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2014-03-05
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REPRESENTATION OF MOON PHASES: A TEXTBOOK ANALYSIS AND CASE STUDY OF GRADE 8 LEARNERS UNDERSTANDING

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A research report submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in partial fulfilment of the degree of Master of Science

Johannesburg October 2013

CANDIDATE'S DECLARATION

I declare that this research report is my own unaided work. It is submitted for the Degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

_____

Lubabalo Albert Bhulana

4th day of October 2013

ABSTRACT

The aim of the study was to investigate the quality of diagrams and explanations of moon phases in grade 6 to 8 Natural Science textbooks; to establish whether the textbooks provide scientifically correct content information for learners and teachers and to investigate whether the textbooks used for teaching are effective conceptual development tools for grade 8 learners, specifically when exploring moon phases. The research consisted of two phases, where the first phase investigated the quality of textbooks, and the second phase investigating learners' ideas about moon phases.

In the first phase, six textbooks were analysed, with varying results. The two grade 6 textbooks analysed introduced cultural stories in an attempt to show how stories were used to help people understand moon phases. The cultural stories looking at scientific application, only achieved to explain the waxing and waning process the moon undergoes. Those stories however failed to explain correctly the cause of the moon phases. The diagrams presented in the textbook are misleading, as either the moon phase sequences are incorrect, or wrong moon diagrams are put for a particular phase. The activities though must be complimented, as they are good activities that would help learners understand the cause of moon phases a bit better. The remainder of the four textbooks, two grades 7 and two grades 8 did not include cultural stories. In terms of content accuracy, it was analysed that the correctness increased the higher the textbook grade was.

In the second phase, it was investigated whether a textbook prescribed to learners at school would help learners understand the concepts on the phases of the moon. For this purpose, 8 learners were chosen to be interviewed. The interview involved learners being given a model of the sun, earth and the moon: where they were to use the models to show the relative position of the sun, earth and the moon for certain moon shapes that came directly from their textbooks. Results from the interview show that all learners had little understanding of concepts relating to the moon. This showed that a textbook alone was not a sufficient tool to help learners understand all aspects relating to the phases of the moon.

The findings of the two phases bring out the following implications:

- Much needs to be done by tertiary institutions in equipping pre-service teachers with content knowledge that would help them identify misconceptions that arise in textbooks, so as to make sure that the misconceptions contained in textbooks are not passed down to learners that they teach.
- Tertiary institutions should also strive to equip pre-service teachers with pedagogical skills that would help them design instruction that would help address learners' misconceptions in relation to the phases of the moon.
- There needs to be intervention by provincial departments of education, in helping to equip current teachers by means of workshops with pedagogical content knowledge in regards to the phases of the moon, and Astronomy education in general.
- Textbooks prescribed by schools and government to learners, need to be taken to content specialist. This will help in providing textbooks that are more scientifically accurate, and help decrease misconceptions being passed on to learners.

ACKNOWLEDGMENTS

I would like to acknowledge the following people and schools for contributing to the success of the research project:

My supervisor, Professor Anthony Lelliott who gave me guidance and taught me how to go about doing a research report.

My friend, Mamta Govind, for helping me with the completion of my proposal

The case study school and the Gauteng Department of Education for giving me permission to conduct the second phase of my research.

The case study learners for willingly allowing me to interview them and giving me permission to use the data obtained from the interviews in my research report.

Samantha Rorthbard for proof reading my work.

My family, for their support and understanding.

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Chapter 1

Introduction

1.1 Preamble

This chapter provides the reader with an overview of the research, the rationale, the aims and objectives of the research, and the methods used in conducting this research.

1.2 Research Background

There are various topics covered at school level, in which teachers are expected to deliver appropriate scientifically correct content. One of the topics which falls under the section of 'Planet Earth and Beyond' is astronomy.

In the RNCS (Revised National Curriculum Statement), 'Planet Earth and Beyond' has specific foci. The RNCS outlines its focus areas as "the structure of the planet and how the earth changes over time, on understanding why and how weather changes, and on the earth as a small planet in a vast universe" (RNCS, p. 6). There are three phases mentioned in the RNCS: the foundation phase, the intermediate phase and the senior phase. Each phase contains different content under the heading of 'Planet Earth and Beyond'. In the intermediate phase, the following is expected to be taught: "the moon's apparent shape changes in a predictable way and how these changes may be explained is by its motion relative to the earth moon and sun" (RNCS, p.69).

In the intermediate and senior phases, which are the focus of my study, the RNCS makes explicit what kind of content is expected to be taught. The content that falls under astronomy includes the day-night cycle, moon phases and weather changes.

A significant amount of research has been conducted on astronomy education, particularly to improve instruction of scientific concepts. Recently, Lelliott and Rollnick (2010) reviewed research conducted on astronomy education, and found that there were three sections that were difficult for instruction, and for learners to comprehend. These sections were: the moon phases, the relative sizes and distances in the universe, and seasons on earth. To give an example, learners are taught the different phases of the moon by the sequence in which they occur, accompanied by the name of the sequence and what each shape of the moon is called,

but it is difficult for learners to explain why these moon phases occur in relation to the position of the sun, earth and the moon.

Moon phases are the common element between the sections outlined by the RNCS and my study. Since there seems to be considerable difficulty in understanding why moon phases occur, especially in the classroom context, textbooks are a source of information that teachers and learners depend on. Thus it would be significant to note how textbooks clarify this difficult concept through text and two dimensional diagrammatic representations.

More importantly, it would be noteworthy to investigate whether the clarifications the textbooks provide are scientifically accurate and whether they promote abstract conceptual scientific development in learners. Furthermore, this study will investigate whether learners are able to use the text and two dimensional diagrammatic representations in science textbooks effectively and apply them three dimensionally.

It is imperative for teachers to understand the content of what they are teaching so that they are able to present content in manner that it would be understandable for the learners. Shulman (1986) makes mention that subject matter knowledge is important for the transformation process. In his model, Shulman (1986) terms transformation as pedagogical reasoning. This term describes how teachers use their knowledge to teach or represent certain content to learners, and in order to transform the knowledge effectively, teachers would need to have good subject matter knowledge.

Having good subject matter knowledge enables the teacher to choose appropriate source materials, such as textbooks, which will help their learners to understand correct scientific content, and to enhance their teaching. Textbooks thus form a crucial part in development. It goes without saying that textbook developers also need to have good subject matter knowledge, so as to represent content in various ways that learners are able to understand.

1.3 Research Problem

In literature that has been reviewed (more detail about the literature is explored in Chapter 2), very few studies have looked at the relation between textbooks used at school by teachers for the purpose of instruction, and how it influences the learning of moon phases from a two dimensional perspective, and what this might mean for the learners' three dimensional understanding. It is the main objective of this research report to address such a problem.

1.4 Aim of the Study

The aim of the study is to investigate the quality of diagrams and explanations of moon phases in grade 6 to 8 Natural Science textbooks; to establish whether the textbooks provide scientifically correct content information for learners and teachers; and to investigate whether the textbooks used for teaching are effective conceptual development tools for grade 8 learners, specifically when exploring moon phases.

1.5 Research Questions

In this research, the following questions will be investigated:

1) **What is the quality of diagrams and explanations of moon phases offered by grade 6 - 8 Natural Science Textbooks?**
   a) What misconceptions can be identified by the content presented in the textbook?
   b) What structure is presented in relation to conceptual development (Does the structure in which content is presented build on concepts to aid conceptual development: i.e. concrete or abstract)?
2) **How do grade 8 learners interpret textbook diagrams of moon phases in relation to a physical model?**

1.6 Rationale

Often the main learning sources given to students for mastery of scientific content is the science textbook which comprises science concepts. In schools with sufficient resources in South Africa, textbooks are given out to learners at the beginning of the year. These are then collected at the end of the year when learners write their final examination. These textbooks mostly provide exercises and texts explaining certain concepts in science. The learners use the textbook for study purposes. Since learners use textbooks in the learning process, it is important for the content to be scientifically correct. Given that this content may influence the learning of key concepts within a topic, accurate graphical representation of content is also imperative.

Through my experience of observing lessons as a pre-service teacher, I have seen that teachers are dependent on textbooks to assist in the teaching of content to the learners, especially if the teacher lacks content knowledge. Further, studies have demonstrated that some teachers are heavily reliant on textbooks as a teaching aid.

Teachers tend to follow a textbook's exact content and format without critically adapting lessons to account for issues such as the accuracy of the content needs of the learners, pedagogical strategies, guidelines regarding how the textbook is best utilised, and guidelines on how to assess learners' grasp of the content (Chiapetta, Sethna & Fillman, 1991; Yore, 1991). Therefore, textbooks have a critical role to play in enhancing learners' content knowledge.

There have been several studies that focus on learners' ideas on moon phases. These studies have looked at how instruction influences the learning of scientific ideas (Barnett & Morran, 2002; Sharp & Kuerbis 2006; and Trundle, Atwood & Christopher, 2007b). Very few studies have looked at the relation between textbooks and how it influences the learning of moon phases. Furthermore there is only a modest literature available linking texts and their corresponding two dimensional graphical representations, as well as their likeness to three dimensional models. Therefore, investigating how textbooks affect learning may help teachers to be cautious in the selection of prescribed textbooks to use for instruction. If the textbooks contain misconceptions, such misconceptions may be transmitted to learners, who then may hold incorrect scientific ideas about moon phases. This study may also help practitioners on looking at alternative ways that could be used to aid the understanding of moon phases to the learners.

As explored above, since these topics are conceptually abstract they are often perceived as difficult topics to cover with learners, and they require teaching the core knowledge of concepts rather than superficial facts (Trundle et al.,2007b). A principal tool in teaching is the textbook. Thus the primary focus of this study is to determine whether textbooks facilitate the process of learning of conceptually abstract topics in a scientifically accurate and dimensional manner.

1.7 Methodology

The research was executed in two phases. Phase one addressed the first research question. Phase two addressed the second research question.

Phase 1: Analysis of Textbook

Materials: Science Textbooks

Six science textbooks were examined to investigate the quality of diagrams and explanations of moon phases.

Textbooks were selected on the basis of whether moon phases content was covered in the section of 'Planet Earth and Beyond'. Of the six textbooks, two are grade 6 textbooks, two are grade 7 textbooks and two are grade 8 textbooks.

Data:

The instrument used for data collection is an adaptation of an instrument used by the British Columbia Ministry of Education (2002, 2008) in selecting appropriate resources that could be used for instruction. A few amendments were made to the instrument, to suit the purpose of the present study. The instrument is discussed in more detail in chapter 3.

Phase 2: How textbooks affect learning

Sample:

The school chosen to participate in the study was the school that the researcher taught in. The reason for choosing the school was based on the opportunity to have immediate access to the learners that were to participate in the study. It was also based on convenience, where it was easier to structure a time period for content to be taught without jeopardising the work schedule set by the Natural Science teaching department at the school. The sample consisted of one grade eight class that was not taught by the researcher. In the grade 8 class, 15 learners were chosen according to their academic performance in the subject of Natural Science. The 15 learners were chosen in such a way that they fitted into the following categories; above average, average and below average. The criterion in the selection of learners was done in such a way that learners at all levels as per the mentioned categories could be represented. For an equal representation of learners, 5 learners per category were selected by the educator

teaching the class. The 15 learners chosen were asked by the researcher about their willingness to participate in the study.

All the learners agreed to participate in the study and were given appropriate consent forms to fill out with consent from the parents of the learners. The learners were then interviewed after they had been taught the section of moon phases.

Interview:

The purpose of an interview is to explore why participants answered the way they did in specific questions (Opie, 2004). The reason behind using an interview for the purpose of my research was to determine whether learners are able to explain why they represent textbook illustrations using models given to them. The models consisted of objects which represented the sun, earth and the moon, and learners were asked to manipulate these models to represent what they see occurring in the illustrations.

Data collection:

An interview schedule was used to obtain responses from interviewees. The responses obtained were transcribed and later analysed.

The interview schedule used by Trundle et al. (2002) was adapted. Only slight changes were made to the instrument to suit the purpose of the current study. During the interview, learners were shown images of the different shapes of the moon from their textbook used at school. Learners were asked to model what they saw using three dimensional replicas of the sun, moon and earth.

Learners were videotaped during the interviews as they demonstrated their three dimensional application abilities. The video footage was used to transcribe learners' responses, and to view the learners' arrangement of the models of the sun, earth and the moon for analysis purposes.

1.8 Structure of Research Report

The research report consists of six chapters, including the introduction within this chapter. In Chapter 2, relevant literature is reviewed that pertains to the current study to give a background on other studies conducted, which involve the teaching and learning of astronomy concepts by teachers and learners, especially on the topic of moon phases.

The theoretical framework used for the study is also presented in this chapter: the two main frameworks guiding the study are constructivism and mental modelling. Both these frameworks are discussed in detail in the chapter.

In Chapter 3, I will present the methodology and procedures used in collecting data in the study in more detail. I will explain what type of study this research is, and explain the sample involved in this study in more detail: the background of the participants in the study is addressed, i.e. the choice of the school and status of the school, the class which the learners come from, and the teacher involved in choosing learners from her class to participate. I will further explain the process involved to refine the research instruments used for the purpose of the study, and look at the validity and reliability of the instruments. I will also look at ethical considerations with regard to the study.

In chapter 4, the results of the textbook analysis are discussed in detail. To start off with, a summary is given on the meanings of the characteristics used in the textbook instrument so as to make the results presented more meaningful. A brief summary is provided at the end to highlight the outcomes of the analysis process.

In chapter 5, data from the interviews is discussed in detail. As in chapter 4, a brief summary is provided to highlight the outcomes of the interview process. Issues around the validity of the instruments used in chapters 4 and 5 are also discussed in this chapter. The reason for discussing chapter 4's instrument in terms of validity in this chapter is because at the end of the chapter, the relationship between the textbook used and learners' understanding of moon phases is summarised in this chapter; therefore, it made more sense to discuss both instruments in this chapter.

In chapter 6, research findings are discussed in the chapter and research questions are answered based on the outcomes of the data presented in chapters 4 and 5. This chapter also presents conclusions in light of the data collected, reflects on the study conducted, presents limitations of the study, and briefly discusses recommendations.

Chapter 2

Literature review

2.1 Introduction

The literature review is divided into six sections. Four sections are dedicated to the themes that are relevant to my research objectives. The sections include moon phases, models and textbook analysis. The last section outlines the theoretical framework that guides my study.

2.2 Moon Phases

Moon phases are caused by the orbit of the moon around the earth. There are three bodies involved contributing to the moon phases; namely the sun, earth and the moon. The positioning of these three entities, gives the appearance of the moon, depending on the relative positions. Below is a summarised version of what the moon would look like with respect to relative positions of the sun, earth and the moon (**Note:** the diagram indicated below is not illustrated according to scale) :

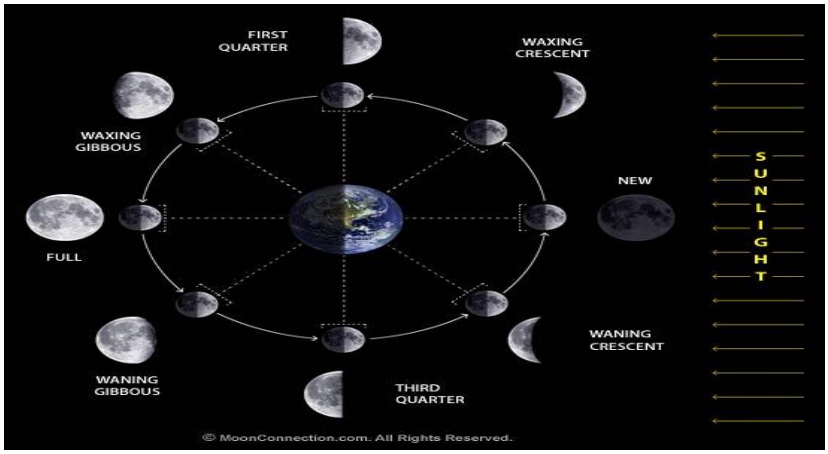


Figure 2.2a: Illustration of moon shapes in respect to the position of sun, earth and moon adapted from http://www.moonconnection.com/moon_phases.phtml (MoonConnection.com).

Looking at the diagram, one notices that on the outer side of the diagram, the moon phases are represented, and on the inner side, one notices that the moon is half lit by the sun all the time. This is a satisfactory summary to the concept of moon phases, as Bailey & Slater (2003) explains that "despite half of the moon being illuminated by the sun all the time, the portion

of that half that can be seen from earth – what we call the phase – depends upon the relative positions of the sun, earth and the moon" (Bailey & Slater, 2003, p. 22).

Moon phases can be observed in the night sky, when weather conditions allow it. The concept as written on paper may look straight forward, yet learners' and teachers' alike still have problems in understanding why the moon phases occur.

Below, literature is explored in more detail with regard to misconceptions learners' and teachers'/adults have about moon phases.

2.2.1 Misconceptions

The term 'misconceptions' is sometimes interchangeably used with the word 'alternate conceptions'. It is therefore important to look at the meaning of both words, as literature used for the study talks of either misconceptions or alternate conceptions.

The word 'misconceptions' is used to refer to aspects of learners' conceptions that do not reflect scientists' understanding of a natural phenomenon (Duit, 1991). This entails learners' holding ideas or conceptions which are not scientifically correct. On the other hand, 'alternate conceptions', were defined by Hewson & Hewson (1983) & Kuiper (1994) as a conceptual understanding contained by an individual about a specific concept, where the understanding of such a concept is at odds with scientifically accepted norms. The definitions, even though slightly different, relate to one another, as both mention the individuals understanding of knowledge which is at odds with the scientific view.

Therefore, for the purpose of the current study, the terms 'misconceptions' or 'alternate conceptions' will be understood to relate to learners' understanding of concepts relating to the phases of the moon that is at odds with the scientific view.

Stahly, Krockover and Shepardson (1999) cited Baxter (1989) in their study in identifying the most common misconceptions held by learners. These conceptions include:

1. Clouds cover the part of the moon we cannot see.
2. Planets cast shadows on the part of the moon that we cannot see.
3. The shadow of the sun falls on the moon, blocking our view of it all.

4. The shadow of the earth falls on the moon, blocking our view.

(Stahly et al., 1999, p. 160)

Out of this list Baxter (1989) noted that the most commonly held conception on the cause of moon phases by children was that of the earth's shadow falling on the moon. The above mentioned conceptions are misconceptions, as the accepted view of what causes the moon phases, is that "the moon's apparent shape changes because of the moon's position with respect to the sun and earth changes" (Suzuki, 2002, p. 893). Without understanding this relationship, it is likely that learners and adults alike would have an incorrect view of the cause of moon phases.

These common misconceptions held by learners' may be disseminated by parents, textbooks or instructional models (Callison & Wright, 1993). Looking at today's schools and certainly in my experience as a teacher, textbooks are a tool used by a teacher to communicate knowledge of concepts underlying a topic.

