authentic science specimens and opportunities to interact with scientists, bringing real things to real people. Further to this they point out that museums have untapped potential to complement formal classroom based education and learning. The museum context may therefore have a profound influence on learners' knowledge and understanding as well as their beliefs, attitudes and motivation to learn. Colvill & Pattie (2002), Krajcik & Sutherland (2010), Webb (2010), Yore (2000), Norris & Philips (2003) and Pearson et al. (2010) stress that the challenge of meeting the need for learners to acquire science skills, and teachers to adapt the way they teach, can be achieved by developing teaching strategies which improve learners' basic literacy skills while stimulating their interest in the world around them.

Although museum teachers do not always have the expertise, resources or time to do the necessary research into the application of new learning and teaching strategies they are at an advantage to their colleagues in main stream education. Unlike such teachers, they are able

to test and implement educational models in a context rich environment in order to implement new and emerging imperatives such as those provided by the new South African curriculum, which underlies the purpose of this study.

10. CHAPTER SUMMARY

In this chapter definitions of museums, as well as the transformation of their roles and functions, are interrogated. A brief history of museums is summarised and the challenges that they are confronted with in the 21st century are considered. The advantages of incorporating new teaching strategies into museum education programmes are outlined and an attempt is made to clarify the differences between schools and museums as formal and informal learning contexts, their complementary roles and influence on learner's knowledge, understanding, attitudes and motivation to learn.

Reference is made in this chapter to the difficulties of uptake in CPD and to the meaning of scientific literacy (Webb, 2010), the distinction between the derived and fundamental senses of science (Norris and Phillips (2003, p. 225) and the role of reading, writing, talking and doing science to promote scientific literacy. The importance of the promotion of scientific literacy and key elements of the integrated strategy for promoting teaching and learning towards scientific literacy are explored. Their role in the South African natural science curriculum is outlined. The paucity of data and literature on the learning of science within a museum context in South Africa (Lelliott, 2009) and the role of scientific literacy in museums is also noted. The purpose of the study, namely, an investigation of whether the participating Port Elizabeth museum teachers could implement the integrated learning strategy to promote scientific literacy in a museum context and to determine which aspects of the strategy was most readily adopted by visiting learners, is described.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

1. INTRODUCTION

This chapter engages with the notion of research paradigms and focuses on understandings of positivism and interpretivism since both qualitative and quantitative data are generated in this study. The research design and methodologies utilized in the pursuit of developing responses to the research questions are illustrated and the value of using a mixed-method approach is explained. The procedures that were employed to collect data are described, as are the design of the data collection instruments. The analysis of the data and the methodological limitations are outlined, and the ethical considerations made when executing the study are considered.

2. RESEARCH PARADIGMS

The term paradigm is defined by Guba (1990) as a basic set of beliefs that guide action. In research the methodological practices are manipulated by the beliefs or paradigms that direct a particular discipline (Morgan, 2007). Kuhn (1970) intimates that when these beliefs, practices or paradigms produce ideas that can no longer be accommodated within the existing framework, they are replaced by new theories and questions, constituting a 'new paradigm'. Many researchers view a paradigm as sets of metaphysical beliefs constituted into a system of ideas, which inform our reality and influence the way in which we research issues (Mertens, 2005). Morgan (2007) claim that the particular paradigm utilised determines the research methods and dictates the research techniques used. Despite the complexity of these ideas, Patton (cited in McFarlane, 2000) describes paradigms as being normative, informing

practitioners of what to do without the necessity of long existential or epistemological consideration.

Researchers may approach and generate their data from varying theoretical perspectives despite having common purposes that link their work (Burrell & Morgan, 1979). They define paradigms by the meta-theoretical assumptions on which they are based and divide them into four quadrants that mutually define exclusive views of the world (Burrell & Morgan, 1979).

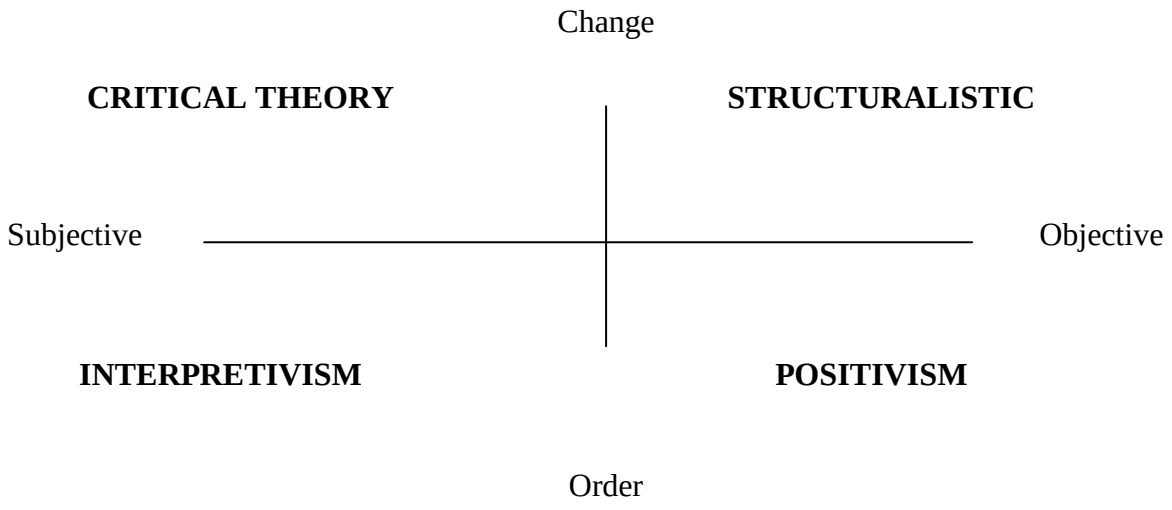

Figure 3.1: Burrell and Morgan's (1979) four quadrants and four paradigms

The above matrix is founded on four established sociological arguments (Burrell & Morgan, 1979). The first argument deals with the concept of reality and questions whether an individual's reality is shaped through societal construction or is it a product of the mind (perception)? The second argument centres round how one understands a new idea, concept or practice and interrogates whether it is necessary to experience something to understand it. The third argument focuses on the concept of free will, whether individuals are guided by free will or if their decisions are influenced by their environment. The final argument focuses

on whether understanding is achieved through a systematic way of thinking, direct experiences or practice-based knowledge. The four arguments are analysed along the axes of the matrix where it can be deduced that positivism aims to find certainty and is seen to be objective and value free, dealing with order. Interpretivism is more subjective but still leans towards order. Critical theory, while also being subjective, leans more to the promotion of change (Burrell & Morgan, 1979).

Lather (1991) asserts that the above model is not always practical when doing research. Consequently, they caution that, because we tend to work in more than one paradigm, researchers need to be consistent by keeping their various decisions in line with their stated postulations. Keeves (1988) cites De Landsheere who asserts that no one paradigm can answer the multifarious questions arising from educational research. A mixed-method approach, straddling traditions and representing a synthesis of paradigms may better address the broad conceptual issues arising from educational research (Keeves, 1988). The questions posed by this study are ideas best answered within the notions of the lower quadrants of Burrell and Morgan's Model, and, as such, positivism and interpretivism will be discussed. However, these paradigms were not applied exclusively in this study, and a mixed-method approach was used which incorporated the qualitative dimension of interpretivism and the quantitative dimension of positivism.

2.1 Positivist Paradigm

The nineteenth-century French philosopher Auguste Comte coined the word 'positivist' and this initiated the general doctrine which held that all genuine knowledge is based on sense-experience that can only be advanced through observation and experiment (Cohen & Manion, 2003). Positivists regard the world of natural phenomena as being tough, real and external to the individual (Cohen & Manion, 2003). The approach is characterised by

methods and procedures designed to discover general laws (Burrell & Morgan, 1979). Using this approach in research results in the meticulous study of data taken from within a certain context for example under laboratory conditions. This is indicative of controlled experimental conditions so that the variable of interest to the observer is the basis of the theory being tested (Kearsey & Atherton, 2003). Positivist research proceeds from the position that a hypothesis be formulated before data is collected. The data is used to confirm theory (Easterby-Smith, Thorpe & Lowe, 1994).

2.2 Interpretative Paradigm

While the positivist paradigm relies on objectivity, interpretavist researchers set out to understand phenomena through their interpretation of the world around them (Glaser & Strauss, 1967). McFarlane (2000) states that the interpretive tradition implies that people form (construct) their own understandings of the world and the researcher seeks to understand the world in terms of the experiences of people in it. The key idea is that research in this tradition seeks to understand and appreciate the different constructions and meanings people make of their experiences (McFarlane, 2000). The paradigm assumes that the world and reality are not objective and external, but are socially constructed and given meaning by people (Easterby-Smith et al., 1994).

The above assertion is supported by Fien and Hillcoat (1996) who claim that the interpretivist maintains that knowledge is internally constructed. Investigators in the interpretive paradigm work directly with the experiences and understandings of others (Kearsey & Atherton, 2003), while knowledge is perceived as a product of individual thinking and consciousness that is constructed by individuals through their interaction with their worlds (McFarlane, 2000).

2.3 Pragmatism

Pragmatism, in general, is regarded as the philosophical basis for mixed-method research. The paradigm is based on the premise that the research question(s) should guide the researcher in selecting the most suitable methodological approaches to address the enquiry (Cresswell & Plano Clark, 2007). The accepted paradigm therefore determines the method of research and dictates the research techniques adopted (Mouton, 2001). Tashakkori and Teddlie (2003) emphasise that within the pragmatist tradition the emphasis is on the research question as opposed to the method or paradigm that underlies the investigation. Furthermore, Johnson and Onwuegbuzie (2004) believed that a practical combination of methods may offer greater insight, or provide the best possibility for answering the research questions.

3. RESEARCH DESIGN AND METHODOLOGY

The research design of this study can best be described as a pragmatic mixed-method design which combines quantitative and qualitative research methods (Creswell & Plano Clark, 2007). The chief tenets of the mixed-method approach outlined by Wiersma (1995) and Johnson & Christensen (2004) include the concurrent or sequential application of quantitative and qualitative methods in the same study. Johnson & Christensen (2004) point out that pragmatism is the philosophical basis for this kind of research. They go on to highlight the chief elements of the approach which includes a research design that indicates the order and precedence given to both the quantitative and qualitative aspects of data collection and analysis. It is the way in which the quantitative and qualitative aspects of the study relate to each other with specific emphasis on how triangulation is used. The use of the mixed-method approach was utilised in this study to capitalise on the merits of both quantitative and qualitative paradigms and to facilitate deeper insights into the effects of the intervention (Rocco, Bliss, Gallagher & Pérez-Prado, 2003; Johnson & Christensen, 2004).

This study attempted to investigate whether or not aspects of the integrated strategies approach to promote scientific literacy could be successfully employed in a museum context. More precisely it had as its objective to ascertain whether or not museum teachers might successfully adopt such an integrated strategy. It also attempted to investigate the influence and possible impact such an intervention had on their view of the nature of teaching and learning to promote scientific literacy within a museum context. Additionally it investigated the type of museum activities that might support the approach, and which aspects of the approach were adopted most readily by learners visiting the museum.

During the study the museum teachers attended three professional development workshops. This was with a view to investigate their understanding of scientific literacy as well as developing their understanding of the integrated strategy. Following the museum teachers professional development workshops they planned and presented three learner workshops of their own. The aim was to investigate whether or not they could apply the concepts to their teaching of grade six learners who visited the museum. The museum teachers discussed the criteria for the invitation and selection of schools to participate in the study. In addition they planned and organised the learner workshops, dealt with the logistics and prepared workshop materials. Together with the researcher they also designed the research instruments. Data were generated as follows:

- Reflexive essays written by the museum teachers on their understanding of scientific literacy
- Observation of their reactions and implementation of the strategy during the learner workshops
- Reflections of the museum teachers in their science notebooks

- A questionnaire completed by the museum teachers after their professional development workshops
- A museum teachers focus group interview was conducted

Learner-generated data were also obtained during the study through questionnaires completed before and after their workshops, inspection of their science notebooks, and via the use of a classroom observation schedule.

3.1 Rationale for using the mixed method approach

Advocates of the mixed method research approach are of the opinion that the exclusive application of the positivisit or intepretivist philosophies cannot be used to deal satisfactorily with the majority of research questions. Cresswell & Plano Clark (2007) point out that mixed method research in disciplines such as education and sociology is increasingly used with the intention of overcoming bias associated with single method studies. The motivation for methodological pluralism resides in the need to match the research method and paradigm to the purpose, research questions and issues at hand in order to generate a more holistic view of the phenomenon investigated (Patton, 2002, Cresswell & Plano Clark, 2007).

The advantage of a mixed method design is the minimisation of weaknesses through the triangulation of varied data (Johnson & Christensen, 2004; Hunt, 2007). Triangulation is the application and combination of several research methodologies in the study of the same phenomenon (Wiersma, 1995; Cohen & Manion, 2003). It provides various perspectives and prevents researchers from only using their preferred research methods, thereby increasing validity. The use of qualitative and quantitative methods provides a clearer illustration of the data and potentially neutralises the weaknesses in singular approaches while building on their

strengths (Creswell, 2005). This is considered beneficial when providing quantitative explanations to qualitative findings, or conversely, presenting qualitative explanations for quantitative results. For example, in this study, teacher reflexive essays, focus group interviews and a questionnaire were used to elicit the participants' presuppositions, experiences and actions. The responses of the participant learners and their teachers to the questionnaire, their recording of processes in the science notebooks as well as classroom observations generated further qualitative and quantitative data.

4. SAMPLE AND SETTING

This study was conducted at the Port Elizabeth Museum School which is situated in the museum at Bayworld (Port Elizabeth Museum and Oceanarium). The school is registered with the Eastern Cape Department of Education and has collaborated with the Port Elizabeth Museum (Bayworld) since 1942. The museum school has access to Bayworld resources including artefacts, vehicles to transport museum teachers to visit local schools, facilities (artefacts, galleries, etc.) and the expertise of scientists if required. The core function of the school is to present school curricula-based programmes to learners from reception grade to grade seven. The annual museum school education programme is planned by the museum teachers and distributed to the local schools through the local education district office at the end of each year. The school groups pre-book their visits to the museum school before the new academic year commences. During the visits museum teachers usually do short (15 to 30 minute) presentations in the classrooms using authentic museum specimens that complement the presentations. After the presentations the learners are accompanied by the museum teacher and their own class teacher to visit the gallery and or live animal exhibition relevant to the presentation to expound on the presentations. Groups from underprivileged township

schools that pre-book for presentations usually visit the museum school at least once a year while groups from more privileged schools visit at least to four time per year.

This study was framed with the notion of museums being well respected education resources and their particular social and physical contexts which interact to contribute to the learner's experience (Falk & Dierking, 2000; Cox-Petersen, Marsh, Kisiel & Melber, 2003). The six teachers deployed at the museum school were all invited to participate in the study. Only one of the six opted not to participate in the study due to her impending retirement which fell during the tenure of the research. As such, five museum teachers initially participated in the study, but sadly only four teachers continued for the duration due to the untimely death of one of the participants. The teaching experience of the teacher participants ranged between 20 to 34 years in a variety of learning areas (subjects) ranging from grade one to twelve in various schools. Each participant had between three to nine years experience in museum education. The group comprised one male and four female teachers. Only one of the teachers was qualified in science teaching (Further Education and Training - grades ten to twelve). The other four teachers comprised one Foundation Phase (grades one to three) and three Intermediate and Senior Phase (grades four to ten) teachers of which one taught languages (English, Afrikaans and Xhosa) and Life Orientation, one Geography, and another Technology and Mathematics. The Museum School teachers were selected as participants because of their contribution to, and participation in, museum education and because the study attempts to answer the research question of whether aspects of the integrated strategies approach to promoting scientific literacy could be successfully employed in a museum context.

An overview of the workshops presented to introduce the museum teachers to the strategy is presented below in Table 3.1.

Table 3.1

Overview of the museum teacher (n=5) workshops

Outline	Date	Duration
Workshop 1	*28.04.2009*	*11:00 – 15:00*

- Strategies for connecting inquiry science, scientific literacy and general literacy
- Simulate aspects of this process by doing a very simple investigation using a Science Notebook (Cohesive properties of water)
- Background and rationale for the integrated strategies approach
- Reflect and summarize the processes used during investigation
- Unpack the difference between the fundamental and derived sense of science

Workshop 2 *30.04.2009* *11:00 – 15:00*

- Explore the role of talking and reading in learning science
- Investigate effective teaching strategies for integrating reading and inquiry in science
- Conduct a second investigation (Otoliths – fish ear bones)
    - Formulate questions for the investigation using the stimulus provided ("Fish have ears" – story written for the workshop)
    - Separate investigable from the researchable questions
    - Select one investigable question for the investigation
    - Use the Science Notebook to record:
        - Prediction, Planning, "What I did?", "What I found out?", Line of Learning
    - Extend the Line of learning using DVD, fact packs and otolith exhibition

Workshop 3 *12.05.2009* *09:00 – 15:00*

Part 1 (09:00 – 11:00)

- Additional workshop requested by the museum teachers to extend their Line of Learning
- Removal of otoliths from fish – led by a museum research staff member

Part 2 (11:00 – 15:00)

- Explore the role of argumentation in learning science
- Investigate effective teaching strategies for integrating argumentation in science
- Implement argumentation strategies in your classroom
- Conduct third investigation (Dolphin skulls) using Science Notebooks
- Organise and present findings to one another

Five schools in the Port Elizabeth Metropolitan Area were invited to send one grade 6 class to participate in the study. The selection, as determined by the museum teachers, was based on a school's previous participation in the Port Elizabeth Museum School's education programmes. Each of the invited schools had participated in the museum education programmes for five years or more. Only two of the schools accepted the invitation to participate in the study. A possible reason that only two schools responded was a required commitment to attend three workshops at the museum. Motivation for choosing grade six learners was that previous studies on scientific literacy in schools in and around Port Elizabeth (Villanueva & Webb, 2008; Mayaba, 2009) were conducted with grade six learners as the sample and therefore could form a frame of reference.

The participating schools are commonly referred to as church schools where the overriding ethos is Christian and they follow prescribed curricula. One school (School 1) was well resourced and located in an affluent community. The majority of the children are White and English mother tongue speakers with English as the medium of instruction. This school implements the Cambridge System (United Kingdom). There were 37 learners following the South African curriculum and 21 learners following the Cambridge System (n = 58). The other school (School 2) was from a Black, previously disadvantaged community. The school is under resourced and English is the prescribed language of instruction despite it, being the learners' second language. This school implements the South African Revised National Curriculum Statements (RNCS).