Teachers give learners exercises out of the textbooks to use, so as learners can test their understanding. Textbooks therefore in some cases tend to be a principal source of content in most classrooms as mentioned by Harnes & Jager (1981). In addition, teachers' who are especially dependent on textbook material for teaching content may also communicate these misconceptions to their learners' (Skamp, 2004; Trundle et al., 2002), as they may not have enough content knowledge to notice the flaws conveyed by the textbook.

King (2001) conducted a survey in the 1990s amongst 150 teachers. This survey was conducted to test teacher knowledge in a learning area introduced in England and Wales by the NCS (National Curriculum for Science). The new learning area was called earth science. King (2001) demonstrated that the teachers' content knowledge was weak, and the same teachers' used textbooks as a source of information. Since the teachers had weak content knowledge, the teachers tended to believe what was written in the textbooks, despite the textbooks containing a lot of misconceptions. The teachers subsequently transmitted the same misconceptions from the textbooks to the learners' through their teaching. His study illustrated the impact textbooks had on the teachers and, subsequently, on the learners that the teachers were educating.

Wandersee, Mintzes, & Novak (1994) reviewed the claim that teachers hold the same misconceptions as learners and commented that the persistence of teachers having these misconceptions "may be an effect of poor college science textbook writing" (Wandersee et al., 1994, p. 189). Science textbooks play a fundamental role both to teacher and learner. Thus, science textbooks that hold misconceptions set off a chain of communication which ultimately disseminates incorrect scientific conceptions.

Cohen & Lucas (1999) warn that misconceptions may arise in textbooks based on 2-dimensional diagrams drawn about the moon. The research makes mention that the traditional moon diagrams drawn in textbooks do not correctly indicate the relative distance and size of the moon, sun and earth. Engestrom (1991) is a researcher who validates the point of scale contributing to misconceptions; by making mention that it is due to scale that has resulted in the culture of believing that the earth casts a shadow on the moon (By scale, it is meant the relative size of the sun, earth and the moon including the realistic distances that exist between sun, earth and the moon: in other words, how far the sun, earth and the moon are from each other). To elaborate more on this point, one could use the drawing shared in the paper written by Engestrom (1991):

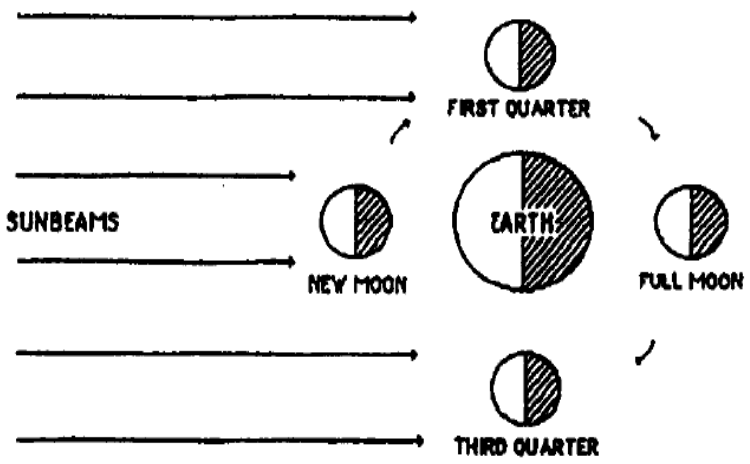


Figure 2.2.1a Textbook Drawing taken from Engestrom (1991)

The diagram shown in figure 2.2.1a is a textbook diagram that Engestrom talks about the importance of scale. Engestrom mentions that by looking at the diagram, it is quite noticeable that the earth is close to the moon in reference to the distance, and that there is also little difference when it comes to the size of the earth and the moon. Engestrom argues that the diagram in figure 2.2.1a is unrealistic, and that these unrealistic drawings are the cause in learners' having naïve misconceptions relating to the moon phases.

To illustrate his point, Engestrom gives a realistic example in regards to scale, by mentioning that "in reality, if the sun were symbolized with a ball with a radius of little over 50 cm, the earth would be symbolized with a ball with a radius of just a little over 0.5 cm and located 150 m from the sun" (Engestrom, 1991, p. 248).

Cohen & Lucas (1999) further point out that the diagrams drawn in textbooks may also fail to expose the direction in which the moon orbits. Furthermore, they note that the 2-dimensional diagrams in textbooks do not clearly reflect the complex aspects such as the relative movements of the sun, earth and the moon in the dynamic system of moon phases. Misconceptions that arise from textbooks "may derive from the author's limited understanding; from poor attempts to simplify ideas for their pupil-readers, or by inadequate attempts to coach their writing to address the views of science that pupils are likely to have" (King, 2010, p. 584). This may then cause a negative effect on both learners' and teachers' alike.

Thus, a point of investigation in the present study was to investigate whether science textbooks that are prescribed to learners' for school use have correct scientific content on moon phases. This may then show whether procedures followed by the South African government in analysing textbooks have merit or not. This may also inform teachers' in taking necessary measures in terms of analysing and choosing the textbooks which have accurate scientific content for learners'.

Now that the most common misconceptions have been highlighted, the literature below explores teachers' and learners' conceptions about moon phases, so as to establish if misconceptions contained by teachers' and learners' correlate to the most common known misconception; that is, the cause of moon phases is because of the earth casting a shadow on the moon.

Further, literature is explored in terms of intervention studies, to establish whether it is possible to change misconceptions that teachers' and learners' have.

2.2.2 Teachers/Adults and Moon Phases

Although this study looks at grade eight learners' in high school, there is a need to look at literature which concerns teachers'/adults ideas about moon phases, as it may inform us on how learners' would have constructed ideas they possess about the phases of the moon e.g.

through teaching. Following this idea, it is also likely that misconceptions held by the learners' would be similar to those of the teacher.

Parents send their children to school to be educated, and teachers' are entrusted with helping these children understand concepts in the respective subjects that teachers' teach. Part of the success in helping learners' understand the correct concepts, is based on the teachers' knowledge of the subject content: the teachers' content knowledge needs to be sound, so that correct scientific concepts can be conveyed. It is therefore important to see what the literature reveals about content knowledge or, moreover, teachers' ideas regarding moon phases.

If teachers have misconceptions about specific concepts, then chances are that the learners' that they teach too will have the same misconceptions. Below, literature is explored to determine what conceptions pre-service teachers' and in-service teachers' have about the cause of moon phases. Even though learners' are taught by in-service teachers', it is however important to also establish pre-service teachers' conceptions about the cause of moon phases, as this would inform us on the thinking of in-service teachers, so as to try and establish if a link exist.

Schoon (1995) conducted a study in the American Midwest to establish conceptions pre-service teachers' had in terms of the cause of the moon phases. Schoon administered a questionnaire to 122 pre-service teachers', which contained questions relating to moon phases, and found that 62, 3 % of the pre-service teachers' believed that the cause of the moon phases was because of the earth's shadow being cast on the moon. This conception is in accordance to the most held misconception mentioned in the above section. Other similar studies conducted earlier, by Dai & Capie (1990), and Callison & Wright (1993) also found that that the majority of the pre-service teachers' did not understand the cause of the moon phases, and had the common misconception of the earth's shadow being cast on the moon.

In the study of Callison & Wright (1993) for an example, 64 elementary pre-service teachers' were investigated on their ideas about the phases of the moon: before instruction commenced, a pre-test was administered to the pre-service teachers', and it was found that 6, 6% of the teachers' had a scientific idea about the concepts underlying the phases of the moon. After instruction, there was a considerable change, as approximately 22% of the pre-service teachers' after intervention developed a scientific idea about the phases of the moon. Even though this was a drastic improvement, there were still pre-service teachers' (the majority) holding non-scientific ideas in relation to the phases of the moon.

Looking at in-service teachers' conceptions about moon phases, Summers & Mant conducted a study where it focussed on an England and Wales curriculum theme named "The earths place in the universe". The theme contained astronomy topics which teachers' were expected to deliver to their learners' through instruction.

One of the topics that fell within this theme was moon phases. Summers & Mant (1995) administered a questionnaire to 120 primary school teachers, where 57 of the questions asked were closed questions. The majority of the teachers' in this study attributed the cause of the moon phases, to being that of a shadow blocking the moon. Most of these teachers said that it was because of the earths' shadow that causes the moon phases to occur. The findings of Summers &Mant (1995) are similar to those found in pre-service teachers.

From the above literature, it can be seen that pre-service teachers and in-service teachers have non-scientific ideas about what causes the moon phases. Below, literature concerning intervention studies will be explored, so as to establish whether it is possible to change non-scientific ideas (by a considerable amount) about the phases of the moon through instruction.

2.2.2a Intervention Studies

Trundle et al., (2007a) investigated twelve pre-service elementary teachers' conceptions of moon phases before, and after instruction. Further, they investigated if conceptual change was possible after instruction.

Before instruction took place, when teachers' were tested on their knowledge of moon phases, it was found that eleven out of the twelve teachers' had alternate conceptions about the cause of moon phases while the remaining participant was unable to explain the cause of moon phases at all.

The instruction in Trundle's 2007a study took nine weeks and involved the pre-service teachers recording their observations of the shape of the moon over a nine week period. The instruction involved the following activities by the pre-service teachers':

- Pre-service teachers' collecting visual data on the moon.
- The data collected being analysed.
- After analysis, results being discussed.

After the pre-service teachers conducted the given activities, which were part of the instruction, post- tests were administered to the teachers, to test for their understanding of the concept of the phases of the moon. The results obtained from the post-test demonstrated that the teaching methodology used subsequently prompted scientific conceptual understanding, as all twelve teachers' showed evidence of holding scientific understanding about moon phases 3 weeks after instruction. It must also be noted that 3 weeks after the study, there was no pre-service teacher that held an alternate conception concerning the phases of the moon. Further some of the teachers' (9 out of 12) still maintained this scientific understanding of the phases of the moon six months after the intervention.

The success of the teaching strategy used was based on a concept termed conceptual change, where the concept was interwoven with pedagogical strategies. Conceptual change is a concept aimed at changing incorrect non-scientific ideas to be scientific. There are processes that an educator can undergo to try to get learners' to change their alternative views (Trundle et al., 2007a). There are four characteristics that apply during instruction, where these characteristics aim at restructuring non-scientific ideas (Vosniadou, 1991; 2003; in Trundle et al., 2007a: 305). These are as follows:

1. Conditions are created in which students' evaluate empirical evidence that is contrary to their beliefs.
2. Instruction provides clear explanations of scientific concepts, preferably through conceptual models or analogies.
3. Instruction utilises demonstrations that show the scientific models and explanations which are superior to non-scientific conceptions and explanatory frameworks.
4. Instruction promotes intentional learning, which is viewed by the learner as being purposeful and is characterised by a high level of meta- cognitive awareness and self-regulation.

To briefly explain what the different characteristics entail for participants to do in order to have an effective conception change, each characteristic will be explained briefly: Characteristic 1 deals with participants going outside to view the moon over a set period of time. The viewing of this moon would also entail participants drawing on a piece of paper the type of moon shape seen on a daily basis for the set period of time. After the period of observation and recording data, the participants view their data, and discuss any trends seen e.g. recurring patterns.

Characteristic 2 involves the participant working with the teacher so as to establish explanations which are scientifically correct to explain what was observed and recorded during the period of data collection.
Characteristic 3 involves using models to prove explanations given as per characteristic 2.
Lastly, characteristic 4 involves a personal introspection by the participant of looking at conceptions that the individual had about the moon phases and reviewing their conceptions with what they have learnt after instruction. In this way, intentional learning is fostered.

The terms meta-cognition and self-regulation are constructs that are used in educational literature, where different meanings are derived from these two terms (Dinsmore, Alexander and Loughlin; 2008). They suggest that the two terms, meta- cognition and self-regulation are sometimes used interchangeably. In the context of the paper written about the 4 characteristics mentioned, this is indeed the case, where the meaning of the two words that are used interchangeably was derived from the researcher White.

White (1998) makes mention that meta-cognition is a term that means inner awareness. In light of characteristic 4, this would mean that the participant becomes aware of the alternate conceptions that they had about the moon, where a change comes about; the change being of altering their alternate conceptions, so as to have an understanding that is in line with the scientific view. In that way, intentional learning takes place.

Other intervention studies conducted for teachers'; where there was an improvement in the teachers' understanding of the cause of moon phases includes (Mulholland & Ginns, 2008; and Ogan-Bekiroglu, 2007) as examples.

Mulholland & Ginns (2008) conducted research with pre-service teachers 'at four universities situated in the United States of America and Australia.
The location of the universities made it possible for the pre-service teachers' to get perspective on observations in the Northern and Southern Hemisphere. This meant that the pre-service teachers' that were situated in the Northern Hemisphere collected data of visual aspect of the moon, and likewise, teachers' in the Southern Hemisphere did the same: later, online discussions amongst the teachers' in the Northern and Southern hemisphere were administered so that the pre-service teachers' could make comparison with data collected (the

data collected by the pre-service teachers' was posted online to enable meaningful discussions). There were a total of 72 pre-service teachers' involved in the study.

Tests were administered to the pre-service teachers' to establish their understanding about the phases of the moon before and after instruction. The same questions were used for the pre and post-tests. The study looked particularly at the correctness of answers before and after instruction. The questions asked were related to 8 concepts relating to the moon, namely:

- Period of the Moon's orbit around the earth.
- Direction of the Moon's orbit around the earth.
- Period of the Moon cycles of phases.
- Motion of the moon from East to West.
- Phase and earth, sun and moon position.
- Phase location in sky time of observation relationship.
- Cause of Lunar phases.
- Effect of lunar phase with change of location on earth.

Results reveal that there was an improvement in the correctness of answers in the post-test. This improvement showed that with the intervention taken, it was possible for an improvement to happen. The intervention used various activities to help teachers' have a better understanding of moon phenomena:

- The pre-service teachers' recorded the shape and location of the moon (included was the time and date of the observation made), and made comments about their observations.
- The pre-service teachers' wrote about differences and similarities on observations made in the Northern and Southern Hemispheres.
- The pre-service teachers' needed to try and explain why the moon changed its shapes based on observed data.
- Learners' shared results obtained from the assignments given to them about the concept of the moon.

Ogan-Bekiroglu (2007) conducted research with 36 Turkish pre- service teachers' about their understanding of concepts relating to the moon. Like Mulholland & Ginns (2008), pre and post -tests were conducted to establish the pre-teachers' understanding of concepts relating to the moon before and after instruction. In terms of the questions posed, Ogan-Bekiroglu looked not only at the correctness of the answers based in questions posed, but rather looked if there was a shift in the mental models of the teachers' after instruction took place (mental

models are discussed in detail in section 2.5.2 within this chapter). Results revealed that before instruction, "teachers held flawed, incoherent and incomplete mental models about the moon and some lunar phenomena" (Ogan-Bekiroglu, 2007, p. 580). Having such mental models meant that before instruction, teachers' contained non-scientific ideas about concepts relating to the moon. The concepts where the teachers' held the most non-scientific ideas were the following:

- Moon rise and moon set
- The seeing of the same phase of the moon
- The moons effect on the tides
- Appearing of the same face of the moon at the same time all over the world
- Magnitude change in the appearance of the full moon
- The number of lunar eclipses

It was found however that after instruction, that some of the pre-service teachers' mental models shifted from "flawed, incoherent or incomplete mental models to correct mental models (Ogan-Bekiroglu, 2007, p. 581). This meant that after intervention, some of the teachers' that had non- scientific ideas about the moon shifted to being ideas that were scientific. The cause of this shift was due to the following activities having being done by the participants in the study:

- Weekly moon observations kept in journal entries.
- Feedback given to pre-service teachers' about their journal entries.
- Comparing of observations with peers, and looking for patterns.
- Construction of 3- dimensional models to explain observed phenomena of the moon.
- Looking at sources to help aid the pre-service teachers' to construct their models.
- Presentation of models to the class, stating limitations of the models created.

(Ogan-Bekiroglu, 2007, p. 564)

In the studies mentioned, before instruction, it was shown that teachers' had a limited understanding about the cause of moon phases. It was only after intervention, that there was an improvement in the teachers' understanding, showing that it is possible to change alternate views contained about the cause of moon phases.

It is important to note that the strategy employed by Trundle et al., (2007a) within the South African context would benefit pre-service teachers more, as it would help them understand

fundamental concepts relating to the phases of the moon. In relation to teachers at school, if the teaching strategy employed by Trundle et al., (2007a) for example, were to be employed by teachers in their instruction to learners, it would prove to be difficult. In a school setting, it is not possible to do such a task as time to teach a concept is limited. However, at least one characteristic from the list above can be incorporated into the education system through textbooks: that being characteristic two, as a textbook provides explanations about content and may simplify content to formulate it to be more understandable by using diagrams, and analogies. This may be especially valuable with content that is perceived to be difficult. The principal aim in the present study was to identify whether or not characteristic two is possible with the aid of a textbook.

2.2.2b Elementary and Middle School Learners

The literature evaluated makes mention of three types of phases, namely Elementary School, Middle School and High School. In the South African context, the terminology of Elementary and Middle school is not familiar, and therefore it is important to define which grades constitute Elementary School and Middle School learners, so as to link the relevance of the theory below to the current study for the sake of relevance. Table 2.2.2b shows the grade system and the relevant age groups for particular grades:

Table 2.2.2b: Different levels of school

Type of School Division	**Relevant age for grade (years)**
Elementary School	
Elementary School has three subdivisions	
Preschool	4-5
Kindergarten	5-6
Grade 1 – Grade 5	6 -11
Middle School	
Grade 6 – Grade 8	11-14
High School	
Grade 9 - 12	17 - 18

While the literature analysed and learners involved in the research fall under Middle School, it is also important to establish what the literature shows about learners at Elementary School level. Learners do not enter the classroom as empty vessels but have, to some degree (whether by previous instruction or observation); some knowledge of astronomical phenomena like moon phases (Lindell & Olsen, 2002). Knowing what learners' think about

what causes moon phases would also provide insight into why learners' have difficulties in understanding moon phases in Middle School.

2.2.2c Elementary School Learners and Moon Phases

Since adults (by the likes of pre-service and in-service teachers' explored above) have alternate conceptions about what causes moon phases, it is very likely that learners both in Elementary School and Middle School will also have alternate conceptions.
Previous research conducted by Philips (1991) and, Bisard, Aron, Francek & Nelson (1994) shows that the common belief in both children and adults is the conception that the earth casts a shadow on moon; this is a common misconception. It is not surprising that both learners and adults would hold the same misconception, as there is a possibility that teachers who have misconceptions about the phases of the moon, may pass on their own misconceptions to the learners that they teach during instruction. Attention in the following paragraphs is paid to intervention studies, since it is a known fact as highlighted by research done, that learners have misconceptions before instruction. The literature explored looks at if there are possibilities that learners' views about the moon phases can be changed.

Trundle et al., (2007b) investigated fourth grade learners' conceptions on moon phases by means of visual representation on a piece of paper. The learners' were asked to do drawings of moon phases and the pattern in which the moon phases appeared. The administration of the drawings took place before and after instruction, to compare whether there was any improvement in knowledge acquisition. From these drawings, learners' conceptions of moon phases could be determined.

The research found that before instruction, learners' had a very poor understanding of observable moon phases and the patterns of the cycle of the moon. After instruction, however, where the task involved the gathering, recording, and sharing of moon data (similar to the instruction adopted for the pre-service teachers' in Trundle 2007a), learners' demonstrated a good understanding of the concepts.

Realistically again, it would prove to be difficult to conduct instruction similar to Trundle's in the South African context, as time given to complete the section of the curriculum covering the phases of the moon is very limited.

An interesting study, where the aim was not on addressing learners' existing alternate conceptions, but was based on a careful planned instruction to help learners' identify their own understanding of astronomical phenomena, and reflecting on the change that occurs in their understanding, was conducted by Barnett & Morran (2002). To establish whether the methodology employed was successful, Barnett & Morran conducted a pre-and post-survey, and as well as a pre-and post-test interview on the participants. The study in particular investigated ideas that grade 5 learners' had about phases of the moon, solar and lunar eclipses. The study involved 17 learners. The researchers found that the concepts of moon phases, solar eclipse and lunar eclipse, were confused with each other. Barnett & Morran (2002:875) concluded "that instruction does not necessarily need to directly address students' alternative frameworks to promote conceptual change", but rather, instruction can be designed in such a way that learners' through carefully designed activities, can discover for themselves their alternate views, and change their own views once they realise that their thinking was incorrect.

2.2.2d Middle School Learners and Moon Phases

In terms of Middle School learners, Brunsell & Marks (2007) conducted research to establish ideas learners from grades 6 -11 had about the moon phases. Again, as seen from the above mentioned research, a small percentage out of each group was able to correctly explain the cause of the moon phases. Rider (2002), who also tried to establish 32 of his learners' ideas about moon phases through semi-structured interviews, came to the same conclusion: that those learners' had difficulty in explaining the cause of the moon phases, and that only a few learners' could correctly explain this phenomenon. The majority of the learners in the study of Brunsell & Marks (2007), and Rider (2002) cited the most common misconception held about the cause of the phases of the moon; the misconception being that a shadow is cast on the moon.

Trundle et al., (2010) conducted a similar exercise with Middle School learners as they did with Elementary School learners as mentioned above, and obtained similar outcomes. Their results demonstrated that learners had a poor understanding of moon phases before instruction and an improvement in the understanding of moon phases and patterns afterwards. This suggests that instruction had an influence on the learners' understanding of moon phases, and that procedures followed during instruction were successful.

Interestingly, both the teachers and learners from the above-mentioned studies had the same alternate non-scientific views about the moon phases and their patterns before instruction. The studies thus suggest that by using the theory of conceptual change, learners and teachers alike will be able to learn and understand correct scientific knowledge about the moon phases.

From my observations as a student teacher during my year of study (2004 – 2007), and as a teacher in a school (2009 – 2013), science textbooks seem to be one of the principal tools in a typical classroom for learners to use to advance their knowledge about content learned in class. Therefore the focal point of the present study is the textbook, looking particularly at the content presented to establish if the textbook alone is able to help learners understand concepts relating to the phases of the moon.

There are set times in which work needs to be completed in a school environment. The activities that are covered in the study of Trundle et al., (2010) take place over a nine week period: in a school system, especially in my workplace, nine weeks is far too much time to spend on a single activity or concept. For this reason, moon observation activities were not considered for the purpose of my study. However, post-test procedures as well as some methodological procedures from these studies were incorporated to explore what the learners know after the use of the textbook.

2.3 Models

Gilbert & Boulter (2000) state that models are a representation of an idea, where the representation of such an idea serves the purpose of making an abstract concept more understandable. Gilbert & Boulter (2000) do acknowledge that there are different representations of models, and mention 5 types, namely:

- *Concrete* – 2- dimensional and is made of resistant materials
- *Verbal* – description of entities and the relationships between them in a representation
- *Symbolic* – consist of chemical symbols and formula, chemical equations and mathematical expressions
- *Visual* – use of graphs, diagrams, and animation. 2-dimensional representation of diagrams

- *Gestural* – makes use of the body or its parts

The present study thus focusses on 3 types of models, namely concrete, visual and verbal, and looking at the relationship that exists between these three types of models, by establishing if visual models enhance explanation (verbal) of what causes the moon phases. The symbolic model is not applicable in the present study as there are no formula and expressions to consider. And likewise, gestural models are not also considered in the present study, as learners' make use of models to explain observed phenomena in regards to the moon.

To determine whether learners understand the concept of what causes moon phases, learners will be asked to explain their ideas by using concrete models: the reason behind using concrete models is explained in the next paragraph.

For proficient understanding of the concepts in moon phases, learners require spatial perception (Mualem & Nussbaum, 2002; Yair, Mintz & Litvak, 2001). Relative distances of the earth, moon and sun, scale and movement are essential concepts that need to be understood fully with regard to moon phases. Typically, diagrammatic representations found in textbooks are 2-dimensional, whereas, in reality, the phenomenon of moon phases occurs 3-dimensionally. Thus, textbooks cannot cater to learners' conceptual understanding exhaustively.

In order for learners to understand astronomical phenomena such as moon phases, they may, in some cases, be required to build mental models, and to make complex mental manipulations on the model to test for their understanding of the position of the sun, moon and earth in different moon phases (Mualem & Nussbaum, 2002; Yair et al., 2001). In other words, learners would thus need to visualise mentally if given, for an example a waxing crescent, to think of the shape, and how the sun, earth and the moon would need to be positioned to get such a shape.

There are studies that show the benefits of including the use of models in instruction, so that learners can understand concepts that they are being taught a bit better. A few of these studies are discussed below.

Stahly et al., (1999) conducted research on third grade students' ideas about moon phases. The research conducted was informed by a series of 6 lessons taught to a class of a total of 21 learners, in which 12 learners were boys, and the rest being girls. Only four learners (2 girls and 2 boys) out of the total of 21 were involved for data collection purposes, based on the

teachers' recommendations. The learners were chosen in terms of academic ability and verbal ability. Stahly et al., used questionnaires and interviews to determine the learners' views about moon phases before and after instruction.

The first lesson, involved finding out ideas learners' had in relation to moon phases. The second lesson to the sixth lesson looked at the introduction of models: model of the sun, earth and the moon. These models in a series of activities were used by learners to explore how the moon would look like, with different positions of the sun, earth and the moon. Learners were encouraged to do drawings, so it could be analysed if learners' understood the concepts. Not all learners' drew scientifically correct drawings, and when this was discovered, there was a lesson time devoted in reviewing the work leading to the drawing of diagrams.

After learners had an opportunity to work with the models, there was a change in terms of their responses as compared to responses given about moon phases before instruction took place. The responses learners' gave after instruction about moon phases tended to have "more scientifically accurate aspects" (Stahly, 1999, p. 174). This shows that conceptual change in terms of learners' thinking about moon phases was possible with the aid of using models. What is striking about this study though is that not all learners' inaccurate scientific notions changed about moon phases, where Stahly (1999) suggested that there are some learners' that would continue to hold inaccurate views about moon phases, depending on what is assimilated by the learners' in their mental structures.

Nevertheless, this study still proved that models do help to some extent, in learners' understanding concepts relating to the moon a bit better. Other studies that included models in instruction to help learners and adults (pre-service teachers) improve their knowledge are Barnett & Morran, 2002; Ogan-Bekiroglu, 2007; and Mulholland and Ginns, 2008 to name but a few. Studies of Ogan-Bekiroglu (2007) and Mulholland and Ginns (2008) have already been discussed

Barnett & Morran (2002) conducted research with 17 grade 5 learners' in a rural elementary school. The aim of the research was to look at whether strategies introduced in instruction would help the learners' improve their understanding of astronomical phenomena. The learners' were given a total of 6 projects. In the study of Barnett & Morran (2002), only two projects are reported on, that being the projects that involve the phases of the moon, and the lunar eclipse. The topic was as follows in the respective 2 projects: '*motion of the moon and phases of the moon'* and '*eclipses and phases of the moon'* (Barnett & Morran, 2002, p. 862).

I will only focus on results obtained from the topic '*motion of the moon and the phases of the moon*' as it is more relevant for the present study.

The project was designed in such a way that there were activities that the learners' had to do to successfully answer the questions posed by the project. The project given to the learners' involved the following activities:

- Gathering information regarding the orbital motion of the earth and moon
- Making observations, and recording the observations of the position and the phase of the moon each night.
- Discussing their data on observations to their peers
- Exploring their observations using a 3 dimensional interactive computer model of the earth, sun and the moon system
- A presentation at the end of the project by the learners', to explain what they had learnt.

Pre and post interviews were conducted to establish the learners' understanding of the concepts involving the moon so as to establish whether instruction benefitted learners' understanding of concepts. In the interviews conducted, learners were given a piece of paper and pencil so as to draw what they were explaining. Learners were also given spheres (in the context of Bannett & Morran's project, the spheres given were required to be used to show the relative positions of the sun, earth and the moon) to manipulate as they were providing explanations to the questions posed.

Results reveal that before instruction, learners' could name the different shapes of the moon within a cycle, but struggled to explain what the cause of these shapes was.

Barnett & Morran (2002) probed further in the interview to establish the source of difficulty that learners' were experiencing in explaining the cause of the moon phases, and established that the difficulty was based on learners' not being able to visualise the relative position of the sun, earth and the moon, depending on the shape the moon had. After instruction, it was discovered that 9 out of 17 learners' improved their understanding on the cause of moon phases.

The studies of models in moon phases therefore have educational purposes; that being able to show competence in understanding the cause of moon phases by looking at the relationship of

the earth, moon and the sun. The concept of the positioning of the sun, earth and the moon being responsible for the different shapes of the moon can be used as an assessment in determining whether learners' understand the cause of moon phases.

In the present study, to test whether textbooks are able to facilitate conceptual understanding as to why moon phases occur, learners' were given physical models to replicate moon phases as depicted in diagrams in the textbook. The models employed represented the sun, earth and moon.

If learners are able to model moon phases accurately from a textbook diagrammatic representation, this suggests that the 2-dimensional depictions are adequate for learners to develop a mental model in order to acquire in-depth conceptual understanding of moon phases. However, if learners are unable to model moon phases from textbook diagrammatic representation successfully, this may suggest that 2-dimensional depictions are inadequate for learners to develop the necessary mental models in order to acquire an in-depth conceptual understanding of moon phases.

2.4 Textbook Analysis

Swanepoel (2010: 8) states that, "Textbook analysis is the evaluation of data about textbook characteristics according to explicitly stated criteria". Researchers determine which characteristics of textbooks contribute to learning. The characteristics that were looked at in addressing the first research question (What is the quality of diagrams and explanations of moon phases offered by grade 6 – 8 Natural Science textbooks) are the content, instructional design, technical design and social considerations. The presence of these characteristics thus form part of criteria against which a textbook can be analysed.
Swanepoel (2010) stresses thus the importance of analysing textbooks, as she mentions that "the analysis of a textbook is often the only viable method of assessing a textbook's quality in isolation" (Swanepoel, 2010, p. 8).

In the present study, an evaluation instrument was used. An evaluation instrument for a textbook is a tool used to analyse the quality of a textbook using a set of desirable criteria as a checklist. The evaluation instrument was used to analyse the quality of diagrams and the explanation of moon phases in textbooks (Refer to Appendix A).

Textbooks are an important source material for both teachers and learners. Research conducted by TIMSS (Trends in International Mathematics and Science Study) demonstrated that teachers spend fifty percent of their time giving instruction with a textbook. This study (TIMSS) shows that textbooks are an important part of classroom practice. From my experience as a teacher, the textbook is an important tool for both teachers and learners, since learners use their textbooks to study for their exams and tests. The textbooks commonly used mostly contain text, diagrams, graphics and various exercises which test for understanding.

Having adequate sources of information may help the learners' understanding of concepts. If the textbook contains information which is not scientifically accurate, then learners' may struggle to understand content as well as concepts contained therein. To illustrate the importance of the influence of a textbook in students learning can be seen in a study conducted by Leite.

Leite (1999) took eleven grade nine Portuguese science textbooks, and analysed the content pertaining to heat and temperature. In her analysis, she focused on three characteristics (1999: 78):

a. Level of conceptualisation and correctness of concepts and arguments;
b. Global teaching approach (sequence of contents, problem solving orientation and requirement of student activity);
c. Learning activities (nature, diversity and level of investigation).

Leite discovered that there were commonalities across the different books in terms of the definition of temperature; however, there were few commonalities in the explanation for heat.

Leite also discovered that the content pertaining to heat in the textbooks was incorrect, and found contradictions on the content of heat. She hypothesised that the reason behind the incorrect content and contradictions was due to the fact that the authors of the textbooks may have had difficulties in dealing with the content of heat.

This may also explain why learners' may have difficulty in learning the concept of heat, since the textbooks they use may have alternate conceptions or information that is incorrect. Thus, Leite found in her study that the content lacked accuracy.

In another study: Cho, Kahle & Nordland (2006) analysed three biology textbooks that were commonly used at high school level. Cho et al., (2006) analysed text relating to genetics, and

looked at whether the text contained in the three respective textbooks contained any misconceptions relating to genetics. The analysis of these three textbooks revealed the following facts:

- Definitions of basic terms varied from the different textbooks.
- Some concepts discussed in the textbooks (where concepts were related to one another) were not interrelated to one another.
- All three textbooks used terms interchangeably (the terms being allele and gene).
- Mathematical aspects within the textbooks foster rote learning, rather than explaining the mathematical applications.

Cho et al., (2006) used the findings on the analysis of the three textbooks to compare them with 4 characteristics that literature makes mention of a contributing factor towards learners developing misconceptions and difficulty in learning genetics. The characteristics that Cho et al., (2006) looked at were: sequence of topics taught, relationship between meiosis and genetics, use of terms, and mathematical elements in genetics (Cho et al., 2006, p. 717). Looking at the list of errors found as highlighted by the bullet points above, and the comparison of characteristics that contribute to misconceptions and difficulty in learning genetics, Cho et al., (2006) came to the conclusion that all three textbooks analysed "provided bases for misconceptions and difficulties in learning genetics" (Cho et al., 2006, p. 717). Cho et al (2006) makes mention that the fact that the textbooks contain textual errors, may contribute to learners having difficulties in learning this topic.

Since learners may rely on textbooks for the learning process, it is crucial that the textbook they are using contain accurate scientific content, as this directly influences the learners' acquisition of vital scientific concept formation.

2.5 Theoretical Framework

Crotty (1998), cited in Bodner & Orgill (2007), defines the theoretical framework as "the philosophical stance informing the methodology" (Bodner & Orgill, 2007: vii). Bodner and Orgill maintain that it is essential for a researcher to state his theoretical framework in advance, since the framework influences the design of the study, the instruments used for the data collection, and the analysis of the data collected for the study.

For the present study, constructivism will be employed as a theoretical framework for the first phase of the research that being the analysis of grades 6 – 8 Natural Science textbooks. The subsection personal constructivism justifies the use of this particular theoretical framework.

2.5.1 Constructivism

Constructivism is defined as "the process of learning, as the gradual re-crafting of existing knowledge that, despite many intermediate difficulties, is eventually successful" (Smith, DiSessa & Roschelle, 1993, p. 123). This suggests that the previous knowledge of the learner is important: this previous knowledge is developed, as more complex structures of knowledge are constructed from simpler ones. Hence, constructivism provides a philosophical and theoretical framework for understanding the processes learners' encounter in learning, and how this learning process can be facilitated.

The role of the teacher in this process is also important, since it is the teacher who unearths learners' pre-existing ideas to identify flaws in these preconceived ideas. With this process, the teacher can then construct a lesson that will address these issues. In some instances, a part of the lesson may involve the use of source materials, such as textbooks.

Learners have to understand the content covered in these textbooks, in order to understand the concepts explained. Textbooks themselves can take a role in constructivism, by the way the text and graphical representation is represented within the textbook.

According to Duban (2008), textbooks can be designed in such a way that they do indeed promote constructivism; however, the textbooks need to have certain characteristics which promote constructivism.

Duban describes the characteristics as follows (2008: 394):

- Books should pay attention to students' prior knowledge and help to change the prior knowledge. Therefore, books should contain conceptual change texts. In these texts, through questions, students' prior knowledge should be activated.
- To provide students' conceptual change, texts with analogies should be used because analogy-based thinking consists of the definition and transfer of constructive information from the known system to the new and relative system.

- To eliminate misconceptions originating from daily spoken language, the differences between concepts and relations should be defined well to students and these differences and relations should be mentioned often within texts (In this context, the concepts are the correct scientific knowledge conveyed by the text, and the relations has to do with how the content found in text relates to the real world).
- In the course books, visual components should be used often. In a good science course book, not only writing and formulae, but also many visual components such as pictures, figures, and graphics should be used.
- Learning develops through individuals' interaction with others, since individuals share their perspectives, exchange information and solve problems on the basis of collaboration. Therefore, in the science course books; there should be activities that will encourage students to work in collaboration by doing group work with their peers.

From my observation as a pre-service teacher, going into schools to observe and conduct lessons, I had noticed that schools that are said to be well resourced, not only conduct lessons using electronic media, but provide textbooks to learners' to help learners' understand concepts a bit better. It is therefore left up to the learner to go do further reading in the textbooks on concepts covered in class. The reason for saying this is that in most lessons that I had observed, teachers give learners' page numbers of textbooks to go read at home to get a better understanding. Therefore, textbook analysis, which is addressed by the first research question, can use constructivism as a theoretical framework to determine whether or not textbooks aid conceptual change in learners' through the text and diagrams used.

With regard to the textbook and the learner, although teachers use the textbook as a conceptual tool in pedagogical processes, Bodner and Orgill (2007) note that it is learners' who construct their knowledge. It is in this regard that personal constructivism informs the study.

2.5.2 Personal Constructivism

This form of constructivism, also known as Piagetian constructivism, is based on the idea that the construction of knowledge is done by the individual learner to meet his/her own needs (Bodner & Klobuchar, 2001). This is only possible, according to Piaget (2003), through a process of assimilation and accommodation. According to Piaget, assimilation is "the

integration of any sort of reality into a structure" (2003: S17). In other words, this is the process of taking in new knowledge, into our existing structure of knowledge.

Accommodation involves changing our ideas within a structure in light of new information being conveyed. This may especially apply if a learner has a misconception which leads to errors. Nesher (1987: 33) states that "if we are lucky enough to detect an error we are then in a position to improve our set of beliefs." This statement summarises accommodation.

Piaget thus sees learning as a situation provoked by external structures, where learning is only "possible when there is active assimilation." This assimilation is done by the learner after he is able acknowledge the shortcomings of his previous mental conceptions (2003: S17).