An overview of the learner workshops are presented below in Table 3.2

Table 3.2:

Overview of the learner (n=58) workshops. Workshop 1 and 2 was offered to School 1, while workshops 1 and 3 were offered to School 2.

Outline	Date	Duration
Workshop 1	*11&18 August 2009*	*09:30 – 12:30*

- "Museum Rallying Cry" composed by one of the museum teachers performed by learners in one of the galleries (relax, & welcome)
- Orientation to the structure and use of Science Notebook
- Doing a very simple investigation using a Science Notebook (Cohesive properties of water)
- Prediction, Planning, "What I did?", "What I found out?", Line of Learning
- Groups formulate, organise and report findings

Workshop 2	*12/13 August 2009*	*09:30 – 12:30*

<u>Otolith workshop</u>

- Shared reading activity ("Fish have ears" – book written for the workshops) and discussion in the oceanarium
- Preparation for the second investigation in the classroom
    - Formulate questions for the investigation using the stimulus provided ("Fish have ears" – story written for the workshop)
    - Separate investigable from the researchable questions
    - Select one investigable question for the investigation
    - Use the Science Notebook to record:
        - Prediction, Planning, "What I did?", "What I found out?", Line of Learning
    - Extend the Line of learning using DVD, fact packs, otolith exhibition and worldwide web
- Learners formulated and organized their findings of the previous investigation
- Represented their data using graphs (new activity for the majority of learners)
- Groups presented their findings

Workshop 3	*19 August 2009*	*09:30 – 12:30*

<u>Dolphin skull workshop</u>

- Shared reading activity in the marine mammal gallery ("Dolphins" – a poem). A discussion about the poem, dolphin and whale characteristics as well as their adaptations while focusing on the exhibition
- Preparation for the second investigation in the classroom
    - Formulate questions for the investigation using the

stimulus provided (the dolphin skulls provided from the museum collection)
    - Separate investigable from the researchable questions
    - Select one investigable question for the investigation
    - Use the Science Notebook to record:
        - Prediction, Planning, "What I did?", "What I found out?", Line of Learning
    - Extend the Line of learning using marine mammal exhibition, DVD and worldwide web
- Learners formulated and organized their findings of the previous investigation
- Represented their data using graphs (new activity for the majority of learners)
- Groups presented their findings

Van Driel and Verloop (2002) point out that research shows that teachers must not only understand the connection between the scientific content and any model they are introduced to. More importantly, they must understand their students' perception of the model being used. A key component of the integrated strategies approach is inquiry-based instruction. Consequently, before the museum teachers were expected to implement the strategy in the museum context with two selected classes of grade six learners, they personally experienced inquiry-based instruction through their participation in three professional development workshops of four hours each. Each workshop focused on the use of the integrated strategies approach to promoting scientific literacy. According to Kielborn & Gilmer (1999) the preparation of teachers to use inquiry methods to teach science can be difficult because many would not have experienced this type of instruction themselves. It was something that became evident when working with the museum teachers. This was reinforced when examining their initial beliefs and practices about scientific literacy which they expressed in their reflexive essays.

5. DATA COLLECTION PROCEDURES AND INSTRUMENTS

As noted earlier, the study was developed through two stages (i) the museum teachers' professional development first then followed by (ii) the learner workshops. The museum teachers wrote pre- and post-intervention reflexive essays (Appendix A). Their investigation findings were written up in the form of science notebooks that were evaluated using a checklist (Appendix F). They were interviewed as a focus group (Appendix C) and subsequently completed a questionnaire (Appendix B) as well.

The participating learners completed pre- and post-workshop questionnaires (Appendices D and H) and during their investigations they produced written artefacts in the form of science notebooks that were evaluated using a checklist (Appendix F). During the learner workshops the teachers' practice and learners' participation were observed using an observation schedule (Appendix G).

5.1 Questionnaires

According to Johnson & Christensen (2004) questionnaires are versatile tools and are extensively used in educational research because they can be standardised. Also they can be designed to ensure anonymity and are economical. In this study the museum teachers and learners completed different questionnaires. The museum teachers' questionnaire (Appendix B) comprised two sections. Firstly, open-ended and then close-ended questions were completed after the training workshops. The learners completed two separate questionnaires, one (Appendix D) prior to their visit to the museum. It started with closed-ended and ended with an open-ended question as well as a second questionnaire (close-ended only - Appendix H). This was distributed to the learners at the conclusion of their final workshop. These questionnaires suited this relatively small scale study in that the open-ended questions invited truthful, direct and personal comment from the respondents (Cohen & Manion, 2003) and

provided both quantitative and qualitative data. As English is not the mother tongue of all the participants, the language used in the questionnaires was designed to be simple and easily understandable. The learner questionnaires (Appendix D & H) were designed in collaboration with two of the museum teachers': one a foundation phase and the other an intermediate phase language teacher. Three colleagues, two Xhosa and one Afrikaans speaking, tested the questionnaires to check clarity of the instructions, questions, and layout. Feedback was provided and the necessary changes were made before using the questionnaires.

5.2 Reflexive essays

Ryan (2009) points out that in the teaching context the reflexive process entails introspection. It is a deep inward look at ones interaction that is shaped and influenced by the context as well as the participants. It is a complex process that can be applied in education research particularly the classroom because the need for teachers to engage in personal reflection as a "means of self development is widely endorsed in education" (Ryan, 2009, p. 1).

In this study the museum teachers wrote a pre- and post- intervention reflexive essay, answering the same questions (Appendix A) on both occasions. The first essay was written before the teachers attended the workshops planned in order to introduce them to the integrated strategies learning approach. The second essay was written after their professional development workshops, but before they presented the learners workshops. According to Sandelowski & Barroso (2002) reflexivity is a characteristic of good qualitative research because it entails the preparedness of both researcher and participant to consider and recognize their contributions to the study. It involves the constant analysis of what, why (theoretical) and how (methodological) we do things (Coghlan & Brannick, 2005).

5.3 Interviews

Interviews are data gathering techniques that entail verbal communication between the researcher and the research participant(s) (Johnson & Christensen, 2004). Cohen & Manion (2003) outline the research interview as a dialogue initiated by the researcher for the specific purpose of obtaining information relevant to the research and determined by the research objectives. Interviews may be used in conjunction with other research methods, as was the case in this study. Van Manen (1990); Mathers, Fox & Hunn (2002) assert that semi-structured interviews are useful when collecting attitudinal information or when the research is explorative and it is not possible to design a list of topics or issues because not much is known about the subject area. A homogeneous group promotes discussion because of a common purpose and focus that enables the researcher to learn the facts as well as the meaning behind the facts (Krueger & Casey, 2000). A further positive factor is that the discussion generated through open ended questions is in the words of the participants.

The decision by the researcher to constitute the museum teachers as a focus group was based upon the untimely death of one of the participants and the effect it had on the dynamic of the group. Forsyth (2006, p. 119) cites Altman and Sherwood who purport that groups have the potential to help members deal with life tragedies, disasters and adversity because they provide emotional support to one another. This buffering effect in groups trying to cope and recover from a distressing incident has been verified by researchers according to Forsyth (2006).

Focus group interviews are particularly useful in that they are effective for providing in-depth information that is easy to understand in a relatively short period of time and it is relatively inexpensive (Krueger & Casey, 2004). During a focus group interview the researcher directs a discussion focused on a specific topic with a small homogenous group of

individuals. In this study a group of museum teachers explored how the group thinks and feels about the topic, namely, the integrated strategies learning approach (Johnson & Christensen, 2004). The museum teachers reflected on their expectations of the workshops within the group. They discussed their views about adopting the strategy, their understanding of scientific literacy and the possibilities of implementing the integrated strategies learning approach within the museum context.

5.4 Science Notebooks

Miller & Calfee (2004) assert that science notebooks have the potential to develop content, process skills and at the same time function as a context to develop literacy. The use of 'Science Notebooks' is advocated by Campbell & Fulton (2003) as a tool to promote scientific literacy and the science notebook checklist (Appendix F) can be used to provide both qualitative and quantitative data. The data contributed to the mixed-method approach used in this study to gain insight into the learners' understanding and the skills developed while using the integrated strategy approach to promoting scientific literacy.

Inquiry-based topics chosen for the workshops were based on the cohesive properties of water, otoliths (fish ear bones) and dolphin skulls. The museum teachers were firstly trained to use inquiry-based techniques and activities, including the use of science notebooks. The total duration of the workshops was 14 hours and initially only three workshops of four hours each were planned. However, the participating museum teachers' requested an additional workshop in order to consolidate what they had learned.

Throughout the three inquiry-based investigation workshops the teachers recorded their questions, observations, illustrations, data and reflections, as suggested by Campbell and Fulton (2003). The teachers planned and implemented three workshops for each of the two grade six classes participating in the study. Each group completed an investigation of the

properties of water. One group worked with otoliths and the other with dolphin skulls. Individual learners completed science notebooks for two separate investigations and six notebooks from each class were randomly selected and analysed using the science notebook checklist (Appendix F). The framework of the learners' science notebooks was specifically designed to be used in the museum context taking into account the time constraint of a class visit to the museum, portability and cost. The checklists for the notebook (Appendix F) used to evaluate both the museum teachers and learners notebooks in this study were based on the research instruments designed and validated by researchers at the University of North Carolina – Wilmington (UNCW) and applied in numerous science inquiry and notebook studies (Nesbit, Hargrove & Fox, 2003; Nesbit, Hargrove, Harrelson & Maxey, 2003; Reid-Griffin, Nesbit & Rogers, 2005). Despite these instruments being developed for American schools they were deemed adequate for use in this study as they have been validated in other studies within the South African context (Villanueva & Webb, 2008).

5.5 Observation schedules

Johnson & Christensen (2004) define observation as a way of gathering data about the phenomenon of interest by watching the behavioural patterns of people in specific situations. They further distinguish between laboratory observation, settings prepared by the researcher in a research lab, and naturalistic observation conducted in the real world. The schedule for classroom observation used in this study (Appendix G) provided quantitative data which were triangulated with other data generated in this study. The researcher, who is also a staff member at the Port Elizabeth Museum School at Bayworld, was the participant-observer along with the class teachers. Observations of the learners using their science notebooks during the two investigations conducted were recorded on the schedule for

classroom observation. The intention of the observation was to examine experience and record the actions that took place when the learners conducted their investigations.

5.6 Summary of the data collection techniques

The nature of the data collection instruments - whether they were designed to generate quantitative or qualitative data (or both) are summarised in Table 3.3

Table 3.3:
Qualitative & Quantitative Data Collection Instruments used in the study

Qualitative only	Both quant & qualitative	Quantitative only
Museum teachers pre- and- post intervention reflexive essays	Museum teachers post-workshop questionnaire	Learners post-workshop questionnaire
Museum teachers focus group interviews	Learner pre-intervention questionnaire	
	Schedule for classroom observation	
	Museum teacher and learners' science notebooks	

6. DATA ANALYSIS

The data generated by the questionnaires were analysed both quantitatively (to provide descriptive statistics) and qualitatively by inspection (to categorise the responses and attempt to group them in themes). The data generated by the Museum teachers' pre- and- post intervention reflexive essays were inspected, and categorized, after which an attempt was made to identify common themes. The interviews were transcribed verbatim, and then coded

by utilising an inductive process that involved breaking up and categorising the text to form descriptions and broad themes (Creswell, 2005).

The five-item Science Notebook Checklist was used to assess learners' writing in science and to determine the degree to which their respective teachers guided and assisted them in using inquiry skills and developing procedural and conceptual knowledge in science. The checklist also assessed various components of the scientific process such as constructing a testable question, writing and implementing the procedures, collecting data, and using visual representations such as labelled drawings. The fifth component evaluated learners' ability to draw conclusions.

The five components were assessed on a rating scale of zero – four. The rating scales illustrate increasing learner ownership and the level at which the learners actively participated in the learning process by constructing their own science knowledge (Nesbit, Hargrove, Harrelson, & Maxey, 2003). A rating at level zero indicates that there was no evidence of the component present. Level one indicated that the learner copied the teacher's information. Level two suggests that the learner was able to generate his/her own information but, some of the information may have been inaccurate. Level three indicates that the learner generated his/her own ideas, although some of the information may have been incomplete or missing details. Finally, a level four rating suggests that the learner generated complete and accurate information.

The classroom observation instrument assessed twelve components in relation to the scientific literacy model:

1. The use of a stimulus
2. Exploratory talk and classroom discussion
3. Investigable question

4. Planning an investigation
5. Conducting or 'doing' an investigation
6. Learner writing with science notebooks
7. Learner reading
8. Teacher questioning skills
9. Teacher feedback to learners
10. Line of learning in relation to the teacher's subject knowledge
11. Line of learning in relation to student generated ideas, and,
12. Learner subject knowledge assessed by means of class argumentation or presentations.

For the purpose of this study components 11 and 12 were combined to afford the teachers and learners the opportinity during the third workshop to present and demonstrate the understanding of concepts learned and ideas generated through the Line of Learning. The data generated examined the level at which the teachers could apply the integrated teaching strategies approach in the classroom on a four point scale.

The levels at which the learners responded to the strategy through classroom discussion (*Component 2*), writing with science notebooks (*Component 6*), reading (*Component 7*) and generating ideas through the Line of Learning and learner subject knowledge through argumentation and presentation (*Component 11*) were also investigated.

The data generated was used in the quest to answer the principal question that guided this study, namely, "Can aspects of the integrated strategies approach to promoting scientific literacy be successfully employed in a museum context?" Furthermore the data also elucidated upon the sub-questions that served the main research question:

- Can the teachers in the Port Elizabeth Museum School at Bayworld adopt the scientific literacy strategy if provided with appropriate support?
- If the strategy is adopted by the participant museum educators, how does it impact their current pedagogical paradigm with regard to the nature of teaching and learning towards scientific literacy?
- What is the nature of the types of activities that can be utilised to support the integrated strategies to scientific literacy in the museum education transaction?
- Which aspects of these strategies do learners visiting the museum adopt most readily?

The data generated through the museum teachers focus group interview, science notebooks, classroom observation and questionnaire completed during the first stage of the study were examined and compared in an attempt to answer sub-question one. Additionally, the teacher focus group interview and the pre and post reflexive essay provided data that responded to sub-question two that investigated if the views concerning the nature of teaching and learning towards scientific literacy were affected if they adopted the strategy. Data presented in the museum teachers focus group interview, the learners notebooks, classroom observations and questionnaires were analysed using the checklists in response to sub-question three. The data from the learner's notebooks, post intervention questionnaire and classroom observation were perused and compared in an attempt to determine which aspects of the strategy the learners most readily adopted as outlined in the fourth sub-question. Data gathered through the pre- and post-reflexive essays, questionnaires, focus group interview, note books and observations will be compared and discussed in a later chapter.

7. RELIABILITY AND VALIDITY

In qualitative research reliability or trustworthiness refers to the truth and accuracy of the findings and interpretations (Kvale, 1996; Creswell, 2005) and there are certain measures that must be employed to attain this (Struwig & Stead, 2001; Creswell, 2005). In this study the aspect of trustworthiness was considered crucial to establish the credibility of the research. Triangulation was crucial in guiding the integrity of the study. Whilst triangulation did not necessarily lead to total convergence, it served as a corrective to latent ambiguity. It therefore served to instil confidence in the design of the research and the results it generated.

Reliability in the quantitative sense suggests that the same results will be achieved if the experiment is repeated and is usually indicated by statistical measures, e.g. Cronbach's α (Gravetter & Walnau, 2002). As no large scale inferential statistical analyses were attempted using the limited data generated in this study, reliability of the data generated in this study fell mainly in the qualitative sense above.

The validity of the data generated relies largely on the data generating instruments used. In this study the instruments used have been validated in previous research that had been undertaken and their design, use and efficacy have been described in peer reviewed publications (see section 5).

8. ETHICAL CONSIDERATIONS

In accordance with the accepted professional ethics of research, as stipulated in Mouton (2001), the objectives of the study, research design and methodologies were communicated to all participants and the appropriate consent was duly obtained. The museum teachers, school principals and class teachers from each school consented to the participation

of the children in the classes which participated in the project in terms of their status of being *in loco parentis*. The rights of the participants to refuse to participate in the study if they were not comfortable doing so, and their rights to privacy were clearly communicated to them. All the participants involved in the study were informed volunteers and were aware that their responses would be used for the study. The right to request full disclosure about the research topic and the results of the study was guaranteed. The results of the study will also be presented to all the stakeholders in terms of research accountability. Written responses were kept for the duration of the study and would be destroyed thereafter. Consent was also obtained from Bayworld (Port Elizabeth Museum) management and the Department of Education (Port Elizabeth District Office) which is responsible for the Museum School and employs the teachers.

9. METHODOLOGICAL LIMITATIONS

The limitations of conducting this study relate to its scope. The external validity may be in question due to the small size of the sample group of teachers from the museum school and the small sample size of schools from the Nelson Mandela metropolitan area who participated. In other words, the sample group of teachers are not representative of all museum teachers and the sample of schools not representative of schools in South Africa. Therefore the findings of this study cannot be generalized to the South African museum and education system as a whole. However, this study presents selected insights to a range of issues which contribute to the challenges and successes of using the integrated strategies learning approach in a museum context and seeks to contribute to debates around the possibility of museums contributing to the promotion of scientific literacy amongst schoolchildren during museum visits.

10. CHAPTER SUMMARY

In this chapter different paradigms were discussed and explanations for using both quantitative and qualitative approaches in the study were outlined. The reasons why a mixed-method approach, symbolising a synthesis of paradigms (Irwin, 1998), was used in this study are noted. The data collection methods, which include selected reflexive essays, questionnaires, focus group interview, science notebooks and classroom observation, were discussed, as were the data generating techniques which provided a variety of insights into aspects of the integrated strategies approach to promoting scientific literacy that could be successfully employed in a museum context. The rationale for the selection of the sample, ethical considerations and methodological limitations of the study are also discussed.