The focus of the present study is on the content of textbooks. This includes the congruence between texts, diagrams and pictures, and whether or not these elements enhance explanation. The accuracy of scientific content in textbooks is also an objective. The second focus of this study is to investigate whether learners are able to translate the knowledge obtained from textbooks to 3-dimensional replications of moon phases using physical models.

The use of constructivism as a lens facilitates these investigations and can generate possible explanations through looking at constructivism characteristics as mentioned by Duban (2008), for the outcomes of this study. Furthermore, constructivism facilitates the scientific inquiry this research study endeavours to achieve whilst also accommodating for the human element, which often cannot be quantified through traditional scientific inquiry methods.

The analysis of science textbooks is particularly important in identifying gaps that may exist in the content found inside the textbooks. If textbooks contain misconceptions, this may cause both teachers and learners to acquire the same misconceptions disseminated by the textbook. Therefore, the knowledge that will be built on will contain flawed scientific concepts.

The coherence (how content is presented in a textbook) of the textbook is important in terms of structure. According to literature, four characteristics constitute coherence in science textbooks. These are:

a) Present a set of age appropriate scientific ideas and connections among them.

b) Clarify the ideas and connections with effective representations.
c) Illustrate the application of the ideas to objects, events and processes in the real world.
d) Avoid the use of unnecessary technical terms or details that are likely to distract the students from the main story.

(Roseman, Stern & Koppal, 2010, p. 50)

In the present study, characteristics a) and b) relate to the structural investigation of textbooks. Point c) relates to the accuracy of text in terms of misconceptions. Point d) deals predominantly with the language and terminology.

While learners construct knowledge through multiple media, they are more likely to refer to their textbooks as study sources since textbooks form a major source of learners' instruction outside of the classroom. Learners' rely on textbooks for homework exercises, for studying, assessment and further conceptual development.

Learners construct scientific knowledge not only from written texts, but also from visual representations in textbooks. Myers (2003) asserts that it is important for teachers and learners to be able to analyse and construct knowledge delivered in verbal, visual and textual form. Schnotz (2002) notes the importance of the coherence of verbal and graphical information in textbooks, and how this can facilitate meaningful association with pre-existing knowledge and allow for the construction of more scientifically accurate knowledge.

Phase two of the study, deals with learners working with physical models of the moon, sun and the earth. Learners are required to move the models in such a way, that they represent the diagram of the moon phases given to them. The use of models thus forms part of an assessment, in terms of determining whether learners' do understand the cause of moon phases.

The theoretical framework thus employed for the second phase, is that of mental modelling. There are various definitions that exist for mental models. The definition though, that will be used in this study, is that defined by Chi & Roscoe (2002). Their definition is that of a mental model being a representation of knowledge as a set of interrelated propositions that are embedded in a structure (Chi & Roscoe, 2002, p. 6).

The framework encompassing mental models was summarised by the diagram below:

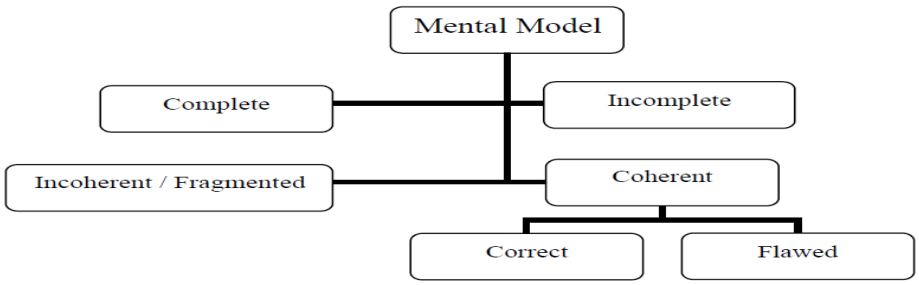


Figure 1. The mental model categorization by Chi and Roscoe (2002)

According to Chi & Roscoe, learners may possess two types of mental models, namely incoherent and coherent mental models. An incoherent or fragmented mental model is seen as "one in which propositions are not interconnected in some systematic way" (Chi & Roscoe, 2002, p.6). If learners are said to have such a mental model, it means that learners' cannot offer consistent and predictable explanations about phenomena, and thus learners' lacking a complete understanding of concepts.

A coherent mental model is when a learner offers propositions that are related with one another in an organised manner. It is said that learners' possess a coherent mental model when they are able to "generate explanations, make predictions, and answer questions in a consistent and systematic fashion" (Chi & Roscoe, 2002, p. 7).

Within the coherent mental structure, there are further two categories. The one that needs elaboration is the flawed coherent mental model. A 'flawed' mental model is one where a learner is said to have explanations and predictions that are consistent, but are flawed as the explanations offered may contain a principal which is not entirely correct.

Chi & Roscoe make mention that "a flawed mental model may share a number of propositions with a correct mental model, but they are interconnected according to an incorrect organising principle" (Chi & Roscoe, 2002, p.7). An example could be that learners' may arrange models of the sun, earth and moon in the correct positions to represent a full moon, but the explanation offered for the orientation of these models may be incorrect.

In terms of completeness, it is said that learners' have a complete mental model when the majority of their conceptions are correct, whereas an incomplete mental model is one in which the majority of the learners' conceptions are incorrect.

These mental models help to classify the extent of learners' explanations about moon phases, where this classification would enable one to determine as per this study, whether learners' understand moon phases or not after the use of a textbook. As mentioned above, the physical models thus can be used as an aid to determine whether learners' truly understand what causes the moon phases. This particular theoretical framework will enable us to determine this notion.

2.6 Emerging Issues and Conclusion

It is evident that both learners and teachers have alternate conceptions about the cause of moon phases; that being of the moon phases being caused by the earth's shadow being cast on the moon. Certainly researchers that were explored in the literature also came to the same conclusion while conducting investigations and generalising their findings: (Baxter, 1989; Schoon, 1995; & Stahly et al., 1999) to name but a few.

These misconceptions however, can be changed, and intervention studies mentioned, showed that there are various activities one could do to enable learners' to understand concepts around moon phases better. One method, where this method stood out in literature, was the introduction of physical models in instruction.

The importance of using models in scientific teaching has been explored in literature. The literature explored shows that the use of models encouraged participants to have a more scientific view about what caused the moon phases. Since the textbook used 2-dimensional diagrams to represent the phases of the moon, it was explored in the present study whether or not the textbook was a good conceptual tool to use alone when teaching moon phases in the classroom environment.

Instruction plays a pivotal role in learners' lives in terms of understanding difficult topics under astronomy education. For learners to understand these difficult topics, pedagogy relies on specific instructional methods to help learners' in some way or other to change their views to be in accordance with scientific theory. Therefore, since most pedagogy uses a textbook as a tool to enhance learning, analysing the textbook is of much importance, as it may provide greater insight into why learners think the way they do.

The theoretical framework of the present study has also been introduced. There are two theoretical frameworks used, as the two research questions posed, could not use one general theoretical framework. The framework which addressed the first research question was constructivism. The second research question was addressed by a theoretical framework called mental models. Chapter three explores the methodology employed for the study.

Chapter 3

Research Design and Methodology

3.1. Introduction

In chapter 2, I reviewed the literature pertaining to astronomy education, and concentrated on the topic moon phases. I also reviewed literature pertaining to textbook analysis using a constructivist approach. In this chapter, I will in detail elaborate on how the research was carried out by looking at the methodology employed, the research design, the rationale that informed the choice of method used and instruments used for the collection of data. I will further discuss issues pertaining to validity and reliability, as well as ethical considerations.

3.2 Methodology

A methodology is defined as "the plan of action which informs and links the methods used to collect and analyse data to answer the original research question" (Bassey, 1999, pg. 58). In this subsection, I will explain in detail, the choice of methodology, the meaning of the methodology used, and why such a methodology is useful for my research.

The research is that of a qualitative nature, and the methodological approach used to guide the study is that of a case study nature. A case study is not easily definable as there are many research method texts available with different meanings attached to what a case study is; examples of theorists who attempt to define what a case study is include (Adelman , Kemmis & Jenkins 1980; Yin 1984 & Fry, Ketteridge & Marshall, 1999)to name but a few. With the varying descriptions of what constitutes a case study, there is little agreement in a universal description of what a case study is (Lincoln & Guba, 1985). For the purpose of my research, the direction taken as to what a case study is, is from Opie (2004), where he describes a case study as "an in-depth study of interactions of a single instance in an enclosed system" (Opie, 2004, p. 74).

To elaborate on the definition provided by Opie about what a case study is, I will explain the terms 'single instance' and 'enclosed system'. By single instance, it is meant that a case study

looks at one particular phenomenon, where the phenomenon is studied in great detail. Studying a phenomenon in great detail helps to provide more thorough explanations about the outcomes of the investigation related to the particular phenomenon. An enclosed system refers to the setting or environment that data is collected. This means that data is collected in a unique location for all participants.

The study concentrates on a group of 15 learners from one class, and an in-depth analysis is done about their understanding of the moon phases after using an education tool which is a textbook. The case in this context is the students and the textbook used for their advancement in learning about the topic. This approach helps in understanding why the learners answered the way they did during interviews, which then may assist in what needs to be unpacked for future research.

There has been much criticism about the use of a case study for research purposes. One of the most common criticisms is that a case study cannot be generalised to a larger population (Denscombe 2007, Bassey 1999). This conception also questions the validity of the research itself. Denscombe (2007) however argues that even though there is much criticism in relation to the generalisation of results, a case study has an important role to play. Denscombe makes mention that a case study may play an important role in research that may have an aspect having the same characteristics, such as the current study; that is looking at how learners interpret 2-dimensional textbook diagrams of moon phases to a 3- dimensional model.

In relation to the issue around generalisation, a case study may not generalise over a large population, but may give us an idea of what might be the thinking behind a problem in other populations; in the context of my research, it might, to elaborate more on the example, give us an idea on what other students in other schools may think about the cause of moon phases, and what the cause of these learners' thinking may be. I therefore chose the case study approach for my research as it was a suitable methodology to help me explore in greater detail on what the contributing factor might be in the thinking of learners about the cause of the moon phases. The case study approach was a suitable methodology to help answer my two research questions, and see the relation that exists between the research questions.

3.3 Research Design

3.3.1 Piloting

Piloting is a process of pre-testing an instrument to be used in research with a sample of a group of people who willingly volunteer to be part of a pilot (Van Teijlingen& Hundley, 2001). There are according to Opie 2004 numerous advantages in conducting pilot studies. The main point that summarises all the advantages of doing a pilot study is that it helps to identify a problem an instrument might have, so it can be corrected.

A draft instrument for textbook analysis was developed and piloted so as to identify the weakness the draft instrument would have. This in turn could help so improve the instrument to collect better meaningful data. The draft instrument contained columns which had a rating scale. The column contained information a person had to look out for, so as to rate the content being analysed. Table 3.3.1a is presented to illustrate what the draft instrument initially looked like

Table 3.3.1a: Table showing initial research instrument

Science Content	**Rating Scale**			
	3	2	1	0
Facts are accurate				
Facts are up to date				
Units and symbols are correct				
Science content emphasises science enquiry				
Content is appropriate for grade level				

The instrument presented in table 3.3.1a mixed incorporated statements worth looking out for when analysing content of the textbooks from Swanepoel's textbook analysis instrument, and the National Science Resources Centre assessment criteria for textbooks. From Swanepoel's textbook analysis instrument, only the science content section was adapted in the instrument, and from the National Science Resources Centre textbook criterion, only the section entitled "criteria for judging science content" was adapted into the instrument.

After testing the instrument on two textbooks, the results obtained were of a poor nature. The reason why they were of poor nature was that only a score was given for the criterions used. This information was worthless, as one could not figure out from just the score what was inaccurate in terms of the science content from the textbook. Therefore from the textbook being analysed by this instrument, no generalisation could be made to help answer the first research question. It was then decided that an instrument with just a rating scale would not provide the necessary information, and thus this instrument was discarded.

Another draft instrument was therefore developed, after looking at a variety of other instruments used for textbook analysis. The instrument for evaluating resource materials developed by the British Columbia Ministry of Education proved to be a worthwhile instrument to adapt to answer the first research question because the instrument had distinctive categories, which would help find rich information for vigorous interpretation of a textbook.

The second draft instrument did not contain numerical rating scale like the first draft instrument. Table 3.3.1b illustrates an example of the draft instrument (Full second draft instrument attached in appendix A)

Table 3.3.1b: Table showing instrument change after pilot study

Evaluation Form For each of the following statements, tick the relevant box that best reflects your judgment of the resource. Use the space following each item for comments, including relevant page numbers. SA – Strongly Agree SD – Strongly Disagree NA – Not Applicable				
Content	SA	SD	NA	Comment
The science content is accurate				
The science content is current				
The level of difficulty is appropriate for the intended grade				

After piloting this instrument to the same two textbooks as the first draft instrument, it was discovered that an additional 2 categories had to be added in the case where in analysis; a

statement was neither SA (strongly agree) nor SD (strongly disagree). The additional categories added were then A (agree) and D (Disagree).

In terms of the piloting of the interview schedule, two learners in Grade 8, within the same school as the research sample grade, but in a different class, were asked to volunteer for an interview. Using a different class, allowed the possibility of the learners relaying what was asked in the interview was limited. Within the interview, clearer moon pictures from the internet were used for the visual aspect, and learners were asked to model out the different phases of the moon as per picture i.e. a crescent moon picture taken from the internet was given to the learner, and the learner was asked to use the models to model out the position of the sun, earth and the moon in order to get the crescent moon as illustrated by the internet picture. There were frowns when the pictures were shown to the learners, as these pictures were not the same as their textbook diagrams. The change that occurred was that the learners' textbook pages containing moon diagrams were photocopied, to eliminate any doubt of learners not having seen diagrams. There was however no change to the questions asked, as the process went smoothly.

3.3.2 Instruments:

The research was executed in two phases. Phase one addressed the first research question, while phase two addressed the second research question.

Phase 1: Analysis of Textbook

Materials: Science Textbooks

Six science text books were examined to investigate the quality of diagrams and explanations of moon phases. Textbooks were selected on the basis of whether moon phases content was covered in the section of 'Planet Earth and Beyond'. Of the six textbooks; two were grade 6 textbooks, two were grade 7 textbooks and two were grade 8 textbooks.

The criterion for the choosing of the textbooks was that they had to be approved by the Department of Education, as these were the textbooks that teachers would receive at their respective schools.

The second criterion was that the textbook had to be in line with RNCS (Revised National Curriculum Statement), as the content specified as per RNCS for all the grades chosen (Grade 6 -8) contain content of moon phases.

3.3.3 Description of the instrument:

The instrument employed for this study (see Appendix A) is adapted from the British Columbia Ministry of Education (2002, 2008). The instrument was developed by the education ministry for educators to use as a guide in evaluating, selecting and managing of learning resources.

The instrument focuses on four aspects in the evaluation of learning resources, namely; content covered in the textbook, instructional design, technical design and social considerations. The four aspects are each explained, and presented below is just a summary to better understand the four aspects (The summary is based on the explanation provided by the British Columbia Ministry of Education 2008):

- **Content:** Evaluator examines the content of the resource to determine its accuracy and relevancy.
- **Instructional Design:** The evaluator determines the resources effectiveness of its organization, teaching strategies, and assessment provisions in supporting the goals and objectives of the specific curriculum.
- **Technical Design:** Looks at technical aspects of the resource to determine if it enhances learner accessibility and understanding.
- **Social Consideration:** Evaluators examine if there are any controversial or offensive elements within the content.

Each of these foci has a set of criteria to check against (the criteria are presented in the next chapter), and some of these foci will be used for the analysis of the textbooks.

The instrument is organised in table format as a rating scale (strongly agree [SA], agree [A], strongly disagree [SD] and disagree [D]). Where the ratings do not fall in either criteria for a specific characteristic that is examined, a qualitative comment was used to provide an explanation regarding what the problem with the textbook may be have been. Comments are also supplied as supporting arguments on to why a criterion falls into the SA, A, SD and D columns.

Phase 2: How a textbook affects learning

Interview

The purpose of an interview is to explore why participants answered the way they did in specific questions Opie (2004). The reason behind using an interview for the purpose of my research was to determine whether learners were able to explain why they represent textbook illustrations the way they do using models given to them.

There are different types of interviews that exist, I will briefly mention the different interviews, and highlight which type of interview was used for my research.

According to Opie (2004), there are three types of interviews that exist, namely: structured, semi-structured and unstructured interviews

Opie (2004) compares a structured interview to a questionnaire, where the interview is tested on a large quantity size, where results can be generalised over a population. The question style is of the nature where respondents can give short immediate answers. In my research, only 15 learners were interviewed, and thus is an inappropriate style to use for my research. Furthermore, the type of study I conducted, sometimes allows for a probe, so that learners can better explain themselves in detail what they mean for a particular response. The type of questions used does not allow for a simple immediate answer, as learners have to explain themselves in greater detail.

A semi-structured interview, which is the style I chose for my research method, is more flexible then a structured interview, and thus allows for more depth from a respondent Opie (2004). It is mentioned by Opie (2004) that it is a style commonly used by Masters students' given the time frame in which the research is to be done.

An unstructured interview is one where there is no direction from the onset, and direction is determined by the respondents' ideas while being interviewed Opie (2004). The research I conducted had specified questions on content, and had specific aims from the onset, thus this type of style was also not appropriate.

For the semi-structured interviews, models were used so that learners could show the researcher the position of the sun, earth and moon for a particular type of a moon phase. The models consisted of objects which represent the sun (a yellow globe), earth (model of the earth supplied by social science department of the school) and the moon (a white hockey

ball), and learners were asked to manipulate these models to represent what they saw occurring in the illustrations.

Selection of the school

The school selected is an all-girls school in Johannesburg. The reason for the selection of the school was that I am currently an educator within the school, thus making it convenient to easily access the learners required to participate in the research with ease, and negotiate with the learners with appropriate times convenient to them, in doing the interview. It made the process of receiving consent from parents smoother, as the parents know who the researcher was, making it easier for the parents to trust the researcher. The grade 8 class had a total of 32 learners, where learners received their education in a Laboratory classroom. This enabled learners to have hands on type of lessons. The task thus given to learners in organising the models proved to be less difficult, as the learners were used to working with equipment on their own, when hands on experiments or tasks were given.

Selection of the Sample

For the purpose of the interview, 15 grade eight learners from the same class were pre-selected by their Natural Science teacher according to three performance categories. The teacher in question is not the researcher himself, but another teacher within the same Natural Science department was asked to choose the appropriate learners in her class. The categories include; above average performers, average performers and below average performers. The learners were selected on the basis of their performance in natural science assessment activities in their class. Five learners were selected from each category, and each gave informed consent from their parents, and themselves to participate in the study.

Data collection

A semi-structured interview schedule was used to obtain responses from interviewees. The responses obtained was transcribed, and later analysed and explained in Chapter 5. The interview schedule used by Trundle et al. (2002) was adapted, and learners were shown images from a textbook (the same textbook that they use in class). Learners were asked to model what they saw using 3-dimensional replicas of the sun, moon and earth.

While learners were modelling out what they saw, and explaining why they arranged the models as they did, the learners were videotaped so as to analyse in great detail their

responses for interpretive purposes. Again, learners were aware that they were to be videotaped, as informed consent was given by the parents and the learners to be video-taped for the interview.

Copies of the instrument used to analyse the textbook (Appendix A) and informed consent forms (Appendix G) can be viewed in the appendices.

3.4. Validity and Reliability

Validity is referred to as the degree to which the method, a test or research tools measures what it is supposed to measure (Wellington, 2000, p. 201).

To ensure the validity of the data to be collected, my textbook instrument was face-validated by science education experts who looked at whether the instrument would offer relevant data that would answer my research questions.

In terms of the interview schedule, the instruments was piloted to two learners in another class not involved in the research, to see if the questions were not too difficult to answer by the learners, or to see if there is no ambiguity.

Reliability of an instrument or data gathering procedure is defined by Scaife (2004) as "the extent to which a data gathering process produces similar results in similar conditions" (Scaife, 2004, p. 68). To increase the reliability of my textbook instrument, I analysed three textbooks using the instrument and recorded my results. I then sent the same textbooks together with the instrument to three other people (3 Natural Science educators not in the school), who analysed the textbooks with the same instrument. When I compared my results with the 3 Natural science educators, there was 100% correlation between the following categories; instructional design, technical design and social considerations. The category 'content' proved to have 95% correlation. The reason for the correlation was that the 3 natural science educators felt that it was still correct to say that a new moon is spotted by means of seeing the first signs of a crescent moon. The researcher made mention that they had a valid point, as in everyday life, this is what is taught. The researcher made mention however, that when referring to the shapes of the moon; one cannot say that a crescent moon is a new moon, and that it was then up to instruction to make it clear to the learners that there are different views in everyday life on how to spot a new moon in the sky, and what science

says about the shape of the new moon. After this discussion, there was 100% correlation in the category ‘content’.

In terms of the interview schedule, the same questions were asked for all the participants involved with the interview.

3.5. Ethical Considerations

“Ethics has to do with the application of moral principles to prevent harming or wronging others, to promote the good, to be respectful and to be fair” (Sieber, 1993, p. 14).

Since my study employs learners’ as participants, ethical principles protecting participants are imperative to consider throughout the study.
These principles not only protect participants, but also influence the design, implementation of the study as well as the analysis and reporting of the data. Firstly, the autonomy of participants must be protected and respected (Frankel & Siang, 1999).Practically in research this is achieved by providing participants with informed consent (Frankel & Siang, 1999). The second principle of beneficence entails maximizing possible benefits for the participants, and minimizing the possible harm from participation in the research (Frankel & Siang, 1999).

Thus the application of these principles can be seen as essential and applicable to my study. Below is a short discussion of how I proposed to implement these principles throughout my study so that ethical standards and principles were adhered to.

The first phase of the research involved analysing natural science textbooks used in schools, from grade 6-8. Specifically, the quality of diagrams and text offered on moon phases by the textbooks were evaluated and the correlation between diagrams and text were compared.

The textbook analysis process is comparable to assessing the quality of content in textbooks. Therefore, it was important that the findings from my study were delivered sensitively, considering the principles of beneficence as well as maintaining the anonymity of textbook titles and publishers.

The second phase of the research involved learners and the educator teaching the learners. Since all participants were treated and respected as autonomous agents, informed consent to all involved parties was provided. This included the school, the principal, the teacher as well

as all learners. Furthermore, since learners cannot legally authorise consent, parents were also given informed consent. Participants were not to be allowed to participate without all parties consent.

Participants

Participants were informed of the nature of this study, as well as their voluntary participation and consent in the study. Participants were made aware of their rights to withdraw their participation or contribution at any point in the study with no penalty or consequence. Participants were made aware that their participation or non-participation in this study would have no influence on their school records or their grades.

The selected group of participants' that would be videotaped were made aware of this and were informed of their rights to refuse or to participate. Furthermore all video footage for analysis was kept confidential and would only be viewed by the researcher and the supervisor. Video footage will be stored securely to prevent any breach of confidentiality.

Participants' anonymity will be protected and personal information will remain confidential. Data collected from participants was coded and only the researcher and supervisor will have access to personal data. Information will be securely stored to prevent any breach of confidentiality.

Participants were provided with contact details of the researcher, supervisor and academic institution if any questions arose.

Informed Consent from Guardians and Principal of school

Informed consent was obtained from the participants' parents or legal guardians before participants were permitted to participate in the study. Letters informing parents or guardians of the nature of the study as well as participants rights were made clear. Parents and guardians were made aware of ethical procedures in the study.

Informed consent was obtained from the principal of the participating secondary school before the study commenced. Informed consent was obtained from the teacher responsible for participants in the school before participants were permitted to participate in the study.

3.6. Ethical Approval

Ethical approval was obtained from the University of Witwatersrand's Human Ethics Research Committee (non-medical) [Wits School of Education] (clearance number: 2011ECE130C) and the Gauteng Department of Education (clearance number: D2012/114).

3.7. Summary

The chapter provided information on the methodological processes involved with the study. Furthermore, details of the piloting involved for the textbook analysis and interview instruments were outlined.

More information in this chapter was provided about the case study group, and the school involved in providing the researcher an opportunity of collect data. Issues surrounding validity and reliability, ethical consideration and ethical approval were also outlined. The data obtained from using the instruments is presented in chapter 4 and 5 respectively.

Chapter 4

Analysis of Textbook Results

4.1. Introduction

In this chapter, I am going to concentrate on the first phase of the study: the analysis of the six Natural Science textbooks. The order of the chapter will thus be as follows: first, I will explain how the textbooks were analysed; I will then present the textbook analysis results, relating my findings back to theory. The instrument used to analyse the textbooks was used to answer question one of my research questions: What is the quality of diagrams and explanations of moon phases offered by grade six to grade eight Natural Science textbooks?

The second phase of the study involved a case study group. The case study group consisted of 15 learners in grade 8 of different abilities, where learners were categorised as above average, average and below average. Learners were chosen according to their academic performance by their teacher in their subject, in such a way that 5 learners were represented per category mentioned. The case study group was interviewed, where in the interview learners were given models of the sun, earth and the moon. The learners were required to answer questions by looking at a diagram given to them from the textbook they used in the learning of moon phases, and moving the models in such a way that the position of the sun, moon and the earth would represent the moon phase presented by the picture in the textbook. The 15 learners were narrowed down to 8 learners for a more in-depth analysis. The reasons for presenting 8 learners were due to the following;

- In each category, the learners within the category were answering questions similarly.
- Only 4 learners then were taken from the above average group, and 4 learners from the below average group were chosen.
- None of the learners in the average group was selected as learners in the average group answered questions very similarly to the below average learners, upon analysis.

Since there were 5 learners per category, the 4 selected learners from the above average and below average category were chosen because of their unique way of answering questions, which made it interesting to report on their answers based on questions of moon phases, especially the question, “What causes the moon phases?”

I will present the results of the case study group in chapter 5 rather than in this chapter, as the results obtained are only relevant to the case study group. The analysis of the results here will therefore make best sense when read and analysed in conjunction with the interview results of the case study group in the following chapter.

4.2. Data Analysis

The instrument used for data analysis is an adaptation of a textbook evaluation instrument developed by the British Columbia Ministry of Education in the year 2002, in conjunction with the revised instrument in the year 2008; both instruments are attached to the appendices (Appendix B1 and Appendix B2). The reason for using the two instruments in conjunction with each other is because even though the latest instrument (2008) was revised, not much of the instrument has changed. In fact, the instrument used in 2002 is almost identical to the instrument of 2008. Not all characteristics mentioned in the original instruments have been included. Only characteristics relevant to my research, which will also help answer the first research question, have been included.

The instrument is in the format of a Likert scale, where there are four rating categories, namely: strongly agree, agree, strongly disagree, and disagree. An extra column has been added to the instrument, namely not applicable. The not applicable category applies to when a textbook does not cover a characteristic mentioned in the instrument.

The instrument in terms of the column headings fits in well to answer the sub-questions under the first research question. The first sub question under research question number one, asks: "What misconceptions can be identified by the content presented by textbook?" The characteristics under content and technical design found in the instrument help to address this question where text is analysed, and a comparison is made in reference to the text and diagrams presented by the textbook.

The second sub-question asks: "What structure is presented in relation to conceptual development?" The characteristics under instructional design and social considerations will address the mentioned question by relating the characteristics to Duban's (2008) characteristics on what makes a textbook constructive as discussed in Chapter 2 under theoretical frameworks.

As a reminder of Duban's (2008) characteristics, I will mention briefly what the characteristics of a constructivist book should contain:

- Book should consider learners' previous knowledge;
- Text with analogies should be used;
- Book should try and eliminate misconceptions from everyday language;
- There must be plenty of visual components present;
- Interaction amongst learners should be encouraged (e.g. group work).

The reason for using Duban's (2008) characteristics is that the focus is on what the textbook does in terms of the manner in which it is presented for the enhancement of learners' conceptual development.

Each characteristic presented by the instrument used for textbook analysis has a checklist so as to know what to look for within the specified characteristic. In the appendences (Appendix C), a table has been provided that summarises what one looks for within a characteristic as per instrument developed by the British Columbia Ministry of Education.

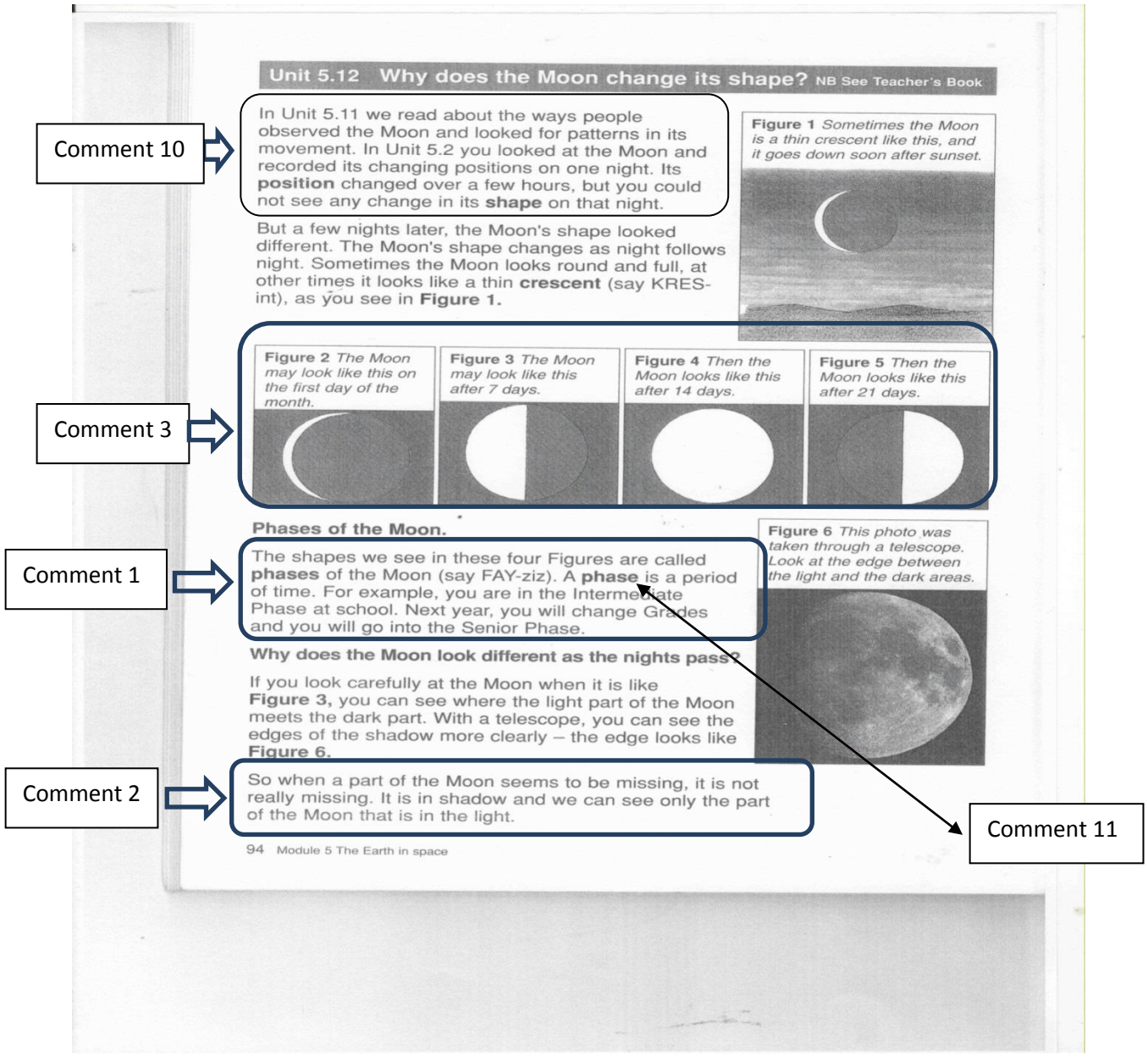
4.3. Textbook Analysis Results

4.3.1 Grade 6 Textbook I

Negative Aspects of the textbook

Content

The science content presented by the textbook is not accurate. Evidence of this can be seen in the text on page 94



Comment 1

Underneath the diagrams of the different shapes of the moon, it is mentioned in the text that the figures are called the phases of the moon. The problem with such a statement is that not all the moon phases are represented in the correct sequence in which they are supposed to appear. The omission of this detail may suggest that there are just four phases of the moon.

Comment 2

At the bottom of page 94, the book also mentions that the dark part that we cannot see is in shadow; however, this is the part where the sun is not shining on the surface of the moon. Good explanations of moon phases use the terms illuminated and sunlit rather than 'in shadow'. Including the statement that the moon is in shadow is therefore inaccurate, as it may bring out the most common misconceptions as mentioned in Baxter (1989), where it is said that the majority of people think that the phases of the moon are due to the earth's shadow. Such a statement may re-enforce the misconception as being correct.

Comment 3

Further analysis of page 94 shows that the manner in which content is presented suggests that the moon undergoes a change in shape every seven days. This can be seen by the text in figures 2-5 (e.g. the moon may look like this in 7, 14 and 21 days). This is again an inaccurate representation, as during a 7 day period, the moon may have undergone two changes in shape within this time period.

Overall, looking at page 94, where content about moon phases is represented, in the real world, the moon does not change 4 times as suggested by the content. There is also a sequence in which the moon undergoes a series of changes, and this information is omitted. Thus the information is flawed.

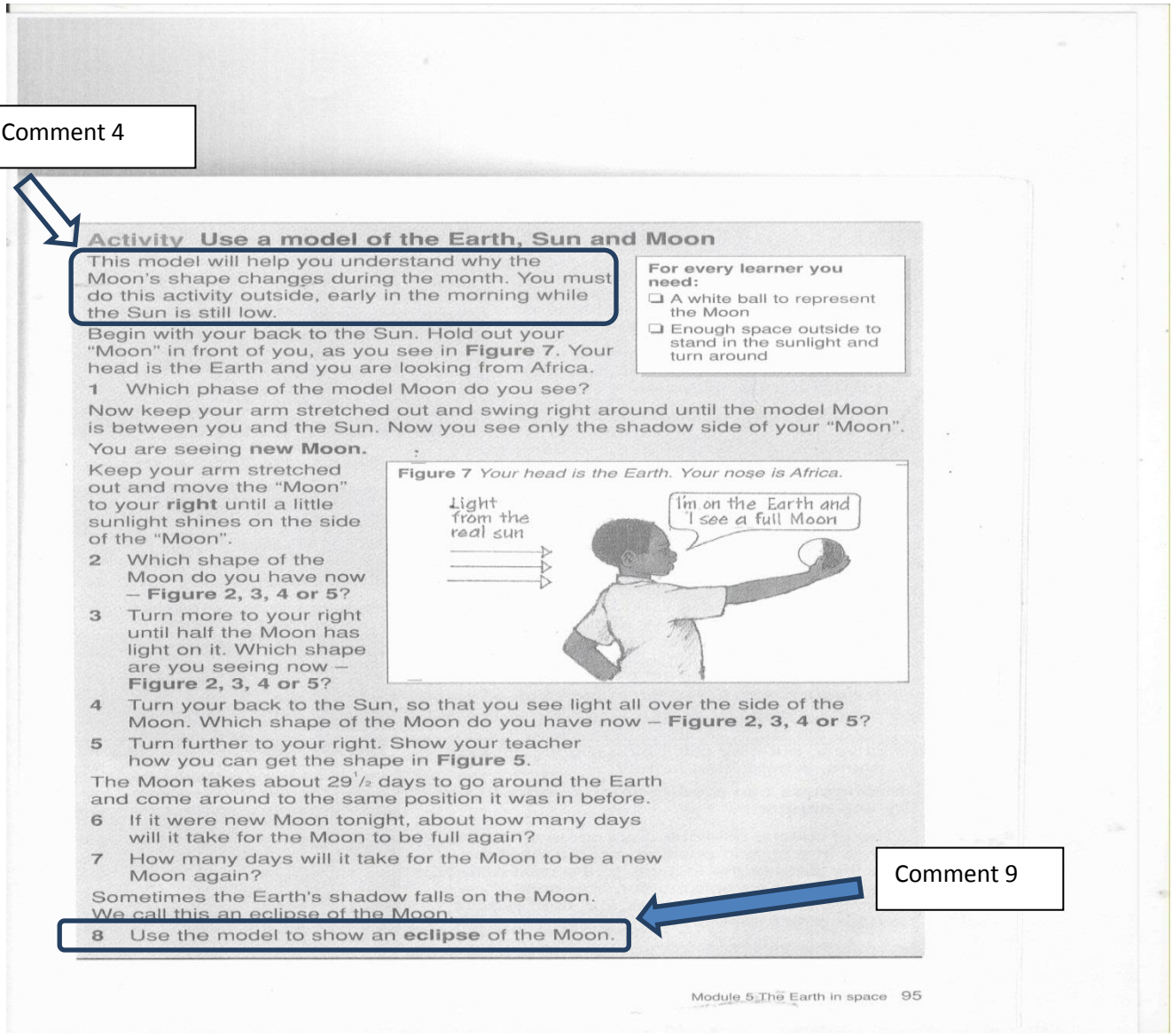
On page 94, figure 2 states that "on the first day of the month, the moon may look like this." There are two things that are problematic with such a statement in relation to the picture. The first thing is that the moon, at the beginning of each calendar month, will not always look like a crescent at all. In fact, the shape may take a form of a different shape either than the crescent as earth calendar days range between 30 and 31 days, except for February, which also depends on whether or not it is a leap year.

The second problem is that it is suggested that the start of a new cycle is indicated by a crescent. The book does not refer to the new moon, where this is a representation of the start of a new cycle.