CHAPTER FOUR

RESULTS

1. INTRODUCTION

In this chapter the data generated in this study are presented in the same order as in the research questions presented in chapter one. The museum teachers' reflexive essays were considered and a tabulated comparison was made of the reflections before and after the intervention. A graphical representation and explanation of the evaluation of the teachers' and learners' science notebooks is presented and the teachers' responses to the focus group interview are elucidated. The teachers' post-workshop questionnaire, the learners' pre- and post- workshop questionnaires as well are presented graphically and explained. Observations of the teachers presenting the integrated strategy and learners conducting investigations are presented and interpreted.

2. PARTICIPANTS

As noted in chapter three, five teachers from the Port Elizabeth Museum School at Bayworld participated in the study. They participated in three professional development workshops (plus an extra session for consolidation) of four hours each on promoting scientific literacy and cooperatively taught two three-day sessions (three hours each) to two classes of grade six learners (n=58) from two different schools in the Port Elizabeth metropolitan area, namely the Harvest Christian School (n=21) and New Brighton Seventh Day Adventist School (n=37). These activities enabled data to be generated in terms of the teachers' ability to adopt the strategy which aims at promoting scientific literacy, the effects of the strategy on their view of scientific literacy, the nature of teaching and learning towards

scientific literacy, and the effect of activities that aim at supporting the promotion of scientific literacy in a museum context.

3. MUSEUM TEACHERS INTERVENTION

As noted earlier, during the first stage of the study the museum teachers participated in three workshops which aimed at introducing them to the integrated strategies approach for promoting scientific literacy. In the process they wrote pre- and post-reflexive essays, wrote-up the findings of their investigations in the form of 'science notebooks', were interviewed as a focus group and completed a post-workshop questionnaire.

3.1 Teachers reflexive essays

The museum teacher's pre- and post-reflexive essays were read and their responses were categorised in terms of their understanding of scientific literacy, and what schools and museums could do to promote scientific literacy outlined below.

Pre-Reflexive Essay responses

The teachers' pre-reflexive essay responses to their understanding of scientific literacy, what schools and museums could do to promote scientific literacy are presented below in Table 4.1

Table 4.1:

Museum teachers' (n=5) pre-intervention reflexive essay responses

Category	No. of responses
Understandings of scientific literacy	
Awareness of science in our lives	5
Basic knowledge of science	5
Use and interpret science language	2
Know and understand how things work	3
Practical science application	2
Know science principles	2
What schools can do to promote scientific literacy	
Encourage learner participation	5
Make science fun	3
Encourage experimentation	4
Present teacher and learner workshops	4
Focus on using scientific language	2
Create an environment that is conducive for learning science	4
What museums can do to promote scientific literacy	
Provide interactive displays	3
Host science teacher workshops	3
Present science programmes	4
Cooperating with schools	2
Linking museum work with school curriculum	2
Allowing learners to experience 'the real thing'	3
Use scientist to promote scientific literacy	1

In the reflexive essay written before the intervention the museum teachers' (n=5) understanding of scientific literacy was being aware of science 'in our lives' and having 'basic knowledge of science' while three thought of it as knowing 'how things work'. The understanding of scientific literacy was further described by two of the teachers as the ability to 'use science language', knowing science principles and applying it practically. The teachers' (n=5) indicated that learner participation and experimentation (n=4) should be encouraged in schools to promote scientific literacy. The data indicated that the majority (n=4) of teachers believed that schools should 'make science fun', 'present teacher and

learner workshops' and 'create an environment that is conducive to learning science'. A focus on the use of science language in schools was also viewed as important to promote scientific literacy. The majority of the responses suggested the role of museums in promoting scientific literacy was to 'present science programmes' while three out of the five teachers believe museums should 'provide interactive displays', 'host science teacher workshops', and allow learners to experience the 'real thing'. The link between museums, schools and the curriculum was specified by two out of the three teachers.

Post-Reflexive Essay responses

The teachers' post-reflexive essay responses to their understanding of scientific literacy, what schools and museums could do to promote scientific literacy is presented below in Table 4.2.

The data reveals that the perception of scientific literacy as being the ability to do science (n=4) and to talk, read, write and reason logically (n=3) had become the major understanding of scientific literacy held by the teachers. After the intervention the responses indicated a greater emphasis on learner participation and the role of language to promote scientific literacy. Furthermore, three out of the four teachers believed that schools can present teachers' and learners' workshops, link with other educational institutions and science specialist in an effort to promote scientific literacy.

Table 4.2:

Museum teachers' (n=4) post-intervention reflexive essay responses

Category	No. of responses
Understanding of Scientific Literacy	
Conduct an investigation / know the steps / solve a problem / discovery / participate	4
Able to talk (discuss), read, write and reason logically to find a solution	3
What museums can do to promote Scientific Literacy	
Do investigations (explore) in the museums to make science interesting	3
Have more science oriented exhibits	2
Work with education institutions	3
Present learner and teacher workshops on SL	3
Change teaching approach to include investigations	4
What schools can do to promote Scientific Literacy	
Collaborate / link with schools, universities and museums	3
Present teacher & learner workshops	3
Work with scientists / specialists to promote SL	3

The responses before and after the integrated strategies intervention initially appeared varied and there seems little correlation between them. However, closer inspection reveal that the responses before and after the integrated strategies intervention on what museums can do to promote scientific literacy were similar except that the teachers used different words to formulate their responses after the intervention. The data suggested similar approaches and emphasis for museums to promote scientific literacy (Table 4.3).

Table 4.3:

Similarities between the teachers' pre- and post intervention reflexive essay responses to what museums can do to promote scientific literacy

Pre-reflexive essay responses	Post-reflexive essay responses
Present science programmes	Change teaching approach to include investigations
Learners experience the real thing	Do investigations in the museum
Interactive displays	Have more science oriented exhibitions
Host teacher science workshops	Present learner and teachers workshops or scientific literacy
Schools and museums work together	Work with education institutions
Link museum work with school work	Work with education institutions
Must understand scientific literacy and use scientists	-

3.2 Focus group interview

The museum teachers (n=4) participated in a two-part focus group interview. Before the commencement of the first workshop the museum teachers formulated their expectations of the planned workshops. After the workshops the second part of the focus group interview reflected on the workshop expectations formulated prior to the workshops, their views about adopting the strategy, understanding of scientific literacy and possibilities within the museum context.

The interview responses of the teachers' initial expectations of the intervention could be categorised into four main expectations, namely, that they wished to:

- Learn more about teaching science in order to improve our own teaching strategies
- Gain an understanding of the integrated strategy to promote scientific literacy and how to use it
- Learn how to get learners to participate
- Learn together as a group

3.2.1 Teachers views about adopting the integrated strategy to promote scientific literacy in the museum context

The teachers were unanimous that all their expectations were met and they gained a good understanding of the integrated strategies approach through their participation in the workshops. They said that they had learnt more about teaching science by conducting the investigations and were convinced that the strategy provided a fruitful way to get learners to participate. This perception was supported by their reading, writing and talking in the group during the investigations. Furthermore they believed, as inexperienced and untrained science teachers, their confidence increased with every investigation through the interactive, hands-on approach to learning science.

As noted above the teachers attributed their understanding of the integrated strategies approach to their direct involvement and participation in the learning process during the workshops. The initial sense of insecurity and uncertainty as untrained science teachers soon dissipated when they conducted the first investigation. They agreed that 'doing science', talking, reading and writing together as a group helped them understand the strategy and recognise its potential to promote scientific literacy. This sentiment is supported in their post-reflexive essay responses where they suggested approaches for museums to promote

scientific literacy. There was consensus within the group during the interview that they felt confident about what they learnt and that the strategy had potential to promote scientific literacy within the museum context. They believed that by adopting the strategy they diversify the museums regular education programmes, including the programmes they offer to children during school holidays and weekends. Although the group expressed confidence in adopting the strategy in a museum context they felt that the number of learners per group and duration of the visits (one hour per visit) that they currently have to deal with present challenges which will have to be met.

3.2.2 Teachers experiences of learning science

The teacher's responses reflected positive attitudes about their experiences while learning science considering that they are untrained and inexperienced in science teaching. They noted the more they used the integrated strategies approach during the workshops their confidence increased and their content knowledge increased. The group concurred that through their experiences they realised that the attitude, enthusiasm, careful planning and focus on the process of learning are essential for effective science teaching and learning. Despite doing scientific investigations for the first time they reported no boredom or frustration, but noted that they generated more questions than answers as each investigation progressed. The fact that the teachers had more questions than answers resulted in them requesting an additional workshop after the second investigation to extend their 'Line of Learning'. They referred to this hands-on approach as 'learning that makes sense' despite knowing very little about science before the intervention and referred to 'it being unlike anything they have done before'. As the teachers reflected on their personal experiences they noted that this approach to teaching and learning science has the potential to alleviate learner

boredom, frustration and possibly delinquency, because teaching and learning in this manner can make science more exciting, interesting and rewarding.

3.2.3 Activities that can be utilised to implement the integrated strategy effectively in a museum context

The teachers agreed that inquiry science is interactive and hands-on, making it exciting. However, they noted that inquiry science requires meticulous planning on the part of the teacher, and that clear expected outcomes to guide the learning process must be reflected in the process. In discussion they highlighted the negative effects of teacher talk and tell conventionally used to teach science. They suggested that teachers must let go of the need to control and be in charge, but must rather guide the learning process and encourage learner participation. Teaching learners the structure of, and the steps required to conduct investigations, were highlighted as essential to implementing the strategy effectively. The teachers were also in agreement that learners should to be encouraged to talk, read, record all aspect of their investigations and report findings. They were convinced that by doing regular investigations the learners will grow in confidence, which could result in more advanced investigations. They suggested that access to, the use of authentic museum specimens in the museum setting, and the use of relevant stimulus or discrepant events were effective strategies to encourage learner's interest and participation. The teachers suggested training the visiting teachers to enable them to facilitate follow up activities with the learners back at their schools.

3.2.4 Aspects of the integrated strategy adopted most readily by the visiting learners

The teachers stated that during the learner workshops they noted from the learner's interaction with one another in their groups that they enjoyed being involved and doing the investigations. The learners appeared initially intrigued by the museum specimens and once

the teachers explain the structure of the investigation and science notebooks they were enthusiastic to get started. Participating in doing the investigations and 'being scientists' were what the learners found most interesting and they became engrossed in collecting the data during their investigations. The teachers had to remind them to record their planning, do drawings and write up their conclusions in their notebooks. They remarked that the learners had reported that what they touched, saw, smelt and heard helped them to learn and echoed what the learners had stated on the post-workshop learner questionnaire, i.e. that they felt free to participate (94%), and that they learned more by doing investigations (93%) and discussing issues (86%) with one another.

3.3 Science notebooks

The museum teachers attended three workshops where they conducted three investigations, wrote-up their findings in the form of 'science notebooks', and they presented their findings during the third workshop. The workshops were held in the education centre at the Port Elizabeth Museum (Bayworld) over a period of one month. The researcher planned and facilitated all three training workshops. The five teachers decided to work in two groups with the three Intermediate and Senior Phase teachers in a group; the Foundation Phase and Further Education and Training teacher in another. During each of the workshops the teachers conducted a separate science investigation while recording their findings in their 'science notebooks'. All five the teachers participated in the first and second workshop, but only four participated in the third workshop due to the untimely death of one of the teachers. Inquiry-based topics chosen for the workshop investigations were based on (i) the cohesive properties of water, (ii) fish ear bones (otoliths) and (iii) dolphin skulls for the first, second and third investigations respectively. The teachers presented their findings of the third investigation (dolphin skulls) in the final workshop. Figures 4.1, 4.2 and 4.3 represent the data compiled

using the five components of the science notebook checklist (Appendix G) to evaluate the museum teacher's science notebooks. The five components in the checklist include:

- C1 - Constructing a question
- C2 - Designing an investigation
- C3 - Collecting data
- C4 - Scientific drawings
- C5 - Drawing conclusions

During the first workshop the teachers conducted their first investigation based on the cohesive properties of water. This was the first time four of the five teachers had conducted a scientific investigation. The teachers were not required to formulate an investigable question during the first workshop because they copied the question provided by the workshop facilitator, namely, 'How many drops of water can a 5c coin hold?' The data presented in Figure 4.1 below suggest that three were able to design an investigation on their own. Four of the teachers' generated complete and accurate information while collecting data and drawing conclusions. Complete and accurate scientific drawings were made by two of the teachers while two made no drawings and one made inaccurate drawings.

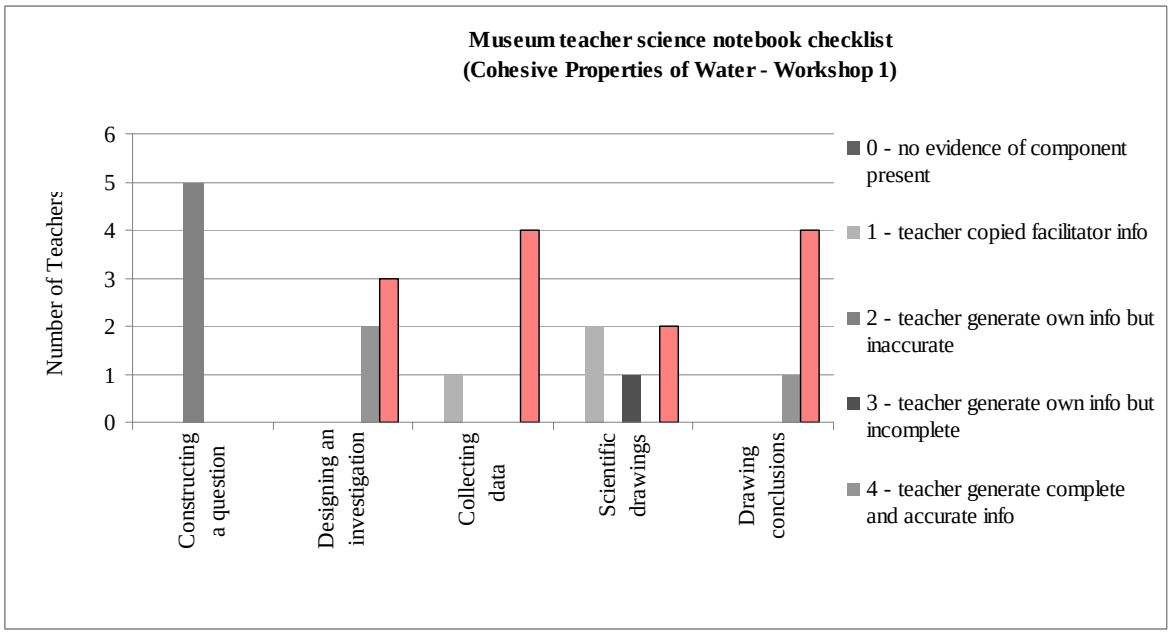

Figure 4.1: Teachers' (n=5) first investigation science notebook data

During the second workshop the teachers' conducted an investigation on otoliths. The data in Figure 4.2 illustrate that all five of the teachers produced complete and accurate information while formulating their investigable question, collecting data and made complete and accurate, scientific drawings. Three teachers designed complete and accurate investigations that could be replicated at a later stage and two recorded incomplete planning. Four of the five teachers drew complete and accurate conclusions.

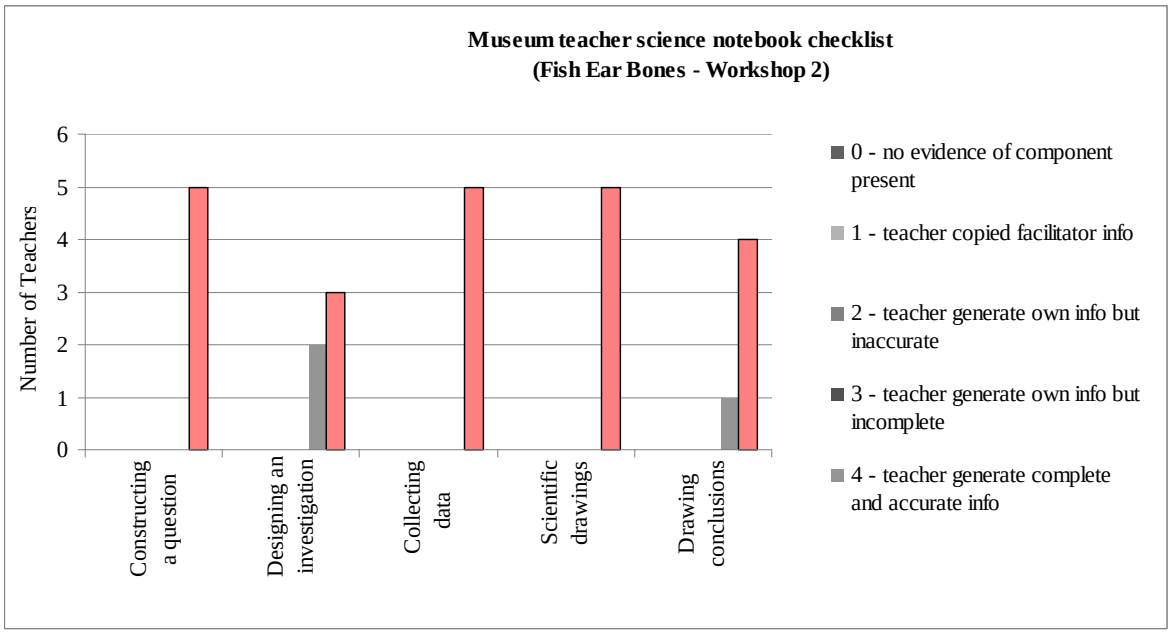

Figure 4.2: Teachers' (n=5) second investigation science notebook data

After this investigation the teachers requested an additional workshop to learn how to remove fish ear bones (otoliths) to extend their "Line of Learning'. A two hour workshop on the techniques of otolith removal was presented by one of the scientists from the Marine Biology Department at Bayworld

Only four of the teachers participated in the third and final workshop. The teachers worked in pairs and conducted two separate investigations on the dolphin skulls. The pairs decided to use a single notebook per pair during this scientific investigation. Therefore the data presented in Figure 4.3 illustrate that all the teachers recorded complete and accurate information. It is evident from the data in Figure 4.3 that by the third investigation the teachers reflected greater consistency in recording all aspects of the investigation. After the investigation each pair used the data collected to formulate and present their arguments.