It is understood that new moon is said to be indicated by the first view of the crescent (general public perception), but in science, this is not an accurate representation.

A third issue on page 94 is the text's attempt to define the word "phase" in the section labelled comment 1. The text states: "A phase is a period of time. For example, you are in the intermediate phase at school. Next year, you will change grades and you will go into the Senior Phase." This analogy is intended to make the understanding of the work clearer, but is not appropriate because no direct relation can be made of the moon phases, as the moon phase is a repetitive cycle, and happens over and over again, whereas, if you are in the senior phase of school, you can't go back to the intermediate phase as you would have completed already that particular stage at school. This phase change analogy also assumes that the child will undergo a changeover a period of about a year to make it to the next phase. The moon phases however, do not take a whole year for a change to happen, as the change happens in the space of a few days. The full cycle also takes place over a time which is just less than a month. So, there is no correlation in terms of the time period.

Page 94is intended to teach learners about moon phases, yet nowhere on the page does it explain the cause of the moon phases. In fact, the cause of the moon phases only emerges on page 95 through an activity that learners are supposed to be actively involved in using models.



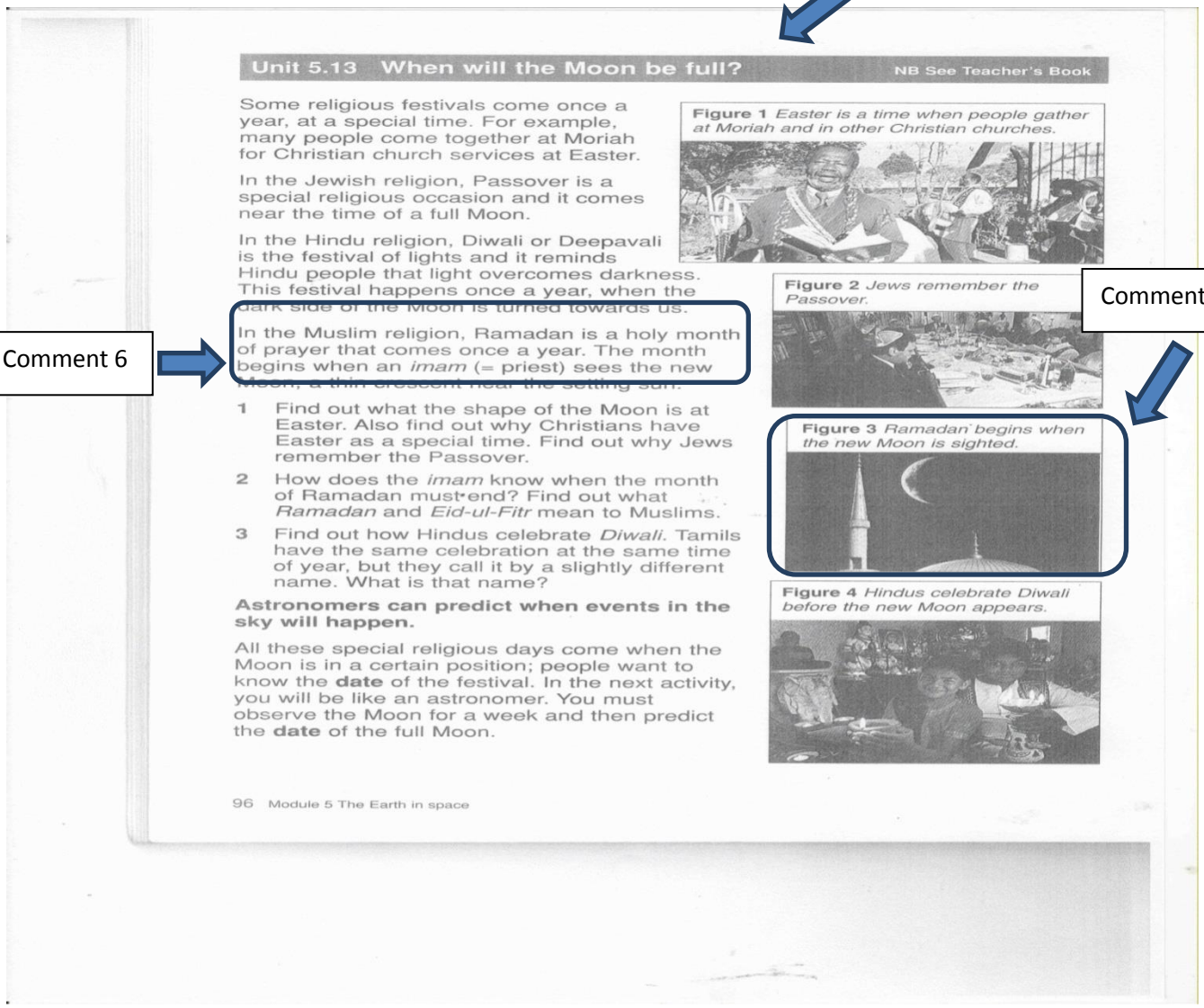
Comment 4

Learners are given an activity to do on page 95, where it is hoped that the learners will understand the cause of the moon phases. There is no problem with such an activity, but no summary of ideas are there to reinforce the idea that the phases of the moon are due to the relative position of the sun, earth and the moon. Such an activity would be thus more effective in the classroom, where the teacher can bring attention to the learners that the cause of the moon phases are due to relative positions of the sun, earth and the moon.

It is therefore fair to say that, from the analysis of the content presented, at no point in the textbook is it properly explained why the moon undergoes phase change; instead, this is left to the learner to discover, provided the given activity is completed.

The only instance in which the content is made relevant to the real world is in terms of one shape that can be observed from the moon phases: the full moon.

Comment 7 Refers to the whole page



Comment 6

Comment 5

Unit 5.13 When will the Moon be full?

NB See Teacher's Book

Some religious festivals come once a year, at a special time. For example, many people come together at Moriah for Christian church services at Easter.

In the Jewish religion, Passover is a special religious occasion and it comes near the time of a full Moon.

In the Hindu religion, Diwali or Deepavali is the festival of lights and it reminds Hindu people that light overcomes darkness. This festival happens once a year, when the dark side of the Moon is turned towards us.

In the Muslim religion, Ramadan is a holy month of prayer that comes once a year. The month begins when an *imam* (= priest) sees the new Moon, a thin crescent near the setting sun.

1 Find out what the shape of the Moon is at Easter. Also find out why Christians have Easter as a special time. Find out why Jews remember the Passover.

2 How does the *imam* know when the month of Ramadan must end? Find out what *Ramadan* and *Eid-ul-Fitr* mean to Muslims.

3 Find out how Hindus celebrate *Diwali*. Tamils have the same celebration at the same time of year, but they call it by a slightly different name. What is that name?

Astronomers can predict when events in the sky will happen.

All these special religious days come when the Moon is in a certain position; people want to know the **date** of the festival. In the next activity, you will be like an astronomer. You must observe the Moon for a week and then predict the **date** of the full Moon.

Figure 1 *Easter is a time when people gather at Moriah and in other Christian churches.*

Figure 2 *Jews remember the Passover.*

Figure 3 *Ramadan begins when the new Moon is sighted.*

Figure 4 *Hindus celebrate Diwali before the new Moon appears.*

96 Module 5 The Earth in space

<u>Comment 5 and 6</u>

Focussing our attention to page 96, figure 3 makes an interesting statement in relation to the picture along the side. It states that Ramadan starts when the new moon is sighted. The picture shown, however, is not that of a new moon, but rather of a waxing crescent. It can be seen that this is a common mistake to see a new moon as a crescent, as the same thing is promoted on page 94. Evidence showing that the textbook writer believes that the new moon is a crescent can be spotted in this statement on page 96: "The month begins when an imam sees the new moon, a thin crescent near the setting sun." This statement supports what was observed earlier on page 94 about the new month beginning with a crescent.

It is important to also note that in common language, as can be seen with the message conveyed in religious beliefs as highlighted on page 95, that the crescent is associated with the new moon. But if the correct science is to be taught to learners, it should be made explicit by the source material that what is conveyed about spotting the new as a crescent is everyday knowledge, and that the everyday knowledge is different from that of the science knowledge of what a full moon looks like. In this way, it helps learners see the contrasts and differences with accepted knowledge of science, as opposed to everyday accepted notions.

Instructional Design

Comment 4 and 3

The activity on page 95 promotes engagement, where learners discover the cause of the moon phases. One problem associated with this kind of activity is the time given for the learners to conduct this activity. It states on page 95 that the activity is to be done outside in the early hours of the morning, while the sun is still low. The problem with this type of an activity is that the learners run the risk of being supervised by an adult who knows very little about the cause of moon phases (as suggested in literature, e.g. Baxter, 1989). Therefore, more misconceptions might arise from ideas presented by the adult supervisor. The activity unfortunately focuses on only the moon phases illustrated by the different figures on page 94. Although such an activity may create an understanding of the cause of moon phases, learners still would be uninformed of the rest of the shapes present in the moon cycle, since the focus is only on the 4 shapes as presented on page 94.

Comment 7

Page 96 promotes learning about the different cultures, and how they use the moon shapes for the progression of their cultural activities. Only certain shapes are concentrated on: the full moon, new moon and the crescent moon. These different moon shapes bring about different meanings depending on the cultural groups. Since only specific shapes are concentrated on, one could conclude that the presentation of the different cultural meaning attached to specific moon shapes do not promote the learning of moon phases within a cultural setting.

Comment 8

The activity on page 97 is problematic as the learning that takes place might be influenced by several misconceptions. Again, the activity leads learners to believe that a waxing crescent is

a new moon. Interestingly, it states that from the time of the new moon, it would take about a week for there to be a half moon; however, if the learners start at the right time (where the moon cannot be seen: start of the new moon), this will not be the case.

Therefore, the wrong information would be recorded and discussed; creating misconceptions about the approximate time it takes for a new moon to form a half moon.

Comment 8

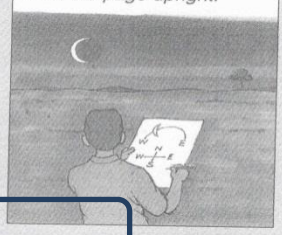
Activity Predict the date and place of the full Moon

This activity takes more than a week, and you must work at home. You will look for the new Moon at 7:00 p.m. on the first night and record where you saw it and what it looked like. Your teacher will tell you when to begin your observations.

In Unit 5.6 you chose a place at home to observe the Sun. You found an east-marker, a west-marker and a north-marker. You need those markers again, to record the position of the Moon at 7:00 p.m. each night.

Face your north-marker and hold the page up, as you see in **Figure 5.** Now look at where the Moon is. Is it more west or more north? Draw it there. Write the date and time.

Figure 5 *Face North, and hold the page upright.*



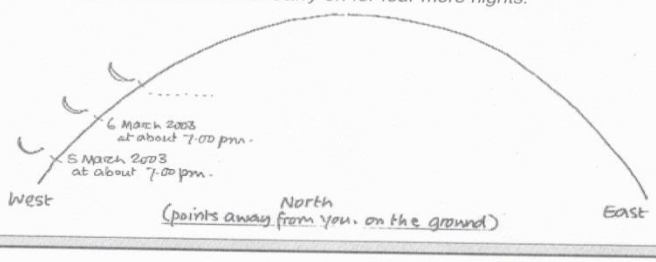
Look at the Moon each night **at the same time,** 7:00 p.m. for seven nights. Bring your record to school every day, and show your teacher.

4 Look at your record after a week. The Moon should be a **half-Moon.** On what date will the Moon be **full?**

5 Where will you see the Moon rise at 7:00 p.m. on that date? **Show the place** on your curved line.

6 Use your model of the Sun-Moon-Earth system that you acted out in Unit 12. Show the class why you think you are correct about the date when you will see the full Moon.

Figure 6 *Your record will look like this. Carry on for four more nights.*



A comparison of pages 94-96 reveals the following; although page 94 should introduce important concepts, and asks "Why does the moon change its shape?" the content produced on page 94 does not answer this question at all. Instead, the activity given on page 95 hopes that learners will discover the answer for themselves, if, of course, learners are able to do the activity. The same problem can be seen on page 96, where the question is "When will the moon be full?" The question is not answered and, instead, an activity with the wrong representation of the new moon is given to learners to establish the number of days it will take for the moon to be full.

Comment 9

On page 95, the introduction on using models to model out eclipses is problematic. The phase of the moon has a close relation to solar and lunar eclipses: therefore the introduction of this question may cause confusion, where learners may think that the cause of the moon phases may be due to eclipses. This then may elevate the common misconception that the moon phases occur due to shadows being cast on the moon. Bearing this in mind, concepts as a whole are not summarised. Therefore one might find that learners may still have difficulty in understanding the cause of moon phases.

Lastly, activities suggested by the book may not be feasible for leaners to do at home. It might be useful if activities were changed slightly, and rather done at school, where the source of light is not the sun, but a torch in a dark classroom. By doing the activities at school has the benefit of having a knowledgeable teacher that is able to guide the learners through the process.

Technical Design

The textbook visual representation of the moon phases is not accurate, as on page 94, only 4 moon shapes are shown to represent the moon phases (Refer to comment 3). This is inaccurate as there are generally 8 moon phases that most books refer to in illustrating the complete cycle of the moon. The sequence in which these moon phases are represented in the textbook are also not accurate, as it can be seen that some shapes have been omitted. These omissions cause the illustrations shown on comment 3 to be ambiguous: they suggest that the moon changes every 7 days and that there are 4 main phase changes that take place. It also suggests that at the beginning of each month, the moon will look like a crescent, and that a new moon is indicated by a crescent.

Social Considerations

Language usage of the textbook was appropriate. There was no evidence of trendy language, profanity, prejudiced terms, slang, or incorrect grammar.

Positive aspects of the textbook

The language used in the text is not complicated, and easy for the learners to understand. The only downside is that the technical words included in the text (e.g. crescent) are not fully explained. The way the word is presented, is such that it could be considered a new word to learn in the science vocabulary, without understanding the meaning.

The activities that are presented in the textbook promote active engagement, as they require learners to be practical in their learning by collecting data, and interpreting their data. These kinds of activities may help learners to understand content that is presented in the textbook. It also encourages independence in learners to discover concepts regarding the moon phases when they make generalisations of their observations.

The pictures and the text used directly relate to each other. This provides learners with a mental picture of what the text is trying to convey to them.

Constructivist Promotion of the textbook

The textbook contains various units, where different content is covered per unit. This content and knowledge when moving onto the next unit can be considered as prior knowledge learners would have, when using the textbook in the order in which it is written. In this particular textbook, at the beginning of the unit on page 94 (Refer to comment 10), learners are referred back to previous units that dealt with the moon. This helps learners to think about what they did previously, and explains what they would have observed if they followed what the activities required the learners to do. This sets the tone for introducing the topic of moon phases. These previous units form a background on what learners are to know when entering the section. Referring learners back to units that were covered may thus activate learners' previous knowledge.

There is evidence of conceptual change within the text when referring learners to previous knowledge. First, learners would have completed activities that involved learners' observation of the moon over a period of one night. This deals with the position of the moon, where the moon remained constant in shape. The text goes on to address the changing shape

of the moon, so as to emphasise the point that the moon does go through a change in shape, but over a period of days, and not just one night. The conceptual change involved is the fact that the moon undergoes changes not only in position, but also in shape. From what is mentioned and observed in the textbook, characteristic 1 from Duban (2008) is achieved.

The textbook does not use text with analogies to help learners with conceptual change, but does use an inquiry-based activity using models. The activity on page 95 (Refer to comment 4 page) has a particular educational objective, and that is for learners to understand why the moon undergoes changes. The use of the models in this case serves the same purpose as an analogy would and provides an explanation for learners to understand the cause of moon phases. To explore this idea further, one could look at the role of an analogy and a model.

Literature makes mention that a model is "used to describe and explain phenomena that cannot be experienced directly," whereas an analogy is used "to explain abstract science concepts" (Coll, France & Taylor, 2005, p. 184). It is true that one cannot experience the cause of the moon phases by mere observation, but we certainly see evidence of the movement of the sun, earth and moon by means of the different shapes that the moon undergoes. The fact that we cannot see these movements causes the concept of moon phases to be abstract. Therefore, it can be said that analogies and models are interrelated because, as per literature, it is mentioned that "analogies can be considered a subset of models" (Coll, France & Taylor, 2005, p. 185).Characteristic number two in reference to Duban (2008) is thus achieved, taking into consideration these ideas about analogies and models.

Comment 11

The technical term mentioned in the textbook is the word *phase*. On page 94, the relationship between everyday language and how it is used in science is mentioned briefly. From reading the text and the way the word is explained, there is a similarity in the word in terms of how it is used in science and everyday language. This idea is taken further on page 96, with a discussion about religious practices, which only happen at a particular time; that particular time is when the moon has achieved a particular shape in its cycle. In this context, therefore, misconceptions can be avoided due to the similar usage of the word. In this regard, characteristic 3 from Duban (2008) is achieved.

There are several diagrams in the textbook. In fact, on each page of the textbook, there are diagrams where relations between what is presented in the text and the diagrams correlate

with one another. With regard to the activities that learners have to do, there are also diagrams presented, so as to show the learners how to go about carrying out a physical activity such as the one on page 95. Therefore, characteristic 4 from Duban (2008) is achieved by the textbook

The textbook however, does not encourage a collaborated effort with a learner's peers through these activities. Therefore, characteristic number 5 as mentioned by Duban (2008) is not achieved in this regard.

In summary, 4 characteristics out of a total of 5 are achieved by the textbook. This means that the textbook has a very high percentage of it being a tool to promote constructivism.

Data Summary:

Table 4.3a: Summary of data from textbook in respect to characteristics

Content	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
The science content is accurate			x			4 Pictures of the moon phase shown. Dark part of moon is a shadow. Phase change occurs after 7 days.
The science content is current				x		Phases of moon not explained in terms of position of earth, sun and moon.
The level of difficulty is appropriate for the intended grade	x					Use of language is simple.
The content relates to the real world			x			Explanation relating to real world is incomplete.
The examples provided are appropriate				x		1st day of moon cycle is suggested to be a crescent Analogy used inappropriate.
Cultural portrayal brings forth correct scientific adaptations				x		New moon is called a crescent.
Instructional Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Promotes engagement			x			Impractical Activity. Risks of activity in learners developing misconceptions are high. Cultural portrayal limits adequate engagement on moon phase activity.
Promotes active learning		x				Promotes engagement when activities get done.
Suitable for intended purpose					x	No outcomes are stated by the textbook.
Concepts clearly introduced			x			Heading in textbook does not correlate to the content presented. The cultural meaning portrayed on a full moon is irrelevant to the concept of moon phases. The activity (pg. 97) on the positioning of the moon in the night sky may cause confusion on the moon phases (Might confuse with day night cycle).