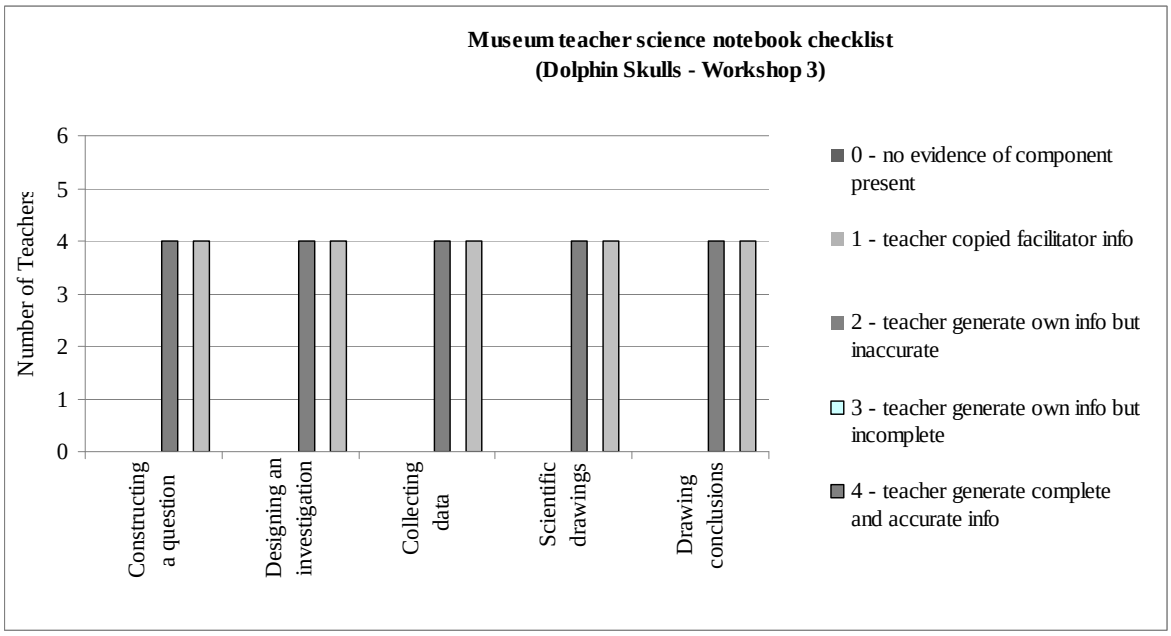

Figure 4.3: Teachers' (n=4) third investigation science notebook data

3.4 Questionnaire

A two part questionnaire (Appendix B) comprised of two sections, firstly open ended and then close ended questions which were completed by the teachers after the training workshops. All bar one, of the teachers completed the questionnaire (one teacher had died after the second workshop). The data generated by the open-ended questions in the questionnaire is presented in Table 4.4. The responses to the open-ended questions suggest that the teachers enjoyed the hands-on nature of the workshops, expressed a need to do more investigations and to learn more about teaching science.

Table 4.4:

Teachers' responses to open-ended questions in the post-workshop questionnaire

Teachers' responses
What they found most helpful in the workshops
Expanding their knowledge Working in groups / Cooperative learning Structure of the scientific approach Steps to conducting and investigation Active involvement / participation
What they liked most during the workshops
Learning a new method to teaching science Doing investigations Think, argue and feeling like a scientist Learning new things Having fun while learning
What they liked least
No comments
Suggested workshop improvements
Need more time for fun like doing investigations Would like to learn more approaches to teach science

In the second part of the questionnaire the teachers were required to respond to nine close-ended questions. All the teachers strongly agreed that after the integrated strategies intervention that the hands-on activities helped them understand the strategy, increased their understanding of scientific literacy, it added to their science knowledge. The group discussions and interaction allowed them greater freedom to participate. Three of the four teachers strongly agreed that they would use the strategy and new concepts learned in their teaching approach. The data generated is expressed in Table 4.5 below.

Table 4.5:

Teachers' responses to the close-ended questions in the post-workshop questionnaire

No.	Questions	Strongly Agree	Agree	Strongly Disagree	Disagree
1.	Hands-on activities helped me understand the strategy	4	-	-	-
2.	Increased my understanding of scientific literacy	4	-	-	-
3.	Prepared to use the strategy in my teaching	3	1	-	-
4.	Prepared to use the concept learnt in my classroom	3	1	-	-
5.	It added to my scientific knowledge	4	-	-	-
6.	Group discussion and interaction allowed me greater freedom to participate	4	-	-	-
7.	My expectations were met	3	1	-	-
8.	Workshop objectives were clear	3	1	-	-
9.	Workshop objectives were met	3	1	-	-

4. LEARNERS INTERVENTION

After completing their workshops and focus group interview the teachers planned the grade six learner's workshops. One grade 6 class from each of the two selected schools attended three consecutive workshops of three hours each at the museum. The participating learners (n=58) completed pre- and post-workshop questionnaires (Appendix E and J),

produced written artefacts in the form of their science notebooks (Appendix G), and the teachers' practices and learner's participation were observed and recorded using an observation schedule (Appendix H).

4.1 Questionnaires

A deliberate decision was made to use two different questionnaires for the pre- and post-workshop questionnaire as the aim was to determine the learner's experiences before and after the interventions. The study focuses on promoting scientific literacy in a museum context therefore the pre-workshop questionnaire focuses on the learner's experiences and perceptions of their previous visits to the museum school. The post-workshop questionnaire focuses on the learner's experience and perceptions of a new way of learning through the integrated strategies approach.

Pre-workshop questionnaire

The questionnaire was completed by the learners at their respective schools before visiting the museum for the workshops. According to the Museum School database records both schools have participated in education programmes offered by the museum teachers for more than five years. The questionnaire, designed by the teachers, had one open-ended and three close-ended questions designed by the teachers to gain an understanding of the learner's experiences during prior visits to the museum school and their perceptions of these visits.

The data illustrated in Figures 4.4, 4.5 and 4.6 below indicates the responses to the three close-ended questions. Responses to question one shows that slightly more than half of the learners (53,4%) thought a visit to the museum was exciting, question two the majority of the learners (70%) indicated that during the museum lessons they listened and answered

questions and (44,8%) said the favourite part of the visit was visiting the live animals and galleries.

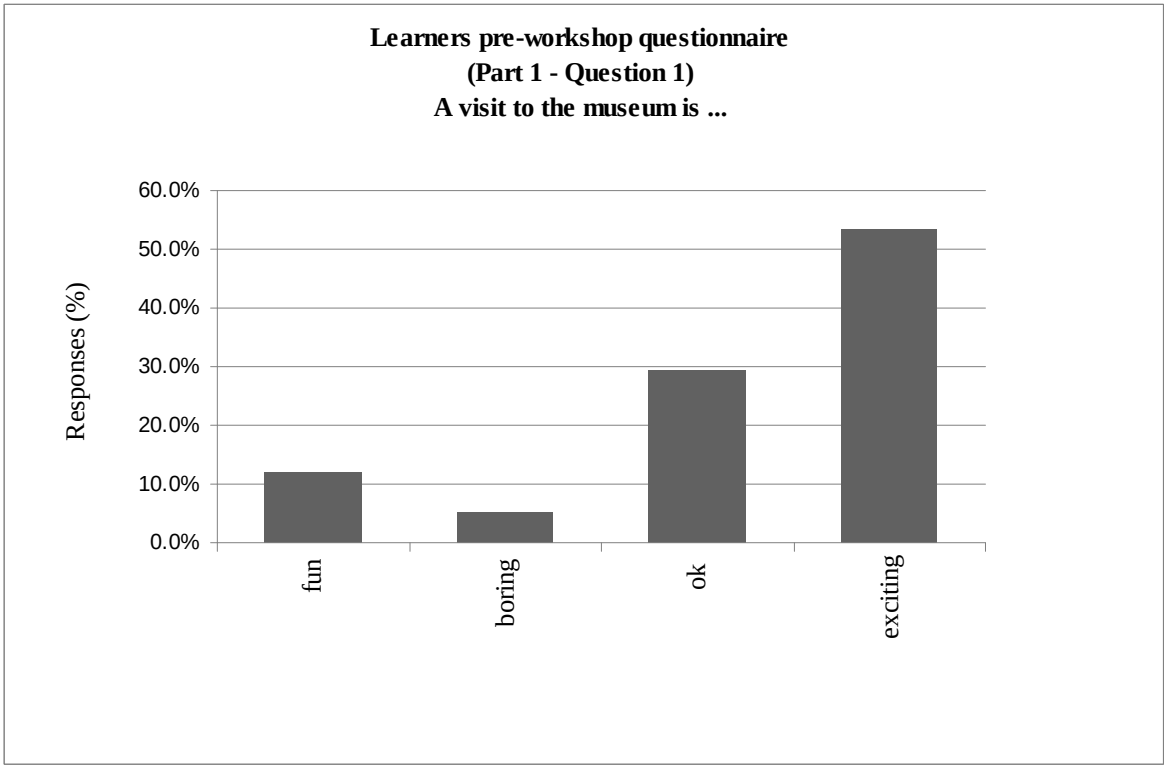

Figure 4.4: Learners' (n=58) responses to question one in the pre-workshop questionnaire

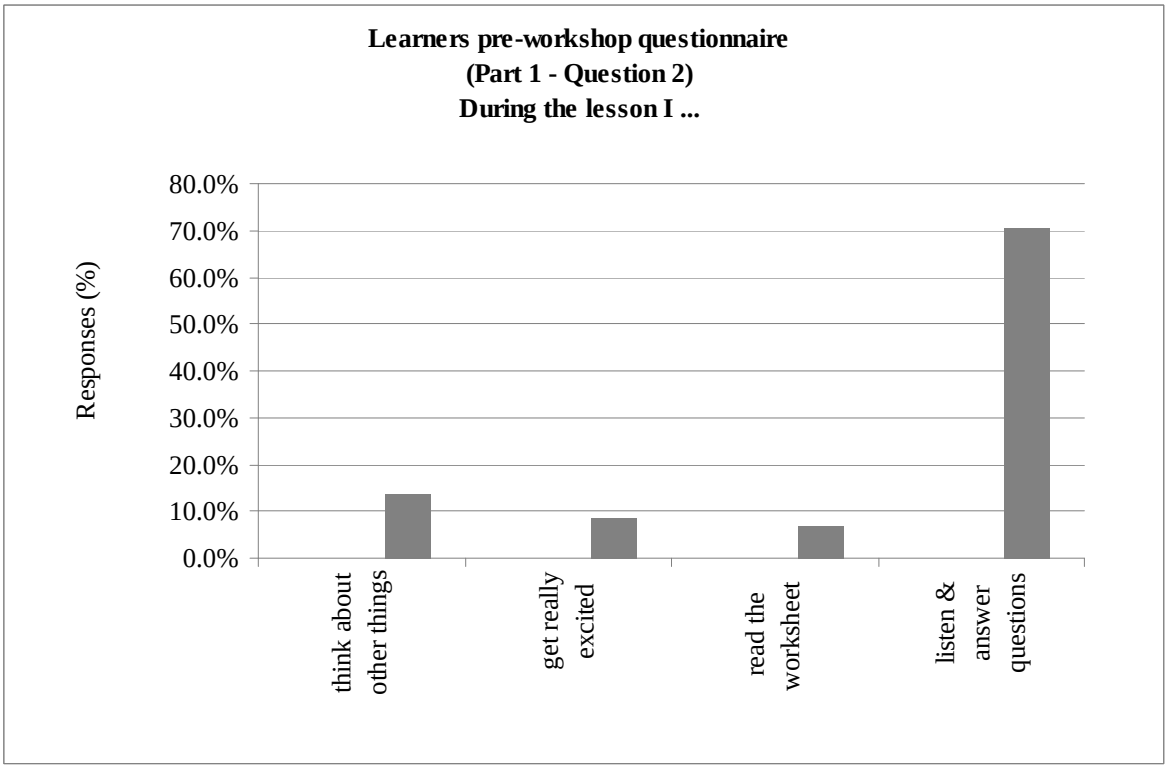

Figure 4.5: Learners' (n=58) responses to question two in the pre-workshop questionnaire

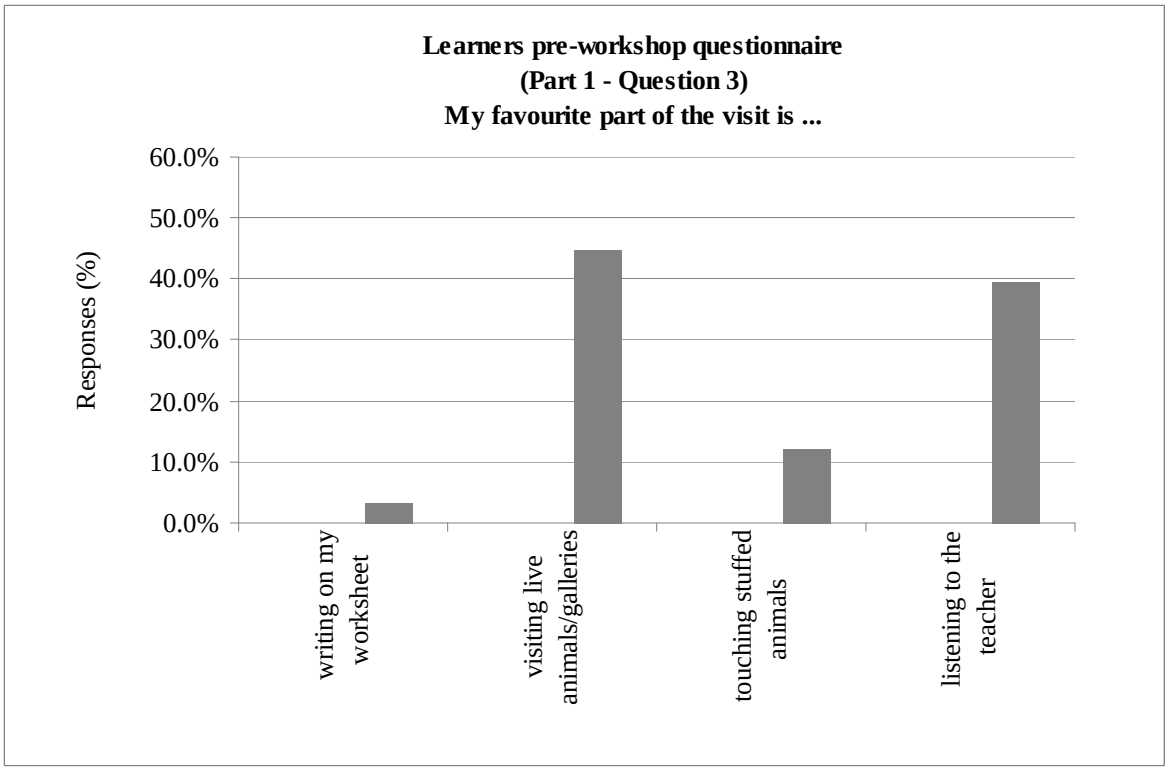

Figure 4.6: Learners' (n=58) responses to question three in the pre-workshop questionnaire

The learner responses to the open ended question suggest that when they next visit the museum they want to see what they hear by visiting galleries and exhibitions, 24% want to see, touch and learn more about living things, 21% would like to participate in learning, 11% learn new things, 5% choose topics, subjects and activities for projects and 3% research, reading, writing and talking.

Post-workshop questionnaire

The post-workshop questionnaire was administered in order to provide insight into the learner experiences and perceptions of the integrated strategies approach which we saw as a new way of learning in a familiar context. The questionnaire had six close-ended questions with a three point rating scale i.e. agree, neutral and disagree (Appendix J). The learner responses are represented in Figure 4.7 below.

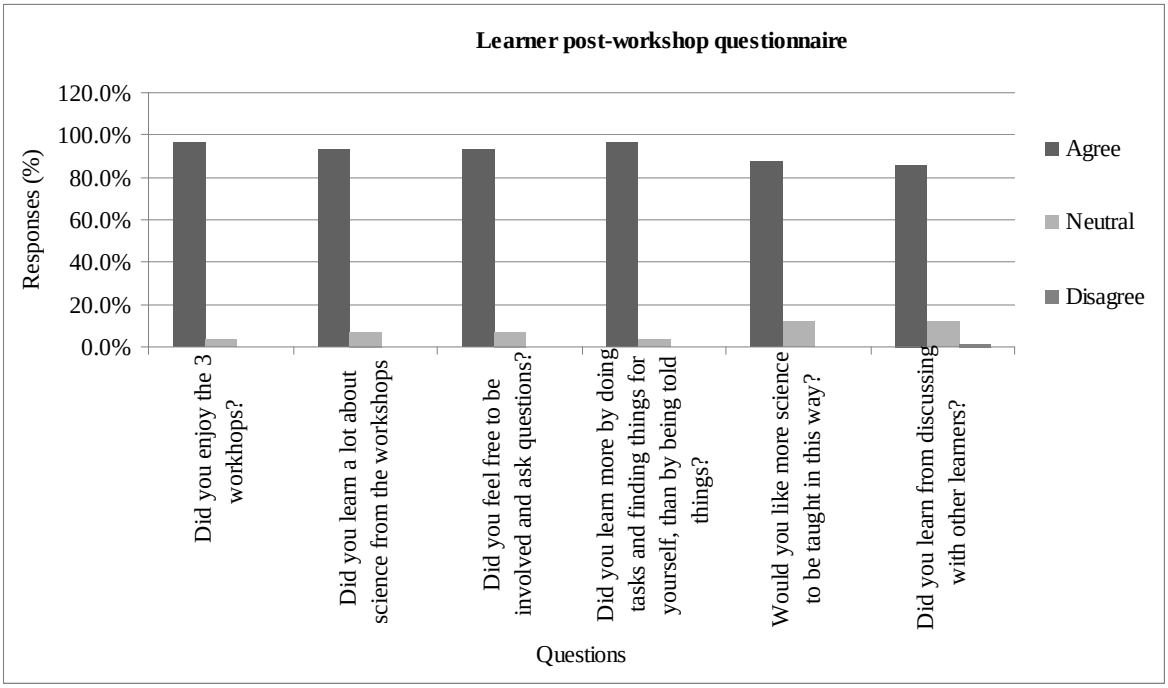

Figure 4.7: Learners' (n=58) responses to the post-workshop questionnaire

The responses to all six questions suggest that the overwhelming majority of learners (+80%) agree that they enjoyed the workshops, learnt a lot about science, felt free to participate, learnt more by doing the investigations, would like science to be taught like this and learnt by discussing with their fellow learners. Less than (10%) of the responses to any of the six questions were neutral.

4.2 Science Notebooks

The learners attended three consecutive workshops presented by the museum teachers; in the first two workshops they conducted investigations and wrote-up the findings in the form of 'science notebooks'. They were required to present their second investigations findings in the third workshop. The same inquiry-based topics used in the museum teachers workshops were chosen for the learner's workshops. The first investigation for both grade six groups was based on the cohesive properties of water. The second investigation was fish ear bones for the first group, while the second group worked on dolphin skulls. Figures 4.8 and

4.9 represents the data compiled using the five components of the notebook schedule (Appendix G) to evaluate the learner's science notebooks. The five components in the schedule includes, C1 - constructing a question, C2 - designing an investigation, C3 - collecting data, C4 - scientific drawings and C5 - drawing conclusions.

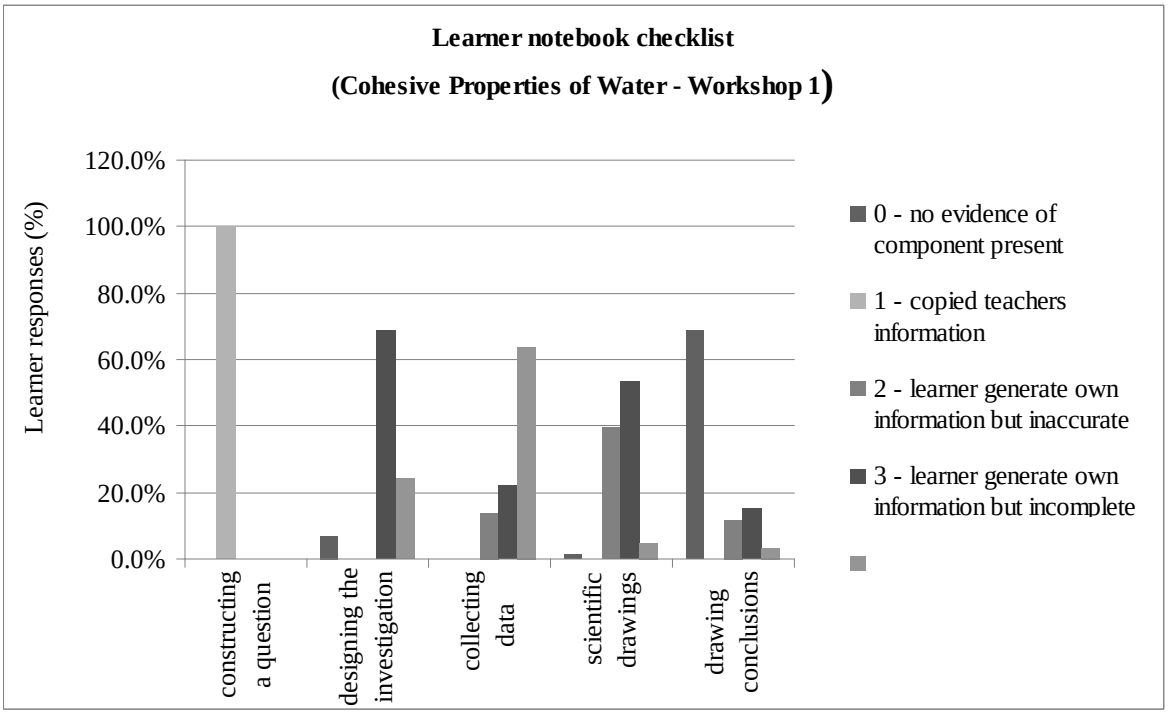

Figure 4.8: Learners' (n=58) first investigation science notebook data

In the first investigation the learners did not formulate an investigable question because one was provided by the teachers. According to the learners this was the first investigation of this nature that they had conducted. The data presented in Figure 4.8 suggest that despite 63,8% of the learners recording complete and accurate data while collecting data, the majority of learners recorded inaccurate or incomplete information while designing the investigation (69%), making scientific drawings (53,4%) and drawing conclusions (69%). This data suggest that the learners were not accustomed to accurately recording all the aspects of their investigations, but found it easier to focus on the collection of data.

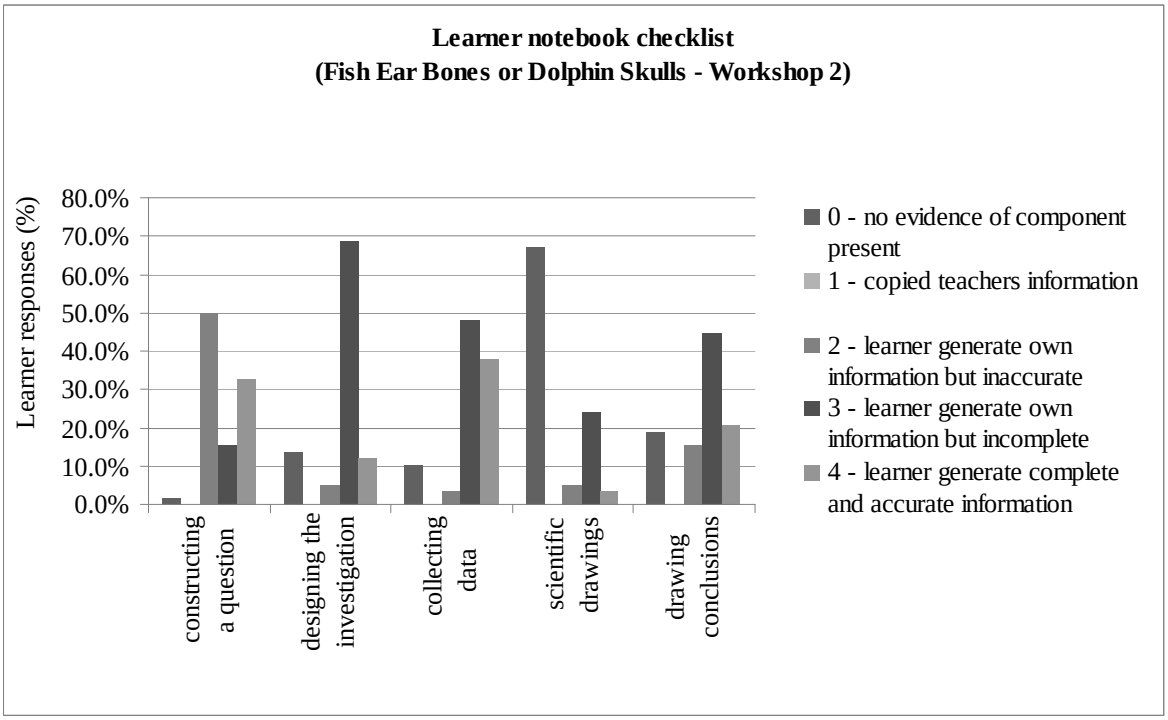

Figure 4.9: Learners' (n=58) second investigation science notebook data

During the second workshop learners were required to formulate their own investigable questions. The data in Figure 4.9 suggest that half of the learners (50%) formulate inaccurate investigable questions omitting relevant details, 15,5% record incomplete information and 32, 8% formulated complete and accurate investigable questions. Only 1,7% of the learners did not formulate an investigable question. The notebooks recorded incomplete information in terms of planning the investigation (69%); collecting data (48,3%) and drawing conclusions (44,8%). The majority of learners (67,2%) made no scientific drawings, 29,3% made incomplete or inaccurate drawings, and only 3,4% were able to produce complete and accurate drawings.

4.3 Observations

Observations of the museum teachers presenting the integrated strategy to the learners, and learners' conducting their investigations and using their science notebooks, were recorded on a classroom observation schedule (Appendix H). The observers included the researcher and the respective class teachers of the two grade six classes. Eight observation schedules were completed, two schedules for each of the two learner investigations conducted. The aim of the observation was to record the activities of the teachers and learners when they conducted their investigations. The observation scheduled used a four point scale for both the teachers and learners observation. The difference in the scale value ranged from four to one, the highest (four) to lowest (one) evaluates the level at which the teachers could apply the integrated teaching strategies approach in the classroom. The instrument is use to examine the teachers use of stimulus (*Component 1*), the formulation of investigable questions (*Component 3*), the planning and doing of investigations (*Component 4 and 5*), questioning skills (*Component 8*), feedback to learners (*Component 9*) and the teachers subject knowledge (*Component 10*) presented in Figure 4.10 . The same instrument was applied to the evaluation of the learners ablity during the investigations to talk (*Component 2*), write (*Component 6*), read (*Component 7*) and present (*Component 11*) what they learned presesented in Figure 4.11. The learner components are presented in italics in the table.

Table 4.6:

Summary of the teacher and learner observation schedule (n=8) scores

Components		**Scores**			
	Component Descriptions	4	3	2	1
C1	Teacher use of stimulus	7	1	-	-
C2	*Learner exploratory talk / discussion*	*5*	*2*	*1*	-
C3	Formulation of investigable question	4	-	4	-
C4	Planning the investigation	4	4	-	-
C5	Doing the investigation	2	6	-	-
C6	*Learner writing with science notebooks*	*1*	*7*	-	-
C7	*Learner reading*	*1*	*7*	-	-
C8	Questioning skills	7	1	-	-
C9	Feedback to learners	8	-	-	-
C10	Subject knowledge	5	3	-	-
C11	*Learner presentations*	-	*3*	*5*	-

The data in Figure 4.6 suggest positive attributes for the way that the museum teachers used stimulus (C1) at the beginning of the investigations, gave feedback to the learners (C9) to encourage further effort and questioning (C8) that explored the learners understanding during the investigations. The teachers provided the investigable question (C3) for the first investigation then successfully guided the learners to formulate their own investigable questions during the second investigation. The teachers facilitated exploratory talk (C2) and the majority of the learners participated in their group discussions while a few were involved with cumulative or disputational discussions preferring to answer questions only. The teachers guided the learners while they did their investigations (C5), but only half of the learners managed to work independently while planning (C4) their investigations and

two or three learners in the other groups engaged in the planning of their investigations. The teachers continuously asked a variety of questions that probed the learners understanding of what they were doing (C8) and constantly provided the learners with encouraging feedback (C9). Although three of the four teachers had no science training or science teaching experience prior the intervention they demonstrated clear understanding (C10) of the concepts being taught. Learners were excited to use the science notebooks, found it challenging doing the investigations and writing at the same time but they made good attempts to record data in their science notebooks (C6) although the text was simplified. The majority of learners (C7) successfully accessed information from the internet to extend their Line of Learning. Through their presentations it was evident that they expanded their knowledge through their own efforts (C11) despite the majority demonstrating partial understanding of concepts taught.

5. CHAPTER SUMMARY

In this chapter the results obtained from the sample of 59 learners and five museum teachers pre- and post reflexive essays, teacher and learner science notebooks, classroom observations and questionnaires are presented. Attention is drawn to the similarities and differences between the teachers pre- and post reflexive essay responses highlighting their understanding of scientific literacy and what they believe schools and museums can do to promote scientific literacy. A change in teaching approach, interactive exhibitions, teacher and learner workshops and establishing links between museum programmes and the school curriculum were indicated as strategies for schools and museum to promote scientific literacy. The teachers' science notebooks revealed that the teachers easily adopted the approach, while the learners' had difficulty in terms of accurately recording all the aspects of their investigations and appeared place greater emphasis on the collection of data. The

classroom observation data revealed that the teachers' constructively used stimuli, questioning and feedback that facilitated learner discussion, as well as being able to promote reading, writing and conducting of investigations.

The museum teachers' focus group interview highlighted their views about adopting the strategy, experiences of learning science, activities to be utilised to implement the strategy and aspects of the strategy most readily adopted by the learners. A difference is noted between the learners' perceptions of visits to the museum school before and after learning through the integrated strategies approach. Before the intervention the majority of learners were excited about visiting the museum, seeing the live animals, listened and answered questions during their lessons. However, after the intervention the overwhelming majority of learners agreed that they felt freer to participate more fully, learnt more by doing the investigations, and enjoyed the integrated strategies approach to promoting scientific literacy.

CHAPTER FIVE

DISCUSSION

1. INTRODUCTION

This chapter examines the primary question in this study, namely "Can aspects of the integrated strategies approach to promoting scientific literacy be successfully employed in a museum context?" This question is answered within a framework of the four sub-questions and the literature review presented in chapter two. The data generated are presented in the same order as the four sub-questions in the study, with each sub-question discussed individually. These questions relate to the museum teachers' ability to adopt the integrated strategies to promote scientific literacy, the effects of the strategy on their view of the nature of teaching and learning towards scientific literacy, the types of activities that support the promotion of scientific literacy in the museum context, and aspects of the integrated strategies approach most readily adopted by learners visiting the museum.

The data used in an attempt to answer the research question were generated using multiple data sources, including the museum teachers' pre- and post-reflexive essays, the teachers and learners science notebooks, a post-intervention teachers focus group interview, a teachers post-workshop questionnaire, classroom observations, learners pre- and post-workshop questionnaires and classroom observation schedule. The findings of the study are reviewed in the light of appropriate literature and explanations are sought.

2. ADOPTION OF THE SCIENTIFIC LITERACY STRATEGY

This section seeks to answer the sub-question which can be loosely phrased as ‘Can (or did) the museum teachers adopt the integrated strategies approach for promoting scientific

literacy that was promoted? Prior to the professional development workshops the teachers wrote a pre-reflexive essay in which they outlined their understanding of scientific literacy as well as their perceptions of what schools and museums could do to promote scientific literacy. They also wrote a post-reflexive essay after the intervention. Their responses to the pre- and post-reflexive essays are presented in tables 4.1 and 4.2 of chapter four. The insights in terms of the pre-intervention reflections are significant as they can be considered to be the perceptions of untrained and inexperienced science teachers before being introduced to the integrated strategies approach to teaching science (Lemelin & Bencze, 2004). The post-reflexive essays, in turn, can be considered to be reflections which reveal which aspects of the strategy the teachers had accepted and internalised.

Casual inspection of the responses in the pre- and post-reflexive essay data suggest that there were differences in the teachers' understanding of scientific literacy and what they believe museums and schools can do to promote scientific literacy before and after the intervention. The pre-reflexive essays responses were broad and often repetitive compared to the more specific responses in the post-reflexive essays. The most obvious change that the data suggested was that the teachers' understanding of scientific literacy moved towards an emphasis on the role of language and science investigations, as would be hoped for after an intervention of this kind. Norris and Phillips' (2003) notion of being able to talk, read and write science appeared to be central to their new understanding of scientific literacy, something which was confirmed during the focus group interview. A variety of literature consulted accentuates that learning is a process of active engagement in a variety of contexts (Donald, 1991; Ramey-Gassert, 1997; DoE, 2002; Tishman, McKinney & Straughn, 2007), a view shared by the teachers after the intervention, and which suggests that this approach to promoting scientific literacy is as viable in the museum as it has been with teachers in 'normal' schools (Colvill & Pattie, 2002; Pearson et al., 2010, Webb, 2010).

The post-reflexive essays suggest that the participating museum teachers felt that all their expectations of the workshops were met. They attributed their newfound confidence in terms of adopting the integrated strategy to promoting scientific literacy in the museum context to their participation in doing investigations, talking, reading and writing; activities highlighted by Pearson et al., (2010) and Webb (2010) as strategies essential for successful implementation of an integrated approach to science teaching and learning. The positive experiences they had experienced stimulated the museum teachers to formulate more questions than answers as investigations progressed, and active participation, in this case conducting investigations (see Appendix K), appeared to be the catalyst for positive experiences and improved attitudes. Their comments suggest that they understood that there needed to be a shift in teaching approach and practice from content acquisition and basic skills, the most common South African teaching approach (Villanueva & Webb, 2008), to learning guided and paced by the learner's interest and knowledge (Paris et al., 1998). Such an approach requires a move from the ‘teacher-talk and tell' to teachers guiding the learning process and encouraging learner participation and is both implicit and explicit in the strategy adopted in this study.

As noted above, scientific investigations and the use of authentic specimens, together with planning, reading, writing, and discussing were seen to be important confidence boosters which both seen to have encouraged the teachers’ participation and promoted their levels of scientific literacy (Norris & Phillips, 2003; Braund & Reiss, 2006; Webb 2010). More specifically, they enjoyed doing what scientists do by touching, seeing, and smelling authentic artefacts, but recognised that they often needed to be reminded to record all activities in their science notebooks, something also noted by researchers such as (Paris, Yambor & Wai-Ling Packard, 1998; Villaneuva & Webb, 2008).

The fact that they felt that authentic specimens are important to the process is borne out by their request for an additional workshop to learn to remove fish otoliths (ear bones), during which they stated that they had fun while learning science and learning and experiencing the new method of teaching science. These findings bear out the suggestion that learning in a museum can have a potentially profound influence on learners' knowledge, understanding and motivation to learn (Anderson, 1997; Arinze, 1991; Bell et al., 1989; Chase, 2002; Hofstein & Rosenfeld, 1996; Screven, 2002). The interview data suggest that the hands-on approach to learning science increased the museum teachers' understanding of scientific literacy, as well as their understanding of the integrated strategy. The teachers' responses also revealed that group participation, learning the steps to conduct a scientific investigation, and expanding their knowledge was what they enjoyed most. Such responses indicated their preparedness to adopt the integrated strategies approach to promoting scientific literacy and towards adopting into their practice new concepts learnt. They also noted that group work and discussion promoted their enthusiasm towards using the approach.

The five components were recorded in the museum teachers' science notebooks during the three investigations undertaken. The data in the notebooks revealed instances of complete and accurate formulation of investigable questions, data collection, and scientific drawings in most cases (see Appendices L, M1 and M2). An investigable question was provided to the teachers for the first investigation, but all of the teachers formulated complete and accurate investigable questions in their second and third investigations. Imbalances between the complementing roles of the cognitive and procedural aspects in the investigations were reflected as incomplete or inaccurate planning of their investigations (Webb, 2007) – at times incomplete or inaccurate information was recorded in terms of planning the initial investigations and/or formulating conclusions. The teachers recognised during the post-intervention interviews that a balance between talking, doing science and

writing to develop scientific literacy was not attained (Norris & Phillips, 2003), but they felt that this issue was less important than the fact that the investigations stimulated their natural curiosity and resulted in a focus on doing the investigations (Paris, Yambor & Wai-Ling Packard, 1998). They also noted the power of science ‘notebooking' as a teaching tool for investigations to both learn science and develop writing skills (Nesbit et al., 2004), and that they felt that the investigations had developed their cognitive abilities through formulating investigable questions, recording data and explaining their findings (Hein, 1991).