Instructional Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Concepts clearly developed						Content does not address heading questions. Eclipses are introduced in section of moon phases.
Concepts clearly summarised				x		Concepts not summarised.
Linguistic level is appropriate for audience	x					Linguistic level appropriate for learner.
Non-technical vocabulary is appropriate		x				Language used appropriately in trying to explain concepts.
Technical terms are consistently explained/introduced	x					Technical term used is "phase" where the terms is explained
Activities are appropriate for level				x		Learners may not be able to do the activities.
Technical Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
The relation between text and pictures is accurate	x					The text relates to the picture.
The textbook visual representation of the moon phases are accurate				x		4 phases represented where each phase is 7 days apart. Phases not in correct sequence.
The illustrations/visuals are clear and unambiguous				x		Illustrations are ambiguous.
Social Considerations	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Language use is appropriate		x				Language is grade and age appropriate.

The textbook proved to be a good tool to promote constructivism amongst learners who would have the privilege of using the textbook. Despite the textbook being a good constructivist tool, there proved to be some problems associated with the content and design of the textbook.

In terms of the content, it can be seen from the table that the textbook was problematic in delivering content that was sound and correct. Content covered in the textbook that was problematic was based on the lit and unlit part of the moon. The textbook made mention that the unlit part of the moon can be seen as the moon being in shadow. Such a statement shows that the textbook contributes to the much held misconceptions of the earth's shadow being cast on the moon mentioned by a few researchers such as Stahly et al (1999) and Baxter (1989) to name but a few.

Another issue raised in the discussion around the textbook was the fact that nowhere in the explanation of what moon phases are, is it mentioned that the relative position of the sun, earth and the moon are responsible for the different shapes of the moon. Instead, an activity is given to learners so that they discover for themselves the cause of the different shapes. What

is worrying is the fact that the activity advises learners to carry out the activity in the early hours of the morning. This may have both positive and negative consequences. The consequences have to do with having adult supervision. The fact that the learner needs to conduct the activity in the early hours of the morning, runs the risk of having an adult assisting the child without having the knowledge about concepts underlying the cause of the different shapes. This means that learners may run the risk of having little guidance when conducting the activity.

Therefore, such an activity would be more beneficial, if done in class, using e.g. overhead projector to represent the sun. This way, learners may benefit on having a teacher to explain important concepts, and thoroughly guide the learners through the activity, making learners aware in an explicit way on what causes the moon phases. In this way, the class learns as a whole, as there are no guarantees that every person in the class would conduct the activity at home. At least this factor gets eliminated when the activity is done at school with maximum class participation guided by the teacher.

Referring to the text inside the textbook, the text presented suggests that the moon undergoes phase changes every 7 days. The reason for the assumption is that in the pages presented on content about the phases of the moon, it is not explained further that the moon undergoes gradual small changes every day. From how the content is presented, there is a possibility that learners may assume that it is every 7 days, that the shape of the moon changes.

In terms of looking at the adaption of the topic of moon phases to the real word, an attempt has been made by the textbook to look at religious celebrations, to establish what the link is between the celebrations and the moon. The examples provided are relevant and correct. The only problem with this relation is that it does not help the learners know more about the moon phases. Instead, only one shape is focussed on, and its relation to festivities in the different religions. A more appropriate example which would have been more beneficial in learning more about the phases of the moon, are cultural stories where they explain by their stories on e.g. why the moon appears to be getting smaller and bigger. This helps to thus relate the stories to the correct scientific knowledge about the moon phases, and the causes of the moon phases. Such stories would help enhance learners understanding about the topic.

The last point which was discussed was the fact that the textbook refers to the crescent moon as the new moon. It is acknowledged that in the everyday world, it is communicated that the crescent moon represents a new moon; but it would be rather advisable that the textbook

explicitly makes mention that in science, what is perceived as the new moon in everyday communication, is in fact known as the crescent moon. This would then be a good step in achieving to communicate the correct science to the learners.

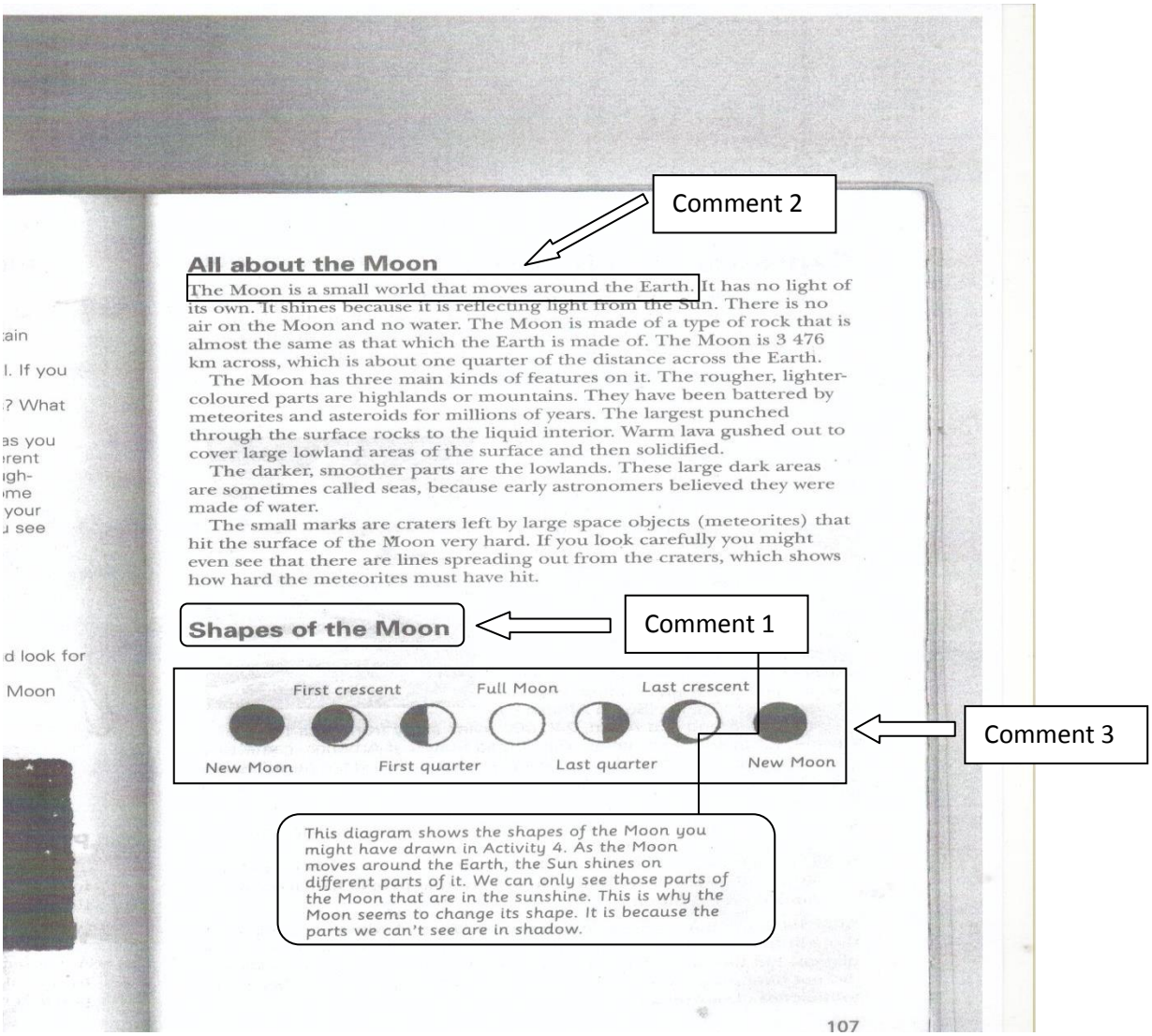
4.3.2 Grade 6 textbook II

Negative aspects of the textbook

Content

Comment 1

On page 107 below, the title "Shapes of the Moon" may be problematic because learners may think that the phases of the moon are the same thing as shapes of the moon. This heading thus is not an accurate description for the figure below the heading. This is because the phases of the moon bring about the different shapes that we see, based on whether one is situated in the Northern or Southern hemisphere:



Another piece of information which lacks accuracy on page 107 is the statement that "We can only see parts of the moon that are in sunshine." The problem with this statement is that the text does not explain fully that what we see is the part of the moon which faces us, which is only the one side of the moon. The other side of the moon which does not face us, we cannot see, yet the sun shines on the other side of the moon all the time. Therefore, such a statement can bring about wrong interpretations of the moon in terms of the lit and unlit side of the moon.

The text further states that "the parts we cannot see are in shadow," but the dark parts of the moon simply tell us that the sun's light is not reflected. Such a statement reinforces the conception that the reason for the moon phases is the earth's shadow being cast on the moon.

Comment 2

Another point worth mentioning is information that is left out, which may constitute as a flaw, as the omitted piece of information plays a vital role in understanding certain concepts about the moon phases. On page 107, it correctly mentions that the moon moves around the earth. What is not mentioned, though, is the fact that at the same time that this is happening, the earth is also constantly moving around the sun. The importance of this concept is looking into also the moon rotating on its axis. It is said that the moon rotates once on its axis in 27, 3 days. This alone brings a misconception that the observed moon phases take place over this time period. Due to the earth also moving around the sun, it simply means that it takes a longer time than the 27, 3 days for the moon to orbit the earth. This omitted piece of information explains why the moon undergoes a complete cycle over a period of 29, 5 days, as seen from the earth. It must be highlighted though that a possible reason for leaving out this piece of information, is of the possibility of this concept being too complex for learners at grade 6 level.

Another inaccurate point on page 107 is the attempt to give an explanation of what the moon is. The textbook states the moon is a "small world that moves around the earth." The fact that the moon moves around the earth is accurate, but describing the moon as a small world is not accurate. The scientific definition of the moon is that it is a natural satellite.

The information presented in the textbook is not current. Not all the general moon phases are represented, which means that the sequence in which the moon phases take place is incorrect.

At the top of page 107, the textbook states that there is no air or water on the moon. This does not take into account the discovery that NASA (National Aeronautics and Space Administration) has made, that the moon's surface contains water. This information though on page 107 does not refer to the phases of the moon, and therefore not much is looked into the text as it does not serve a purpose for the current study.

Comment 3

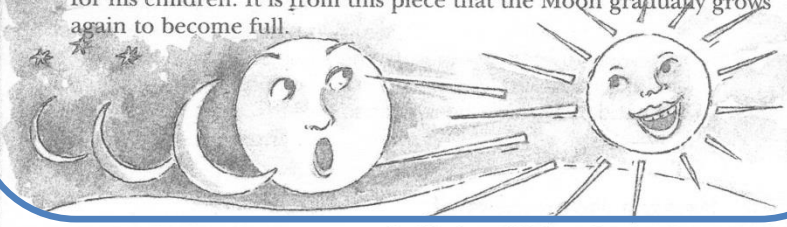
In the example of the different shapes of the moon, the last crescent representation of the moon is inaccurate. The picture looks like a gibbous. Again, the sequencing on the moon phases is not appropriate, as there are omissions of the waxing gibbous and the last crescent.

African stories



One of the African stories about the Moon explains how the Moon changes from full moon to new moon and back again.

In this story the Sun was once a man who made it day when he raised his arms, for a powerful light shone from his armpits. But as he grew old and slept too long, the people grew cold. Children crept up on him, and threw him into the sky, where he became round and has stayed warm and bright ever since. Another story says the Moon is a man who has angered the Sun. Every month the Moon reaches round prosperity, but the Sun's knife then cuts away pieces until finally only a tiny piece is left, which the Moon pleads should be left for his children. It is from this piece that the Moon gradually grows again to become full.





In Khoisan life hunting by the light of the Full Moon is usually successful. But it was considered bad luck to look at the Full Moon at the time of shooting an animal because hyenas or lions might eat the wounded animal. This is of very practical value. Can you work out why? Hint: Khoisan hunters use bows and arrows and they might have to follow the wounded animal for some way before they can catch it.

Proverbs about the Moon

There are many proverbs about the Moon. Some have scientific accuracy, for example, *Clear Moon, frost soon.* If the Moon is clear in winter, it means there is no cloud and then it could be a cold night with frost.

What are your ideas about the Moon?

As a group project collect all the ideas, proverbs and stories you can about the Moon. For each one try to find out if the story or proverb has a practical value, and if there is any scientific truth in what it is saying.

105

Comment 4

Comment 5

Comment 5

The Moon

ACTIVITY 3 — Map the Moon

u will need:
paper and pen
binoculars, if possible

1. Find out when it will be Full Moon. Many diaries contain information about the phases of the Moon.
2. Plan to go outside one evening when the Moon is full. If you go out at about 6 p.m. you could watch it rising.
3. Look at the Moon. How big do you think the Moon is? What do you think it is made of?
4. On your sheet of paper draw a round Moon as large as you can. Now look at the real Moon. Do you see the different shapes on it? See if you notice the light-coloured, rough-looking parts, darker-coloured, smoother parts and some marks that look a bit like holes. Add these shapes to your drawing. Try to draw them in the same areas that you see them on the real Moon.
5. What do you think these shapes are?

ACTIVITY 4 — Keep a Moon journal

You will need:
- a notebook
- a pencil

1. Every third or fourth night for a month, go outside and look for the Moon.
2. Draw its shape (you will notice that the shape of the Moon changes each time you go out).
3. Next to each drawing, write the date and the time.



4. Why do you think the Moon has different shapes?
5. What happens to the missing parts of the Moon?

106

Instructional Design

Comment 4

Concepts are not clearly developed in the textbook. The cultural story found on page 105 has to do with the waxing and waning process of the moon, where reference is made to "size". This concept is not carried through to the activities given to the learners. Rather, the activities focus on the characteristics of the moon, specifically the actual shape of the moon. There is thus no relation made with the cultural stories, even though they contain important correct scientific principles in terms of the waning and waxing process. It thus can be said that concepts developed do not promote learning about the phases of the moon.

Technical Design

Comment 1

On page 107, it is explained how we are able to see the different shapes of the moon. The content relating to the cause of the moon phases is accurate, but the explanation of the movement of the moon around the earth, and the influence of the shining sun on the moon does not relate to the diagrams shown. Instead of showing the relationship of the sun, earth and the moon relative to the moon shape that is shown, only the shapes or phases of the moon are shown.

Comment 3

The textbook visual representations of the moon phases are also not accurate. On page 107, the textbook correctly starts with the new moon and progresses with accuracy to the first crescent. A waxing crescent would be the next correct phase, but this image is skipped and the diagram instead shows the next phase to be the first quarter moon. After the first quarter moon, the waxing gibbous has been omitted and the next image is that of the full moon. Similarly, the waning gibbous is omitted in the sequence of the moon phases. Interestingly, an incorrect picture is put to represent the last crescent (instead of showing a crescent, a waxing gibbous moon is drawn). Including an incorrect diagram for a particular phase (i.e. the last crescent picture in the textbook) may cause learners to mistake the last crescent for the image of a waxing gibbous.

The omission of certain images from the moon phases sequence may cause potential learning problems of these phases for the learners. Learners may think that the moon phase diagrams

in the textbook are correct in terms of sequence, and that the images of the phases the moon undergoes in its cycle are also correct.

On closer inspection of the sequence, however, there is an element of ambiguity that emerges. From the start of the new moon, it can be seen that the moon is waxing (getting bigger). After the full moon, according to correct scientific interpretations, the moon should be waning (getting smaller); the information in the textbook does not sufficiently convey the concept of waning. The inclusion of the incorrect drawing of the crescent causes this ambiguity, because the sequence shows moon getting smaller, then suddenly it becomes big again. This has the potential to cause a lot of confusion.

Social Considerations

Language usage of the textbook is appropriate. There is no evidence of trendy language, profanity, prejudiced terms, slang, or incorrect grammar.

Positive aspects of the textbook

The language used in the textbook is appropriate for the learners' age group. The cultural activities in the textbook bring about important scientific applications. Even though the cultural portrayal does not explicitly bring forth scientific applications as to what causes the moon phases, it does try to express important ideas that pertain to moon phases. First of all, through the cultural stories, the stories convey that the moon undergoes a process of waning and waxing, to explain why the moon has the different shapes, and why the moon becomes bigger and smaller. In reality, by sheer observation, the moon does appear to be getting bigger and smaller in its cycle.

The second point is that the language used within the text stresses the fact that moon phases happen over and over again, bringing forth the concept of a cycle.

Comment 5

The activities given in the textbook on page 105 and 106 promote active engagement among the learners. Page 105 introduces stories that are used in different cultures to explain the moon phases and why they occur from a non-scientific perspective. On page 105, the learners are then given an activity to engage with the different stories from different cultures, from which they attempt to extract scientific facts. This activity helps learners to separate fact from fiction. What makes the activities beneficial is that they require learners to reflect on their

understanding and interact with their group members by discussing their ideas. In this way learners are able to learn from one another.

The activities that follow on page 106 explore the characteristics of the moon and the notion of the moon phases. Learners not only work in groups to elicit facts from stories, but also to work with data. This is done by learners via observation, where they record what they see. Leaners later interpret the data collected. Such activities are good for the learners advancing their knowledge about moon phases as these activities allow learners to find out information about the moon before engaging with the theory of moon phases. Such activities therefore promote active learning. The concepts build on each other, starting from a cultural perspective and leading to the scientific concepts relating to the phases of the moon. The section is summarised by using key questions to highlight the main concepts that are covered by the books.

Constructivist Promotion of the textbook

The textbook starts off the section with cultural stories before venturing into concepts relevant to the phases of the moon. Nowhere in the textbook does it inquire about what learners know about the moon phases. Only the end of the chapter tests the content knowledge of the learners. Since no attention is paid to prior knowledge, it can be concluded that Duban's first characteristic is not achieved.

There are no analogies given to enhance the explanation of the moon phases. What can be seen from the textbook is that the content is varied: the textbook covers cultural aspects of the moon, characteristics of the moon, the first people to land on the moon, and some facts about astronauts. Not much detail goes into looking at the cause of moon phases, however one activity asks learners to go out at night and record what the moon would look like every three to four days in a month.

The activities given in the textbook did not encourage learners to use models to try to come up with an explanation for why the moon undergoes phase changes. It also can be concluded that without the use of analogies and models, that Duban's (2008) characteristic 2 is not achieved.

On page 107 of the textbook, the phases of the moon are referred to as "shapes of the moon" (Refer to comment 1). The moon undergoes phase changes within its cycle. It is when we have a phase change that we are able to see the shapes of the moon that we are able to

observe in the sky. In other words, phases of the moon bring about the shapes we see. None of this, however, is explained within the text. Not having this explanation though does not make the text presented about moon phases poor. In fact, the explanation presented in the textbook as to why the moon has different shapes may bring forth some correct thinking (bearing in mind the misconception contained in the text about the dark part of the moon being in shadow) that learners are supposed to have: that the moon goes around the earth, and as a consequence the sun shines on the different parts of the moon for us to see the different shapes. This explanation gives learners the basic foundation for why we see the different shapes of the moon. Bearing this in mind, it can be said that Duban's (2008) characteristic 3 is not achieved, as the text itself contains misconceptions, which learners may internalise when learning the section.