A classroom observation schedule was used while observing the teachers present the integrated strategy to the visiting classes of children. The majority of teachers successfully used stimulus, questioning and feedback strategies to enthuse and motivate the learners during the workshops. The teachers successfully made use of visuals, objects, reading and questioning to stimulate involvement (Millar, 1994; Lind, 2001). Furthermore, their successful use of questioning and regular feedback encouraged the learners to discuss, observe, and conduct authentic investigations (Xanthoudaki, Tirelli, Cerutti & Calcagnini, 2007). Together with the stimuli provided, the teachers encouraged exploratory talk that facilitated planning and the execution of the learner investigations (Webb, 2007). However, the promotion of exploratory talk remained, with the formulation of an investigable question, one of the most difficult aspects of the strategy to promote (Webb & Treagust, 2006) as at least a quarter of the learners engaged in disputational or cumulative talk only during their investigations. The teachers demonstrated clear to adequate understanding of the concepts being taught but, despite what the teachers expressed as their "best attempts' to implement all aspects of the strategy, their enthusiasm to do the investigations got in the way and resulted in a ‘rushed' approach where a balance between the learners talking, doing and writing was not maintained

3. THE NATURE OF TEACHING AND LEARNING

The second sub-question in this study is "If the strategy is adopted by the participant museum educators, how does it impact on their current pedagogical paradigm with regard to the nature of teaching and learning towards scientific literacy?" To answer this question data were again generated through the teachers' focus group interview, the classroom observation schedule, the teachers' post-workshop questionnaire and their science notebooks. These data were inspected in order to better understand the impact on their perceptions of teaching and learning towards scientific literacy.

During the focus group interview the teachers indicated that their perceptions of teaching and learning science had been influenced by both what they experienced in their own workshops and the lessons they presented to the children. The teachers believed that the approach, attitude, enthusiasm and planning by the teacher is important when teaching towards scientific literacy. The adoption of the integrated strategies approach was reported as "learning that made sense" and "unlike anything they had done before". Colvill and Patti (2002) note that the acquisition of science skills is challenging therefore, it is personally challenging for teachers (particularly non-specialists) to adapt the way they teach science. Pearson et al. (2010) see integrating science and literacy teaching methods was a fruitful way to meet such a challenge. This notion is supported in this study as the teachers felt that adopting the integrated strategies in a museum context can be fun, rewarding and exciting, a notion also purported by Braund and Reiss (2006).

The data generated via the focus group interview further suggests that the teachers altered the way they normally taught by facilitating learning through talking less, letting go of the need to control, and by guiding the learning process. They described learning through the integrated approach as ‘structured but not restricted'. This point was supported by their

response, in their post-workshop questionnaire, that the ‘the structure of the approach', ‘steps' to conducting an investigation and ‘active participation' during investigations were most helpful. During observations it was noted the teachers attempted to guide the learners during investigations in planning, use of apparatus, data collection and writing in their science notebooks, although it was noted that at times they rushed some of the activities. Observations revealed that the learners' interest was evident and that their eagerness to participate in the investigations resulted in fairly detailed and illuminating findings (see Appendices N, O1 and O2). Setati, Adler, Reed & Bapoo (2002) record South African learners are accustomed to being passive with the teacher doing all the talking, and the children who took part in this study agreed that the approach used was new and refreshing to them.

Arinze, 1991; Chase, 2002; and Screven (2002) assert that the inquisitiveness, discovery and free exploration that become evident during practical activities (in this case of conducting scientific investigations in a museum context) are the result of the power and influence of authentic objects. However, Webb (2010) cautions, although hands-on activities are necessary they should be balanced with planning, reading, writing, discussion and argumentation. This statement is supported by the data generated via the post-workshop learner questionnaire, where the learners’ suggested that they learnt most about science by doing tasks, discussing with their peers and finding out things for themselves. Classroom observations suggest that the approach used served to both wet their appetites for learning science and provide the children with a structured opportunity to plan, read, write, discuss and do investigations (Webb, 2010). The teachers suggested during the post-intervention interview that more frequent investigations would have the potential to increase learner confidence, speed up the way they work and learn more about science in the process.

During the pre- and post-intervention interview the teachers' views on the nature of teaching towards scientific literacy were solicited. There was a clear shift in their attitudes towards careful planning, focussing on the process of learning and effective time management from before to after the intervention. These assertions were supported by classroom observation and the records in their science notebooks. These sources show that their confidence increased with each investigation. During the post-intervention interview they were emphatic that learning must be structured, but not restricted. They also said that they wanted to use the integrated strategy as it "makes sense as it has the potential to alleviate learner boredom and frustration as well as bolster confidence and the learners' desire to want to know more". Such utterances give explicit meaning to Tishman, McKinney & Straughn's (2007) reference to learning being a process of active participation in a variety of contexts. In the case of this study it was the museum which provided the context in which meaning was constructed.

Pearson, et al. (2010) suggests that when learners are not engaged in science learning they are passive and rely on the teachers for science knowledge. The observation data suggests that the teachers were enthusiastic in their use of stimuli, questioning skills and in providing feedback to encourage their learners. The data also indicate that the majority of learners accepted the guidance given in terms of the use of the apparatus during investigations, and how to record text in their science notebooks. However, the learners' oral presentations of their findings demonstrated only superficial understanding of the concepts investigated, suggesting that they probably needed more time and guidance in reading, analysing and internalising other sources of information. This observation supports suggestions that it is important that a balance between investigations (practice) while recording (writing) what is learnt (theory) and stimulating children's' interest in the world around them should be maintained (Krajcil & Sutherland, 2010). With adequate support

teachers should be able to motivate learners to work productively through meaningful interaction in this manner (Pearson, et al. 2010).

4. ACTIVITIES THAT SUPPORT THE INTEGRATED STRATEGY APPROACH

The third sub-question, namely, "What is the nature of the types of activities that can be utilised to support the integrated strategies to scientific literacy in the museum education transaction?" is discussed below. In this study an approach was used that emulates what scientist do; namely read, talk, formulate a question, plan an investigation, do investigation, argue and present findings. Before attending the workshops at the museum the learners completed a questionnaire at school about their perceptions of their previous visits to the museum school. Their responses to the first part of the pre-workshop questionnaire (close-ended) reveal a small percentage of learners thought a visit to the museum school was boring and during lessons they thought about other things or read the worksheets while the teacher talked. They enjoyed most the interaction with museum teachers, live animals and one another in the galleries.

In this study fish otoliths and dolphin beaks were used to stimulate interest. The learner responses to the second part of the pre-workshop questionnaire (open-ended) highlighted the significance of the use of authentic objects in museums (Hofstein & Rosenfeld, 1996). Their responses indicated that they would like to visit galleries, touch and learn about living things, and actively participate in learning. Numerous researchers (Chase, 2002; DeWitt & Osborne, 2007; Hofstein & Rosenfeld, 1996; Ramey-Gassert, 1997) suggest that learning takes on greater meaning when members of a group interact with one another using real objects to complete a task or answer a question. During the post-intervention interview the teachers described learning inquiry science as interactive, hands-on and

exciting. In the teachers post-workshop questionnaire they all strongly agreed that the hands-on activities helped increase their scientific knowledge, literacy and understanding of the strategy as well as facilitating participation, discussion and interaction within their groups. They pointed out in the post-intervention focus group interview that it was "fantastic to be able to learn together", "support within a group is great" and the things "seen, touched, smelt or heard' during the investigations made learning easier because it felt like "ordering" or "reorganising" things already known. The teachers highlighted writing and representing data (drawings and graphs) during the investigations and indicated that it "affords teacher' the opportunity to monitor the learners' progress".

During the lesson observation it was noted that the teachers facilitated exploratory talk and the majority of learners participated in group discussions, made good attempts to write in their science notebooks while doing the investigations and successfully accessed information to extend their Line of Learning. The data in the learners' science notebook supports the classroom observation data that suggest despite the learners' enthusiasm, they found it challenging to write at the same time while doing the investigations. Although the majority demonstrated only partial understanding of the concepts taught they did expand their knowledge through their own efforts. The learner post-workshop questionnaire responses suggest that the overwhelming majority enjoyed the workshops, learnt a lot about science and would like science to be taught in this way in the future. Their responses further indicate that they were comfortable with being involved, asking questions, discussing with their friends and that they learnt more by doing the task. Cameron (1971) purported that museums should be places that stimulate debate, discussion, pose questions and find answers. In meeting these needs museums are gradually adapting their roles and functions (Donald, 1991).

The responses generated in the teachers pre- and post-reflexive essays presented in Table 4.3 of chapter four highlight the types of activities discussed above as well as activities for schools and museums that can be utilised to support the integrated strategies to scientific literacy in the museum education transaction. Museums have the advantage of changing the teaching approach and create greater synergy between their programmes and the school curriculum to promote effective learning (Arinze, 1991; DeWitt & Osborne, 2007). The responses in the teachers' reflexive essays suggest museum links with schools and universities to present workshops to conduct investigations using authentic objects, and engaging with museum staff or specialists at the museum provide unique learning experiences and great potential for education (Bell et al., 1989; Chase, 2002; DeWitt & Osborne, 2007). Gardner (1991) suggests that such efforts have the ability to engage and stimulate learners to take responsibility for their own learning.

5. STRATEGIES ADOPTED MOST READILY BY LEARNERS

The fourth and final sub-question, "*Which aspects of these strategies do learners visiting the museum adopt most readily?"* During the focus group interview the teachers indicated that "children love being involved" and that "doing is fun". Classroom observations suggest that the activities employed while teaching investigations did engage children and that the investigations (doing science) did stimulate their natural curiosity; and that the authentic specimens did intrigue and fascinate learners resulting in discovery and exploration (Paris, Yambor & Wai-Ling Packard, 1998). The overwhelming majority of learners in the post-workshop questionnaire agreed that they learnt more by doing the tasks and finding things for themselves and would like more science to be taught in this way (see Appendix N). In the focus group interview the teachers said that it was their opinion that "self discovery is learning" and that "reading, writing and talking" helped the children to learn via active

engagement (Tishman, McKinney & Straughn, 2007). They also believe that development of the literacy aspects including talking, reading and writing for scientific literacy are important and can be developed through scientific investigations (Norris & Phillips, 2003; Yore & Treagust, 2006; Pearson et al., 2010). However, the teachers' statement about the literacy aspects of the strategy was not supported by the learners as only two out of 58 respondents to the questionnaire alluded directly to reading, writing and talking as being important in the process. Nevertheless, data generated via the teacher group interview, learner post-workshop questionnaire and classroom observation schedule show that the majority of the children participated in group discussions (and the teachers noted the importance of this aspect of the strategy). DeWitt and Osborne (2007), Donald (1991), Webb and Treagust (2006), and Yore and Treagust (2006) all note that discussions promote social engagement, promote learner focus, and improve their problem solving abilities. Classroom observations in this study revealed that the teachers did facilitate exploratory talk and were able to decrease the level of learner disputational and/or cumulative talk during the contact sessions.

The initial science notebook entries suggest that the learners were not accustomed to accurately recording all the aspects of their investigations, but found it easier to focus on the collection of data (see Appendices O1 and O2). Although the learners were excited to use the science notebooks they found it challenging writing and doing investigations at the same time. However, they made good attempts to record data in their science notebooks using simple text and diagrams and observational and questionnaire data showing that they enjoyed the hands-on nature of the integrated strategy approach to learning science. The strategies most readily adopted by the majority of learners during the intervention was doing what scientists do: conducting investigations, asking questions, discussing with fellow learners, writing in their notebooks and presenting their conclusion to their peers.

6. CHAPTER SUMMARY

In this chapter the purpose of the study, namely, an investigation of whether the participating Port Elizabeth museum teachers could implement the integrated learning strategy to promote scientific literacy in a museum context, is noted. The qualitative and quantitative data gathered through the various instruments during the study are considered with respect to the four sub-questions which underpin the main research question. Firstly, the ability of the museum teachers' to adopt the integrated strategies approach to promoting scientific literacy in a museum context was examined. Secondly, the effect of the strategy on the teachers' view of the nature of teaching and learning after their adoption of the scientific literacy strategy was considerable. Thirdly, the types of activities that can be used to support the employment of such a strategy within a museum context were outlined and finally, the aspects most readily adopted by visiting learners during the implementation of the integrated strategies approach was summarized.

In this chapter reference is made to the ability of teachers to adapt their teaching approach when provided with support (Lemelin & Bencze, 2004), as are opportunities presented by teaching and learning in a museum context (Braund & Reiss, 2006). The role of literacy skills in the development of scientific literacy (Webb, 2010; Pearson et al., 2010), and significance of the relationship between the natural curiosity of children and learning through self discovery (Paris, Yambor & Wai-Ling Packcard., 1998; Tishman, McKinney & Straughn, 2007), are considered.

CHAPTER SIX

CONCLUSION

1. INTRODUCTION

Although museums are synonymous with education the challenge worldwide is to adapt their roles and functions to respond to the demands of changing times (Anderson, 1997). The role and function of South African museums have come under the spotlight since new political dispensation in this country (Lelliott, 2009). One of the challenges has been to respond to the changing needs of the education system (Department of Education, 2002). DeWitt and Hohenstein (2010a) state that museums are ideally positioned to respond to the challenge of providing learning opportunities not available in schools and Ramey-Gassert (1997) believes that museums can adapt their roles and functions by incorporating new teaching strategies into their education programmes.

Lelliott (2009) suggests that in the South African context museums are in a transformation phase. In an attempt to help a particular museum respond to transformational imperatives, and a perceived need to promote scientific literacy as one of its educational purposes, this study investigated the possibility of introducing a literacy reading, writing, talking, doing approach when working with visiting schools. Aspects of this approach, namely the integrated strategies approach (Webb, 2009), have been reported on by a number of international science education researchers, for example Krajcik and Sutherland (2010) and Pearson et al. (2010). These authors, amongst others, believe that learners can be helped to acquire science skills, and that teachers can be assisted to adapt the way they teach, by developing teaching strategies which improve learners' basic literacy skills.

2. MAIN FINDINGS

This study revealed that the attitudes of teachers and learners towards learning science improved as a result of their active participation in the learning process that was employed. A consequence of the teachers' engagement and positive experiences during the learning process was their ready adoption and implementation of the integrated strategy when working with the visiting learners. Group work increased teacher confidence and facilitated their preparedness to host the learner workshops. Their motivation in wanting to know more by way of extending their own Line of Learning is also linked to the support they experienced while learning. Careful planning, clear goals and focusing on the learning process are ingredients for successful learning interventions, as observed during this study. This aspect of the process was evident from the way in which the teachers formulated insights and strategies to effectively provide learning experiences for the children (Pearson et al., 2010). The teachers' attitude, passion and approach during the learner workshops were seen to be important in enthusing and motivating the learners. The perception of their role as knowledge provider was seen to be altered after the intervention to that of knowledge facilitator and guide, and it was clear that the teachers invested considerable time and effort which resulted in personal development, as revealed via the data generated by the research instruments used in this study. There was a move away from a focus on content acquisition and basic skills to investigations using authentic objects and catering for genuine interests. A natural consequence of doing such investigations appears to have promoted greater confidence in the teachers in terms of engaging in science activities.

The approach of being guided by the interests of the learners was affirmed in this study and is a process supported by current literature (Pearson et al., 2010). The children felt that they learned more by doing the actual scientific investigations, and expressed a desire for

a paradigmatic shift from the 'teacher-tell' approach. The authentic objects, including the live animal exhibitions, were noted as being stimulants of the natural curiosity of the learners and of their motivation to learn. There was however an imbalance between the cognitive and practical aspects of the investigation, with the children's' focus being more on doing the activity than recording it (both the procedural aspects of the investigation and the new knowledge that they developed). Webb and Villanueva (2008) assert that continued participation in investigations should afford opportunities to correct such imbalances between doing investigations and recording activities. As such, it does appear that aspects of the integrated strategies approach to promoting scientific literacy can be successfully employed in a museum context, the primary question of this study. It might also be the case that the facilitation and encouragement of this kind of learning within a museum context can be claimed to be a contribution to the ongoing transformation of museums within South Africa

3. LIMITATIONS OF THE STUDY

The findings of this research cannot be projected across the eclectic group of schools in South Africa that comprise the current constituency that visit the museum education programme. Nor can the findings be generalised to all South African museums, which have different contexts and settings. The sample was limited and the duration of the intervention was short (six months). A broader range of schools, topics and museums would contribute to a better understanding of the possibilities inherent in the process, and of the process itself within museum settings.

However, the findings of this study should be of interest to museums running similar museum programmes and, although the findings cannot be projected across a broad spectrum of schools that visit museums, they are useful as a starting point. As schools contexts are different, the findings should not be seen as a model for all normal classroom settings.

However, the data do appear to support the earlier findings of South African researchers in this field (Webb, Williams & Meiring, 2008; Villanueva & Webb, 2008), and should make a contribution to the debate around the educational roles of museums and the promotion of scientific literacy.

4. IMPLICATIONS FOR FURTHER RESEARCH

It becomes apparent from the literature review of this study that learning in a museum context may have a profound influence on the knowledge and understanding of learners as well as their beliefs, attitudes and motivation to learn. Work by Hofstein & Rosenfeld (1996), Ramey-Gassert (1997), Chase (2002), Screven (2002) and DeWitt & Osborne (2007) suggest that museums are ideally positioned to support both formal and informal learning. It is important that more attention is given to the acknowledgement and development of the educational role these institutions can play in complementing school based education.

An appropriate challenge for South African museums could be to determine how they can implement the integrated strategies approach to promote scientific literacy through the rich cultural and oral traditions of indigenous peoples, for example isiXhosa speakers in the Eastern Province, who constitute 80% of the provincial population (South African Government, 2010). These indigenous knowledge systems directly impact on South African exhibitions (Department of Science and Technology, 2007). In this way it may be possible for a museum to impact on a community that has previously been marginalised by adopting an approach to teaching and learning that is introduced within a framework of explicit cultural recognition.

The natural science curriculum in South Africa promotes scientific literacy and museums in this country, as noted earlier, are in a transformation phase due to an agenda

determined by a changing political landscape. Lelliott (2009) believes that science learning in museums present opportunities to explore additional skills that would aid teaching praxis and the pedagogical endeavour. Although it is clear that museums must respond to the changing needs of an evolving education system, they are not schools. Nevertheless many museums have former school teachers in their education departments developing teaching resources which complement the school curriculum. This suggests that the educational and motivational aspects of museum programmes are ripe for research interventions that focus on the application of new teaching theories.

Results in this study indicate the need to focus on the literacy aspects of science with a view to ensuring and promoting effective science learning and teaching (Norris & Phillips, 2003; Yore & Treagust, 2006). Research should examine how the cognitive tools and communication abilities of children can be unlocked and developed to ensure the promotion of scientific literacy, and research the impact of these strategies on teaching and learning. Comparison of the implementation of the integrated strategies approach could potentially generate data that result in further comparison of learners from a broader range of museums schools. Possibly this work would contribute to demystifying science as only the province of the privileged, and provide more light on how museums can contribute to the process.

Finally, this study deals with only one aspect of the national curriculum namely, natural science, and the approach has an implicit emphasis on utilising current understandings of the nature of science (Norris & Phillips, 2003; Yore & Treagust 2006). The question is whether the integrated strategies approach to learning science can be applied to other learning areas, taking into account the underpinning notions of the nature of the knowledge area concerned.

5. CONCLUDING REMARKS

Museums play an important role in science education and are places of learning where children can develop their understanding of science (DeWitt & Osborne, 2007). They are providers of both informal and formal learning and, as noted earlier, are synonymous with education. Museums can also provide support for teachers by way of professional development. As such, Department of Education officials and teacher trainers should be aware of the educational propensity and potential presented by museums as providers of different kinds of learning otherwise not available in the classroom, but which complement the school curriculum in various learning areas (DeWitt & Hohenstein, 2010a).

The findings of this study suggest that museums should probably engage more meaningfully with teachers and encourage them to work with them to promote important social issues, such as scientific literacy (Lelliott, 2009; Lemelin & Bencze, 2004; Pearson et al., 2010). One definition of scientific literacy is framed within the ability to make effective decisions as consumers, members of the electorate and society (Krajcik & Sutherland, 2010). Further to this description, Norris and Phillips (2003) draw a distinction between the fundamental and derived sense - something that requires learners to be competent in science language, thinking, and the ability to make informed decisions on matters pertaining to matters scientific and the public, respectively. If museums in South Africa wish to respond to the challenge presented in the national natural science curriculum to promote scientific literacy, which includes science investigations as one of the main learning outcomes, the stakeholders in control of museums and education should bear in mind the role and functions of museums as disseminators of knowledge. Ongoing research into the support potential of museums for formal and informal learning, as well as the influence on the knowledge and understanding of learners appear to be important, as is the disclosure of such research

findings to all stakeholders as synergy between museums, schools and education officials could only benefit education in general, and the promotion of scientific literacy in particular.

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APPENDICES

APPENDIX A:

Museum teachers pre- and post workshop reflexive essay

Instructions:

Write a short essay on what you think it is to be scientifically literate, what schools can do to promote scientific literacy, and what museums can do to promote scientific literacy.

APPENDIX B:

Museum teachers post workshop questionnaire

As a participant, your perceptions about these workshops are important to us. Please take a few minutes to offer feedback. Thank you!

OVERALL WORKSHOP

1. What part of the workshops was most helpful to you?

_____

_____

_____

2. What did you like most about the workshops?

_____

_____

_____

3. What did you like least about the workshop?

_____

_____

_____

4. How could the workshops be improved?

_____

_____

_____

Please tick (√) the appropriate block

	Strongly Agree	Agree	Disagree Strongly	Disagree
PARTICIPANT				
The hands-on portions of the workshops have been helpful to me in understanding the strategy discussed.				
The presentation has increased my understanding of scientific literacy.				
I am prepared to attempt to use the strategy in my teaching.				
I will use the concepts presented in my classroom.				
These workshops have added to my scientific literacy knowledge.				
The group discussions and interaction allowed me greater freedom to participate.				
OBJECTIVES & EXPECTATIONS				
The workshop expectations were met.				
Objectives were clear.				
My expectations were met.				

APPENDIX C:

Museum teachers focus group interview

Instructions:

The researcher leads the discussion with the group of museum school teachers.

Before the professional development workshops to:

A. Formulate their expectations of the planned workshops

After the professional development workshops to:

B. Reflect on the expectations they formulated prior their workshops.

C. Experience of the workshops
    a. What was your experience of the workshops and what did you learn?

D. Views about adopting the strategy
    a. What is your opinion about the integrated strategy to promote scientific literacy?
    b. As a teacher, what do you think you will do to use / implement the strategy effectively?

E. Learning about science
    a. What did you learn about science?
    b. How did you feel doing investigations?
    c. Working in groups:
        i. What did it feel like working in groups?
        ii. What were your experiences and thoughts?

F. Museum context
    a. In your opinion, can the strategy be implemented in a museum?
    b. If it can be implemented, how will you make it happen? What will you do to implement it in the museum?
    c. Identify some challenges you will face implementing the strategy.

APPENDIX D:

Learners pre – workshop questionnaire

Instructions:

The questionnaire is completed by learners before attending the workshops (Scientific Literacy Strategy) to record their perceptions of the current education strategy at the museum.

What I think about visiting the Port Elizabeth Museum School (Bayworld)?

Read each statement and circle your answer

1. A visit to the Museum School is
   a) fun
   b) boring
   c) OK
   d) Exciting

2. During lessons at the Museum School I
   a) Think about other things
   b) Get really excited
   c) Read the worksheet while the teacher is not looking
   d) Listen and answer the teacher's questions

3. My favourite part of the visit to the Museum School is
   a) Writing on my worksheet
   b) Visiting the live animals and galleries
   c) Touching the stuffed animals in the class
   d) Listening to the teacher

When I visit the Museum School next time, I would like to

_____

_____

_____

_____

APPENDIX E:

Science notebook exemplar used during learner workshops

My Investigation

The Question ?

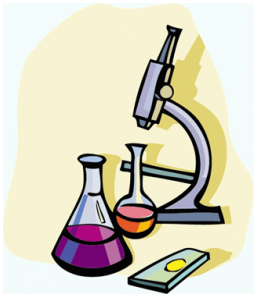
My predictions (What do I think will happen?)

1

Plan the investigation (What are you going to do?)

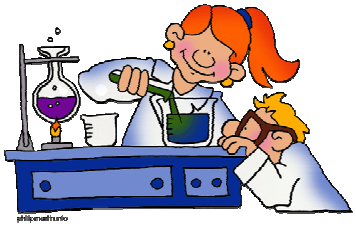
2

Equipment needed (What will we need for the investigation?)



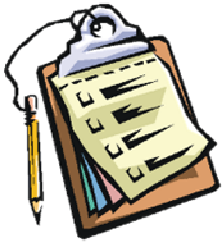
3

Method (What I did?)



4

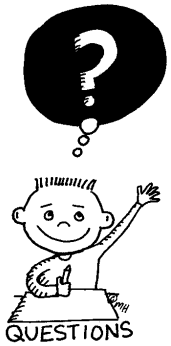
Results (What I found out?) **Write and Draw**



5

Draw your Line of Learning

Why did this happen?



What else can I learn from this?

APPENDIX F:

Science notebook checklist

Teacher's Name: _____ School: _____

Learner: _____

Constructing a Question	How well does the learner construct an investigable question?				
Investigable question	0	1	2	3	4
	There is no evidence of a question	Learner copies teacher's question	Learner writes a question using his/her own words. Question is not investigable	Learner writes an investigable question using his/her own words. The question is missing important details	Learner writes an investigable question using his/her own words. The question has all the relevant details
Comments:					

Designing the investigation	How well does the learner design and implement a plan to answer the question?				
Experimental Procedure	0	1	2	3	4
	There is no evidence of what was done	Learner copies teacher's sequential procedure	Learner writes a plan using his/her own words. Plan is incorrect for answering the question	Learner writes a plan correctly using his/her own words, but plan is missing details. Investigation cannot be replicated.	Learner writes a plan correctly using his/her own words. It contains relevant details. Investigation can be replicated.

Comments:	

Collecting Data	How well did the learner record data?				
Testability	0	1	2	3	4
	There is no evidence of data collection	Learner copies teacher's data	Learner records his/her data. Data are not accurate.	Learner records his/her own data. Data are accurate, but incomplete.	Learner records his/her own data. Data are complete and accurate.
Comments:					

Scientific Drawings	How well does the learner draw their observations?				
Experimental Procedure	0	1	2	3	4
	There are no drawings	Learner copies teacher's drawings	Learner produces original drawings. They are not labelled correctly. Drawings have no relevant detail.	Learner produces his/her own drawings which are labelled and have limited relevant detail.	Learner produces his/her own drawings which are correctly labelled and have relevant detail.
Comments:					

Drawing Conclusions	How well does the learner construct scientific meaning from the investigation?				
Experimental Procedure	0	1	2	3	4
	There is no evidence of understanding the science concept investigated.	Learner copies the teacher's words for the explanation.	Learner explains the concepts in his/her own words. The explanation is not correct.	Learner writes a correct and complete explanation using his/her own words. The explanation is missing relevant detail.	Learner writes a correct and complete explanation using his/her own words. The explanation includes relevant detail.
Comments:					

APPENDIX G:

Classroom observation schedule

School name:.....

Teacher name: ... . Gender: .....

Qualifications: .....

Grade level:.....….. Number of learners: .....

Observer name: ..... ……..

Date of observation:……...

Component 1: Use of Stimulus			
4 Educator uses a stimulus, such as a reading or discrepant event as an introduction to a science topic.	3 Educator begins the lesson by asking higher order questions and linking the questions to the science topic.	2 Educator provides a brief introduction and asks closed-ended questions to introduce the science topic.	1 Educator has no introduction which gets the students thinking about the science topic.
Description:.....			

Component 2: Exploratory talk and class discussion			
4 Educator facilitates exploratory talk.	3 Learners involved cumulative or disputational discussion.	2 Learners answer questions, but provide little else in terms of discussion.	1 No discussions in class. Educator lectures, learners listen to teacher
Description:			

Component 3: Investigable Question			
4 Learners pose investigable questions.	3 Educator guides learners in asking an investigable question.	2 Educator provides a question for learners to investigate.	1 There is no question for learners to investigate.
Description…… ……			

Component 4: Planning an Investigation			
4 Groups of learners discuss problems, questions and come up with ways to answer the investigable question by themselves	3 Only two or three learners in a-large group interact and offer ideas in ways to answer the investigable question	2 Educator provides step-by-step instructions to answer the investigable question	1 Learners are unable to formulate ways to answer the investigable question
Description:.....			

Component 5: Doing an Investigation			
4 Each group of learners independently uses their apparatus, collect their data and draw conclusions appropriately	3 Educator guides students to use their apparatus, collect data and draw conclusions	2 Educator leads/demonstrates learners through the use of the apparatus, data collection and drawing conclusions of the investigation	1 Learners are unable to use their apparatus, collect data and draw conclusions
Description:…….. …….... …….			
Component 6: Learner Writing with Science Notebooks			
4 Learners write effectively to record findings and enhance their learning	3 Learners write to record their findings but the text is so simplified that it does not enhance their learning	2 Learners write ineffectively – reveals only incoherent findings	1 Learners do not write at all

Description:……. …….. ……..			
Component 7: Learner Reading			
4 Learners read effectively from written text to enhance their learning	3 Learners read from written text with limited effect on their learning	2 Learners struggle to read from written text with limited to no effect on their learning	1 Learners do not read at all
Description:…….. ……. …….			
Component 8: Questioning Skills			
4 Teachers ask a variety of questions, including open-ended questions that probe for learners' understanding	3 Asks mostly close-ended questions and 1 or 2 open-ended questions	2 Asks simple-recall questions only or close-ended questions	1 Teacher asks no questions
Description: …… ……..…….			
Component 9: Teacher Feedback to Learners			
4 Gives feedback about correct and incorrect responses in a manner that encourages further effort	3 Gives feedback about incorrect responses only, in a manner that encourages further effort	2 Gives feedback about incorrect responses only, in a manner that discourages further effort	1 Gives no feedback
Description:……. …….. ……..			
Component 10: Line of Learning - Teacher Subject Knowledge			
4 Teachers demonstrate clear standing of concepts being taught	3 Teachers demonstrate adequate understanding of concepts being taught	2 Teachers demonstrate partial understanding of concepts being taught	1 Teachers demonstrate inadequate understanding of concepts being taught

Description:…… …… ……			
Component 11: Line of Learning – Argumentation, Presentation and Student Generated Ideas			
4	3	2	1
Through their own efforts learner presentations demonstrate clear understanding of concepts and procedures being taught	Through their own efforts learner presentations demonstrate adequate understanding of concepts and procedures being taught	Through their own efforts learner presentations demonstrate partial understanding of concepts being taught	Through their own efforts learner presentations demonstrate very limited understanding of concepts being taught
Description:…… …… ……			

APPENDIX H:

Learners post – workshop questionnaire

Please tick the box that describes your feelings about the following questions. You may write any other comments below, if you wish to.

Question		☺ Agree	😐 Neutral	☹ Disagree
1.	Did you enjoy the three workshops?			
2.	Did you learn a lot about science from the workshops?			
3.	Did you feel free to be involved and to ask questions?			
4.	Did you learn more by doing tasks and finding things for yourself, than by being told things?			
5.	Would you like more science to be taught in this way?			
6.	Did you learn from discussing with other learners?			

You may add any other comments (happy ☺ , not sure 😐 or sad ☹) about the workshops.

_____

_____

_____

_____

_____

_____

APPENDIX I:

Consent from Port Elizabeth Museum (Bayworld) to conduct research

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BAYWORLD

BAYWORLD
PORT ELIZABETH MUSEUM SCHOOL
P.O. BOX 13147, HUMEWOOD
PORT ELIZABETH 6013
TEL.: (041) 584 0650, FAX: (041) 584 0661

RESEARCH CONSENT FORM

Background Information

The title of this research is *The Promotion of Scientific Literacy within a Museum Context.* Nicolette Deidré Daniels from the Port Elizabeth Museum School at Bayworld will conduct the research supervised by Prof Paul Webb from the Nelson Mandela Metropolitan University (Faculty of Education).

This research will examine whether the aspects of the integrated strategies approach to promoting scientific literacy can be successfully employed in a museum context? Data will be collected from the teachers at the Port Elizabeth Museum School, visiting grade 6 learners and teachers.

Research Question

The principal question in this study is:

- Can aspects of the integrated strategies approach to promoting scientific literacy be successfully employed in a museum context?

The sub-questions that must be answered to answer the principal question are:

- Can the Port Elizabeth Museum School teachers at Bayworld adopt the scientific literacy strategy if provided with appropriate support?
- If they do adopt the strategy, does it affect their view of the nature of teaching and learning towards scientific literacy?
- What are the types of activities that can be used to support this approach?
- Which aspects of the strategy do the learners visiting the museum adopt most readily?

The research involves the museum teachers participating in two workshops to learn the scientific literacy strategy. These teachers will then be able to practice the strategy with visiting learners. The teachers will write an essay on what they think it is to be scientifically literate, what schools can do to promote scientific literacy, and what museums can do to promote scientific literacy prior to being introduced to the strategy. They will be asked to rewrite on the same issues when the study is completed.

The implementation of the strategy will be monitored and interviews with teachers and learners and classroom observation conducted. Please feel free to ask questions now if you have any.

CONSENT STATEMENT

1. Participation is voluntary and participants may withdraw from the research at any time, without giving any reason.

2. Participants consent will be obtained and involvement in the research will be outlined in writing prior participation.

3. There are no risks involved in the participation of this study.

4. All questions pertaining to the nature of the research and use of data collected will be answered prior the commencement of the research or as the need arises during the research process.

5. Any changes in the implementation of the research strategy will be communicated with participants and their consent obtained.

6. Findings may be used in a research project leading to a degree; results may be published, although no learners or teachers will be identified by name.

7. All reports and/or written publications generated from this research will acknowledge the Port Elizabeth Museum/ Bayworld as a participant and host.

8. Copies of all reports and publications will be filed in the Port Elizabeth Museum / Bayworld Library

I agree that this study can be conducted.

Bayworld / Port Elizabeth Museum

Director's signature: .....

Director's name (please print): .....Sylma van Zyl.....

31 July 2009

APPENDIX J:

Consent from Port Elizabeth Education District Office to conduct research

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BAYWORLD

BAYWORLD
PORT ELIZABETH MUSEUM SCHOOL
P.O. BOX 13147, HUMEWOOD
PORT ELIZABETH 6013
TEL.: (041) 584 0650, FAX: (041) 584 0661

RESEARCH CONSENT FORM

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I agree that this study can be conducted.

Eastern Cape Department of Education
Port Elizabeth District Office

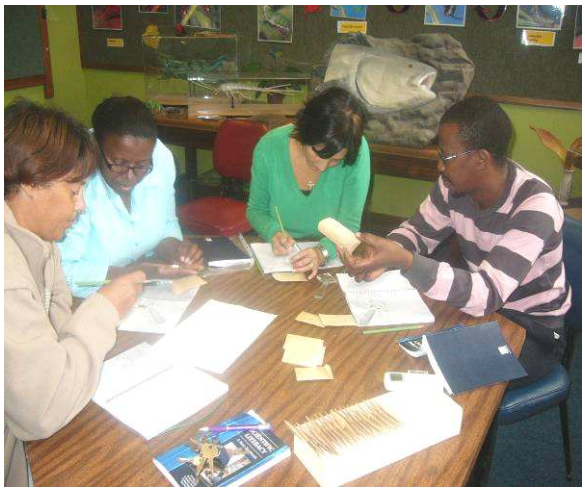
Managers signature: .....

Managers name (please print): T. B Kola .....

August 2009

APPENDIX K:

Teachers conducting investigations



Investigation1: Properties of water

Investigation 2: Otoliths

Additional workshop requested

Investigation 3: Dolphin Skulls

APPENDIX L:

Teacher science notebook - Formulation of investigable questions

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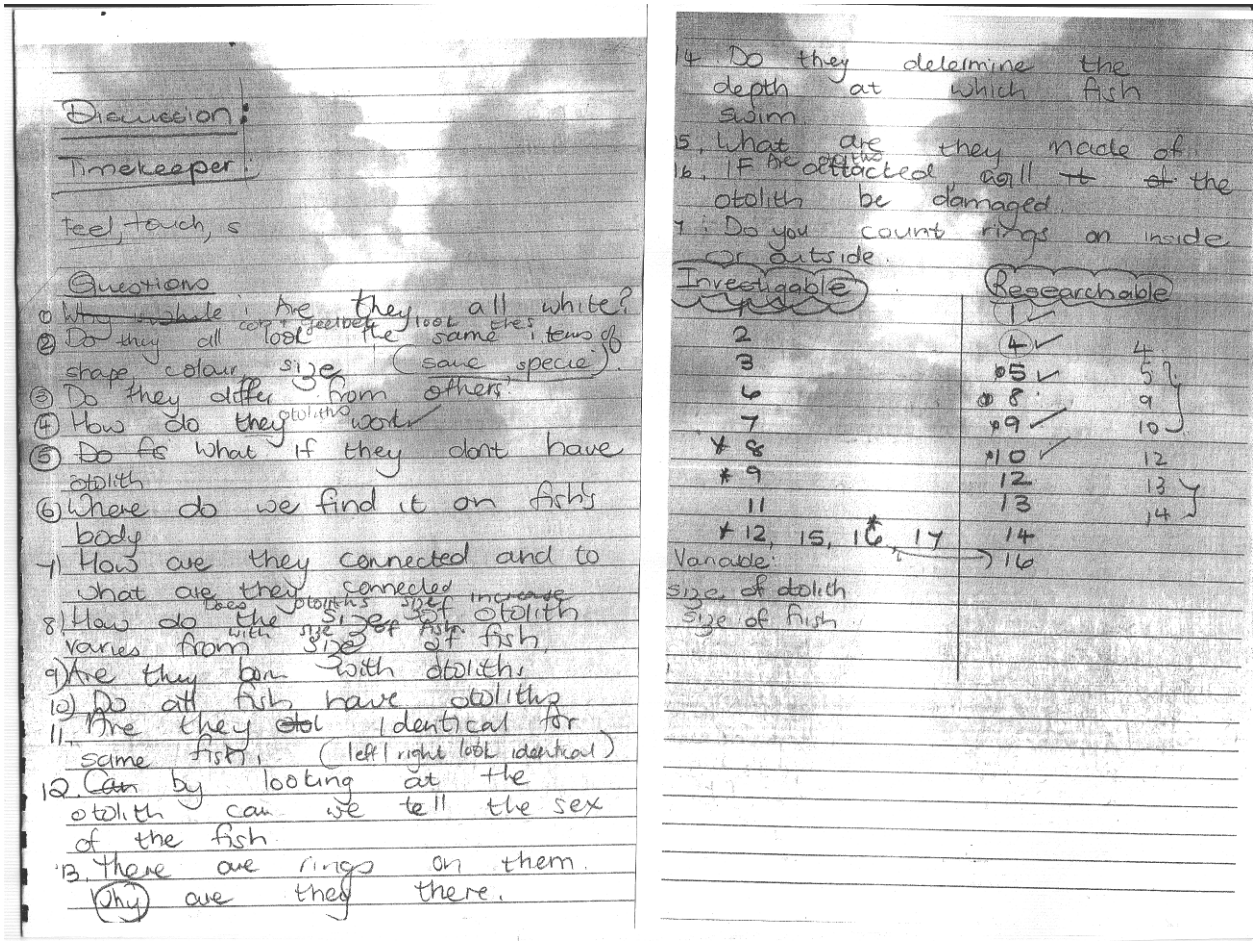


Discussion:

Timekeeper:

feel, touch, s

Questions

1. ~~Why whale~~ Are they all white?
2. Do they all look feel look the same (same specie) shape, colour, size. (tens of)
3. Do they differ from others?
4. How do they otoliths work
5. Do fs what if they dont have otolith
6. Where do we find it on fish's body
7. How are they connected and to what are they connected
8. How do the size of otolith varies from size of fish. (does otoliths size increase with size of fish)
9. Are they born with otolith.
10. Do all fish have otoliths
11. Are they ~~otol~~ identical for same fish. (left/right look identical)
12. ~~Can~~ by looking at the otolith can we tell the sex of the fish.
13. There are rings on them. Why are they there.
14. Do they determine the depth at which fish swim.
15. What are they made of.
16. If are attacted (are some) all ~~it~~ ~~of~~ the otolith be damaged.
17. Do you count rings on inside or outside.

Investigable	Researchable	
2	4 ✓	4
3	*5 ✓	5
6	*8	9
7	*9 ✓	10
*8	*10 ✓	12
*9	12	13
11	13	14
*12, 15, 16, 17	14	
Variable:	16	
size of otolith		
size of fish		

APPENDIX M 1:

Teachers science notebook - Data collection

30/04/09

SESSION 2

Alternative Conceptions in Science

* Social – building the language knowledge
  Interacting (Construction listen contribute

* Constructivist Theory:
  build the knowledge by reading & writing

Parts of Conversation

* Analysis of a concept

words – vocabulary (lexicon)
Sentences – grammar (syntax)
Discourses – Meaning (Semantics) Ambiguous

Questions

① ~~Why~~ Is there a relation between the length of otolith and the length of the fish for
ⓐ cob
ⓑ Geelbek

② Is there a different between the (CL) and R

30 April 2009 13:35

Predictions

① Yes : the bigger the otolith the bigger the fish

Planning

- measure the length of otolith
- read the length fish
  record
- Compare length of otolith & fish (both)
- Arrange increasing/decreasing order

WID

cob

length of otolith	length fish
16mm	468 mm
17	478 "
21	596 "
26	935 "
26	940 "
26	955 "

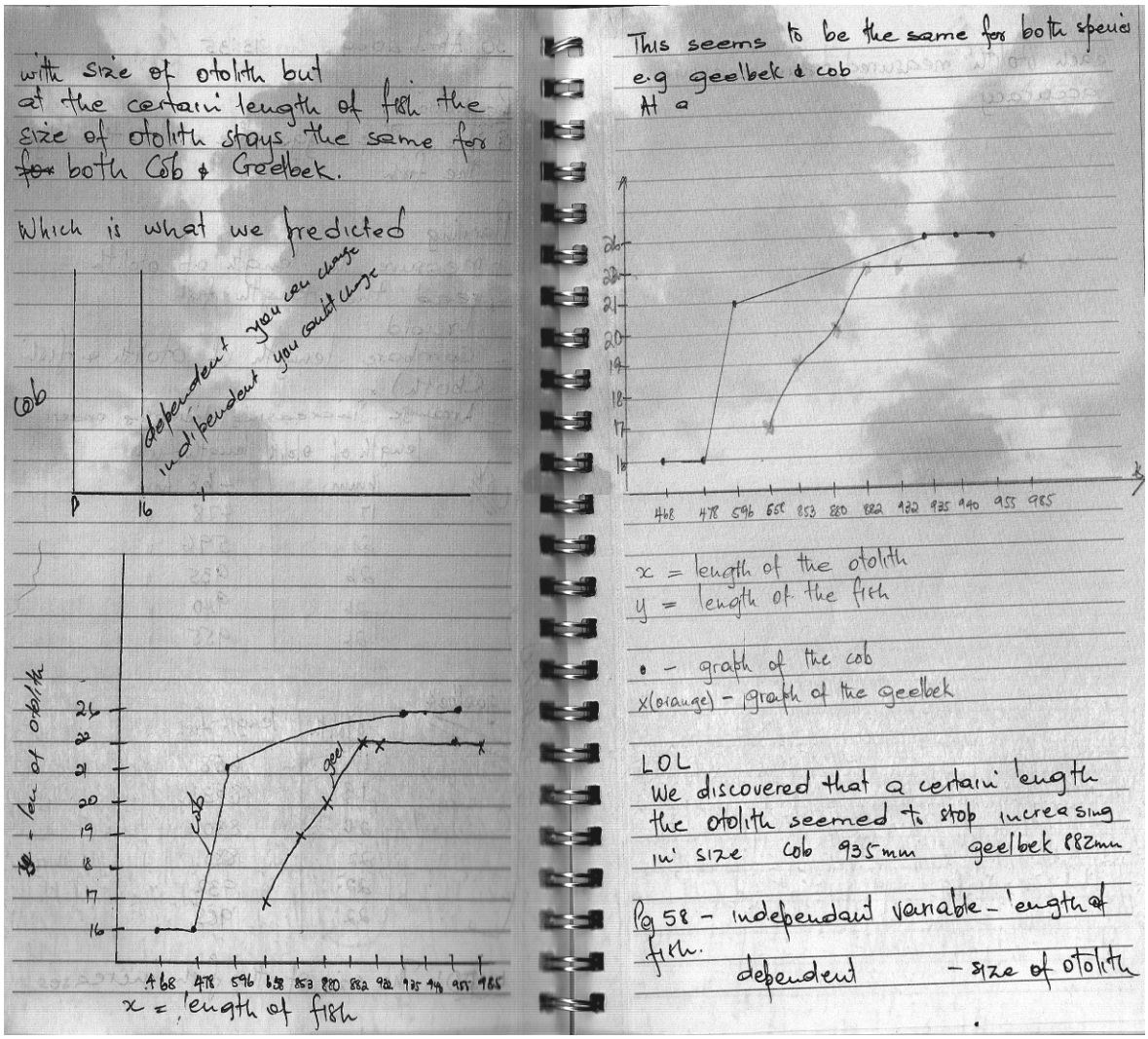
geelbek

otolith	length fish
17	658
19	853
20	880
22	882
22	932
22	985

WID:- The size of the fish increases

APPENDIX M 2:

Teachers science notebook – Data representation and line of learning



with size of otolith but
at the certain length of fish the
size of otolith stays the same for
~~for~~ both Cob & Geelbek.

Which is what we predicted

cob

dependent you can change
independent you can't change

0 16

length of otolith

x = length of fish

This seems to be the same for both species
e.g geelbek & cob
At a

x = length of the otolith
y = length of the fish

• - graph of the cob
x(orange) - graph of the geelbek

LOL
We discovered that a certain length
the otolith seemed to stop increasing
in size cob 935mm geelbek 882mm

Pg 58 - independant variable - length of
fish.
dependent - size of otolith

APPENDIX N:

Learners conducting investigations

Group 1: Properties of water

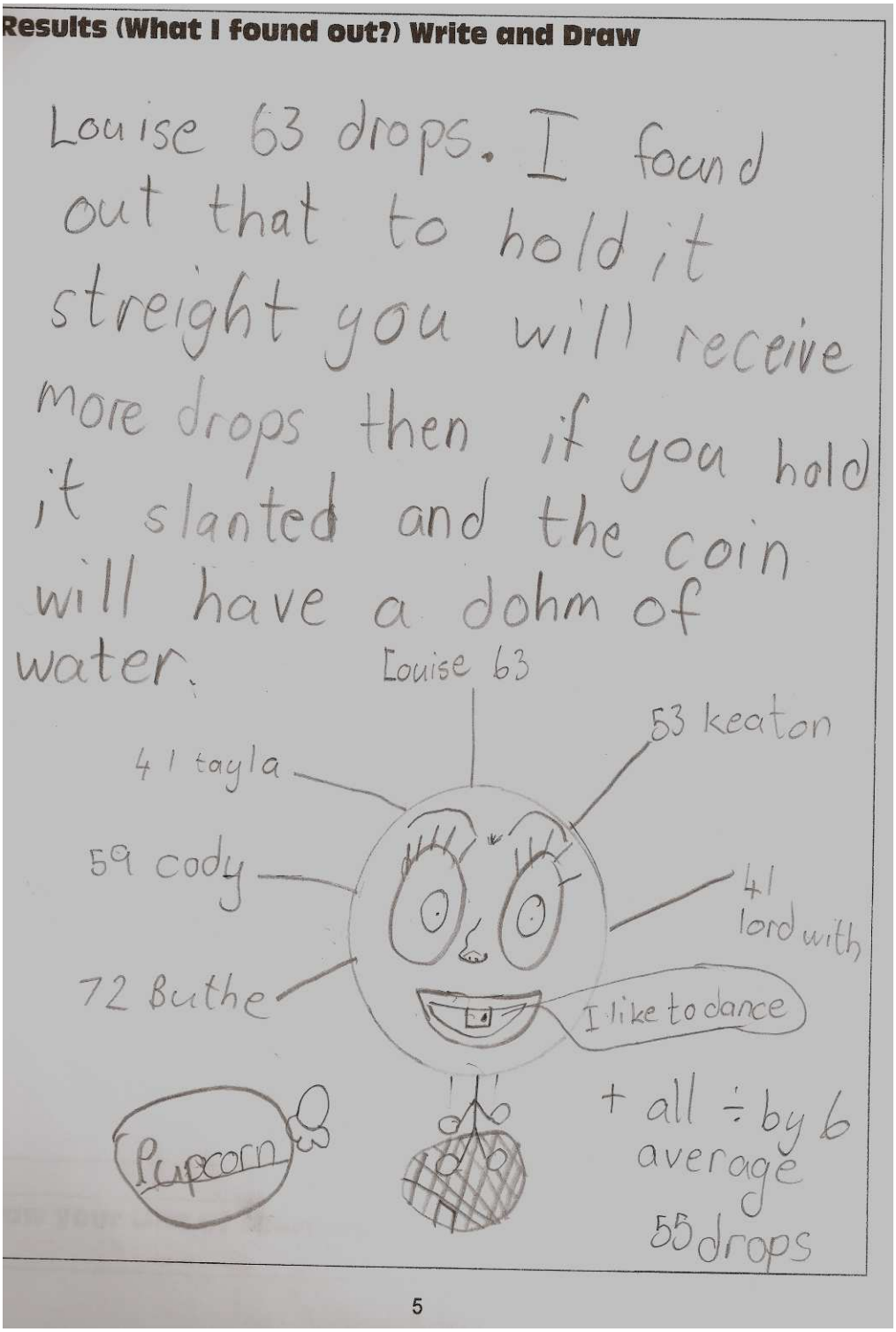
Group 1: Otoliths

Group 2: Properties of water

Group 2: Dolphin skulls

APPENDIX O 1:

Learner science notebook - Data collection



Results (What I found out?) Write and Draw

Louise 63 drops. I found out that to hold it streight you will receive more drops then if you hold it slanted and the coin will have a dohm of water.

Louise 63

41 tayla

53 keaton

59 cody

41 lord with

72 Buthe

I like to dance

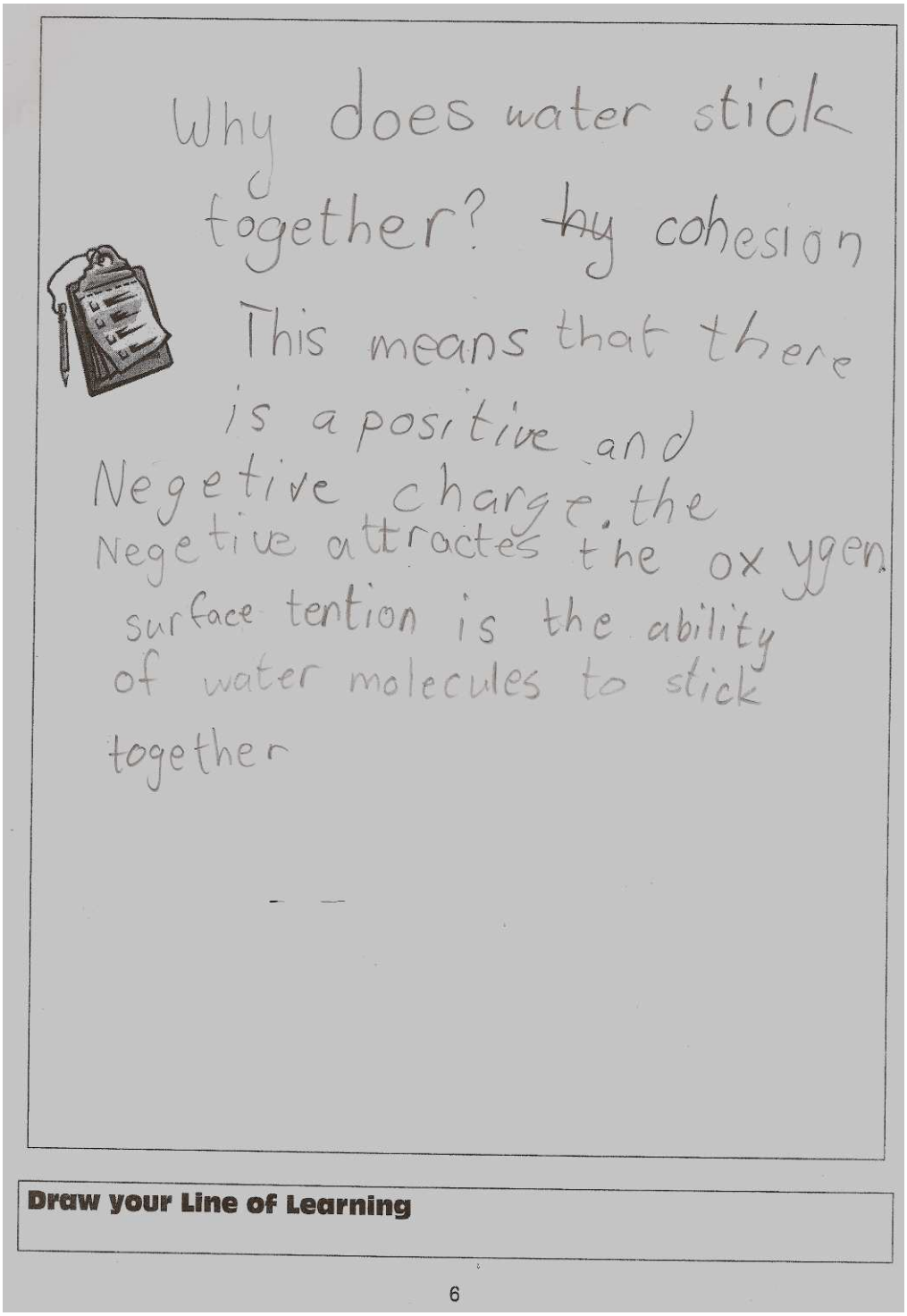
Pupcorn

+ all ÷ by 6 average 55 drops

5

APPENDIX O 2:

Learner science notebook – Formulation of conclusion



Why does water stick together? ~~hy~~ cohesion

This means that there is a positive and Negetive charge. the Negetive attractes the oxygen. surface tention is the ability of water molecules to stick together

Draw your Line of Learning

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