On each page, there is a diagram to complement the text. There is therefore a direct relationship between text and picture. The pictures presented are enough to form a summary of the content presented. It therefore can be said that the 4th characteristic of Duban (2008) is achieved.

The textbook contains five activities. The book does not consider all tasks as activities, but I will briefly summarise the tasks to show that they can be considered activities. The five activities entail the following:

- Learners collect ideas, proverbs and stories about the moon and try to determine if there are any scientific truths attached to them. (Group work activity)
- Activity which involves finding out information about the moon through research and observation.
- An activity which involves keeping a moon journal.
- An activity which involves interviews with parents and older relatives.
- An activity testing learners on their knowledge of the content presented in the textbook.

Only one activity out of the five encourages group work. This means that the learners do not get to work together on the majority of the remaining activities. Since there is such a small amount of group work, it can also be said that 5th characteristic of Duban (2008) is not achieved.

In summary, 1 characteristic out of a total of 5 is achieved by the textbook. This means that the textbook has a very high percentage of it being a tool that does not promote constructivism. This means that learning with such a textbook will not necessarily enhance learners' conceptual development in learning about the moon phases.

Data Summary:

Table 4.3b: Summary of data from textbook in respect to characteristics

Content	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
The science content is accurate			x			Wording of text causes confusion. Information left out in terms of the movement of sun, earth and moon. No reference made to the moon being half lit all the time. There is a shadow on the part of the moon we cannot see. The moon is described as a "small world."
The science content is current			x			Information about no water on the moon is outdated. Omissions in text and diagrams.
The level of difficulty is appropriate for the intended grade		x				Language used is simple to understand.
The content relates to the real world		x				There is a relation (?) in terms of what is observed.
The examples provided are appropriate			x			Waxing gibbous and waning crescent left out. The example of a waxing crescent moon is inaccurate.
Cultural portrayal brings forth correct scientific adaptations	x					Cultural portrayal of moon may bring forth correct conception of moon phases.
Instructional Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Promotes engagement	x					Learners engage with different cultural stories of moon phases. Learners are encouraged to extract scientific facts. Learners are encouraged to observe and interpret what they observe.
Promotes active learning	x					Learners are encouraged by the activity to interpret their own observations and use their own thinking.
Suitable for intended purpose					x	No outcomes stated.
Concepts clearly introduced	x					Progression of concepts is smooth and logical.
Concepts clearly developed			x			Activities do not relate cultural stories presented to moon phases. No definition of a moon phase provided. Sequence of moon phases is not strongly emphasised.
Concepts clearly summarised	x					Concepts summarised at end of section.

Instructional Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Linguistic level is appropriate for audience	x					Linguistic level appropriate for grade and age.
Non-technical vocabulary is appropriate		x				Language used appropriately in explaining concepts.
Technical terms are consistently explained/introduced					x	No technical terms used.
Activities are appropriate for level	x					Activities appropriate for grade and age.
Technical Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
The relation between text and pictures is accurate			x			What is explained in text is not shown on the diagram.
The textbook visual representation of the moon phases are accurate				x		Sequence of moon phases is incorrect. Two moon shapes left out.
The illustrations/visuals are clear and unambiguous				x		Illustrations ambiguous because of omitted moon shapes.
Social Considerations	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Language use is appropriate	x					Language use is appropriate for learners.

Looking closely at the table, under the characteristic *content*, it can be seen that the content has a split of almost 50/50 when considering the tick in the respective columns; looking solely at the columns tending to the sides of disagree and agree. This split though does not necessarily mean the content is fifty percent good. Looking at the characteristics, the ones that received a tick under the column heading "disagree" are the following:

- The scientific content is accurate
- The content is current
- The examples provided are appropriate

It can be seen that, on the contrary, the content is poor and contains misconceptions which learners may internalise while learning the underlying concepts of moon phases.

This limitation of the textbook is seen by the poor technical design presented by the textbook. What is striking from the analysis is the accuracy of the moon phases as mentioned earlier on. One could therefore conclude that the textbook is of poor quality, and slight changes made to the textbook, especially the section of moon phases, could enhance the textbook.

4.3.3 Grade 7 Textbook I

SECTION 4: PLANET EARTH AND BEYOND

15 Chapter

The effect the sun and moon have on the Earth

In this chapter

You will learn:
- that the movements of the moon and Earth together around the sun cause the phases of the moon, tides and eclipses
- about the phases of the moon
- what tides are and what causes them
- about solar and lunar eclipses.

You will:
- find information from pictures and diagrams
- make links between something that happens, and its causes
- give explanations
- make a poster.

You will think about:
- how tides affect the things people do
- why we see the phases of the moon the way we do
- what it would feel like to watch a total eclipse.

1. The moon

1.1 The phases of the moon

Figure 1 on page 148 shows the moon at different times in the month. You will see that the moon is a different shape in each picture. These different shapes are called the phases of the moon. Each phase has a name.

The phases that you see in Figure 1 are (from left to right): first crescent, first quarter, waxing gibbous, full moon, waning gibbous, last quarter and last crescent.

Comment 1

LO1 AS: Plans investigations.
AS: Evaluates data and communicates findings.

LO2 AS: Recalls meaningful information.
AS: Categorises information.
AS: Interprets information.

147

Realist Moon Diagrams

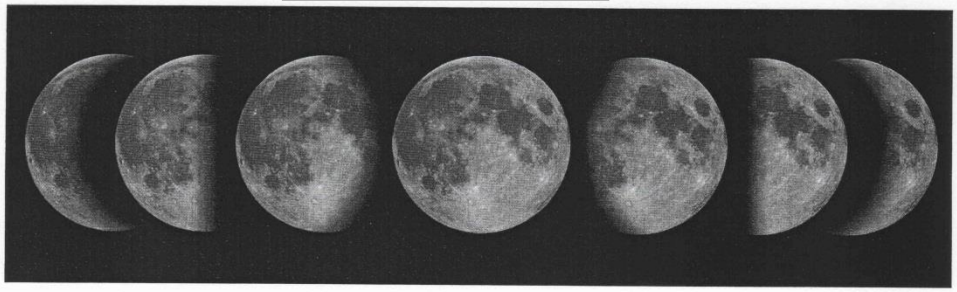


Figure 1: The phases of the moon

Comment 1

When the moon is ***waxing***, the part we see of it is getting bigger.

When the moon is ***waning***, the part we see of it is getting smaller.

Comment 1

If you look at the shapes of the moon from left to right, you will see that the moon looks like it grows bigger, until full moon, and then it gets smaller again, until it is almost invisible. As it is growing bigger, we say that it is **waxing**. As it grows smaller, we say that it is **waning**.

Comment 2

1.2 Why does the moon have phases?

The movement of the moon around the Earth means that we see a different portion (part) of that half of the moon that is lit at different times. Figure 2 will help you think about why this is so.

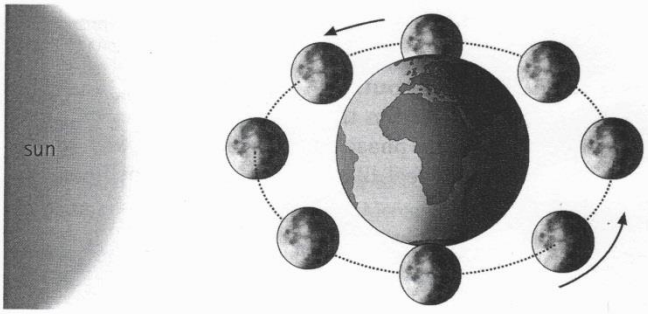


Figure 2: The phases of the moon in the Southern hemisphere

Comment 2

148

Negative aspects of the textbook

The textbook represented is an example of a good textbook, with few negative aspects attached to the content, instructional design, technical design and the language.

Content

Comment 1

On page 147, there is no mention of what is happening to the two different crescents shape moon - that is, whether they are waxing or waning. The reason for this analysis is that waxing and waning are explained on page 148, yet they are not used when naming the two different crescents phases, which is odd. What is odd is that the textbook is able to mention successfully on what is happing to the gibbous shape moon (whether the gibbous shaped moon is waxing or waning), yet with the crescent moon this is not mentioned.

In terms of the appropriate examples given, on page 148, the moon phases are represented in a diagram with one omission, which is the new moon. Evidence of this omission can also be seen on page 147, in the naming of the moon phases. In everyday cultures, e.g. religious celebrations, the waxing crescent is a symbol of a new moon, but in science, this is an incorrect view of the moon. The omission of this type of moon may cause learners to believe that the phase of the moon begins with a crescent.

Comment 2

On page 148, it is correctly stated that the moon moves around the earth, but this statement alone would make one assume that the body that is moving is the moon, while the earth and the sun are still. Evidence of such a statement can be elicited from the drawing depicted. If this is mentioned, it could also be mentioned that the earth orbits the sun at the same time. This inclusion would be more of a suggestion to help learners understand that not only one body is in motion.

Instructional design:

The instructional design is appropriate for learners to do, and encourages learners to engage with the concept of moon phases.

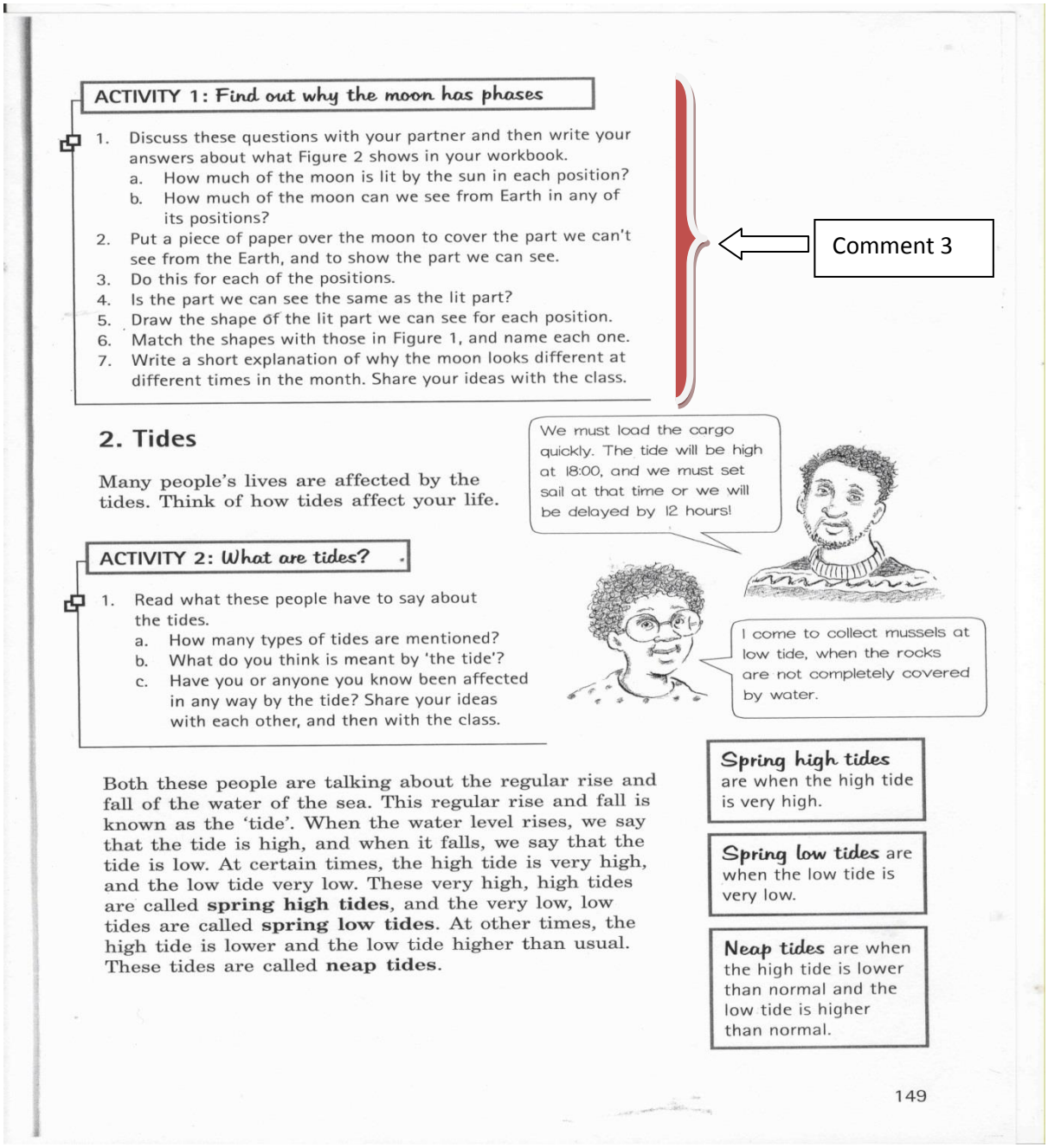
Even though the chapter places good emphasis on questions, presenting the summary of moon phases and eclipses together may cause potential problems for learners' understanding moon phases, as the two concepts are related to one another.

Technical design:

The only problem with the technical design is the omission of the new moon, as the sequence of the moon phases is not complete with this omission.

Social Considerations

Language usage of the textbook is appropriate. There is no evidence of trendy language, profanity, prejudiced terms, slang, or incorrect grammar.



ACTIVITY 1: Find out why the moon has phases

1. Discuss these questions with your partner and then write your answers about what Figure 2 shows in your workbook.
   a. How much of the moon is lit by the sun in each position?
   b. How much of the moon can we see from Earth in any of its positions?
2. Put a piece of paper over the moon to cover the part we can't see from the Earth, and to show the part we can see.
3. Do this for each of the positions.
4. Is the part we can see the same as the lit part?
5. Draw the shape of the lit part we can see for each position.
6. Match the shapes with those in Figure 1, and name each one.
7. Write a short explanation of why the moon looks different at different times in the month. Share your ideas with the class.

Comment 3

2. Tides

Many people's lives are affected by the tides. Think of how tides affect your life.

We must load the cargo quickly. The tide will be high at 18:00, and we must set sail at that time or we will be delayed by 12 hours!

ACTIVITY 2: What are tides?

1. Read what these people have to say about the tides.
   a. How many types of tides are mentioned?
   b. What do you think is meant by 'the tide'?
   c. Have you or anyone you know been affected in any way by the tide? Share your ideas with each other, and then with the class.

I come to collect mussels at low tide, when the rocks are not completely covered by water.

Both these people are talking about the regular rise and fall of the water of the sea. This regular rise and fall is known as the 'tide'. When the water level rises, we say that the tide is high, and when it falls, we say that the tide is low. At certain times, the high tide is very high, and the low tide very low. These very high, high tides are called **spring high tides**, and the very low, low tides are called **spring low tides**. At other times, the high tide is lower and the low tide higher than usual. These tides are called **neap tides**.

Spring high tides are when the high tide is very high.

Spring low tides are when the low tide is very low.

Neap tides are when the high tide is lower than normal and the low tide is higher than normal.

149

Positive aspects of the textbook

The textbook uses an important keyword to illustrate something that we observe, but which is not necessarily true: that word is "looks like". The textbook explains on page 148 that it "looks like" the moon is getting bigger or smaller, where in actual fact it is not. What is good about the text mentioned on page 148, that it explains why is it that they mention that the moon looks like it is getting bigger or smaller.

The diagrams on page 148 are a more realistic representation of what we would observe in the sky when looking at the moon, as compared to a drawn black and white picture.

Comment 3

Interaction with the content is promoted by the textbook. On page 149, the questions asked deal with using the textbook's two dimensional diagrams to try to come to an understanding of the cause of the moon phases. This is in relation to a figure drawn on page 148, of the different moon positions in relation to the earth and the sun.

This activity directs learners to determine the real cause of the moon phases: that the cause of the moon phases is due to the relative position of the sun, earth and the moon.

Learners on page 148 are encouraged to work in pairs, before answering the questions e.g. "Discuss these questions with your partner and then write your answers about what figure 2 shows in the workbook." The learners are therefore also encouraged to share their ideas with the class on the different shapes of the moon. This has many instructional benefits, as a teacher can determine via learners' responses whether or not concepts are clearly understood.

On page 149, the questions asked do encourage active learning, as learners are encouraged to draw a picture of what they think the moon would look like at different positions. The learners are then encouraged to compare their diagrams of the moon phases to those in figure 1 on page 148. This allows the learner to evaluate the accuracy of their drawings and forces learners to think spatially

The textbook sets out goals on what the chapter would like learners to achieve upon completion. The exercise given to the learners on page 149 therefore enables learners to work towards the intended purpose of the chapter.

The development of ideas and concepts is smooth. Explanations and illustrations are available where necessary so learners can relate what is said in the text with an appropriate diagram.

Constructivist Promotion of the textbook

The chapter in the textbook deals with many aspects of the moon and does not only concentrate on the moon phases: the textbook within the same chapter also covers tides and the cause of tides. The textbook also looks at solar and lunar eclipses.

For this textbook, I will only report on the content regarding moon phases, as the other topics are not relevant to my research.

With regards to characteristic one according to Duban (2008), there is no evidence within the text and activities that examines a learner's prior knowledge. Instead, the activities deal with concepts pertaining to the phases of the moon that were covered within the chapter. In this regard, characteristic one is not achieved by the textbook.

On page 148, rather than an analogy to explain the causes of the moon phases, a 2-dimensional model is used.

It was discussed earlier that the models have more or less the same effect as analogies when explaining the causes of the moon phases. The model presented by the textbook therefore would be able to help learners achieve conceptual change, as a visual picture is represented to aid learners in understanding the real cause of moon phases. This allows for characteristic two of Duban's (2008) characteristics to be achieved.

On page 148, issues around language are dealt with in a simple and concise way: that is by looking briefly at the use of everyday language and its meaning in science. In the first instance, an important keyword is used, and that keyword is "looks like." This emphasises the fact that the moon is not really getting bigger, and thus addresses this misconception by the use of the keyword. Secondly, the scientific terminology is introduced for naming something that seems to be getting bigger, and similarly, seems to be getting smaller. Therefore, characteristic 3 is achieved.

The textbook makes good use of diagrams on page 148, showing the moon phases as we would experience them on earth, and then following with a 2- dimensional diagram to illustrate why we see the different phases. The text thus serves a great purpose as it explains what is represented in each diagram, making characteristic 4 achievable.

Collaborative learning is encouraged by the activities presented by the textbook. On page 149, the learner is first encouraged for the first question, to work with a partner. This enables learners to share ideas and learn from each other. The learner is then encouraged to work on their own, and present their work with the class after working on their own. By the learner sharing their ideas with the class, encourages further interaction with peers and the teacher alike. Characteristic 5 therefore is achieved.

In summary, 4 characteristics out of a total of 5 are achieved by the textbook. This means that the textbook has a very high percentage of being a tool able to promote constructivism.

Data Summary

Table 4.3c: Summary of data from textbook in respect to characteristics

Content	**SA**	**A**	**D**	**SD**	**NA**	Summary of findings
The science content is accurate		x				Book uses an interchange of scientific and everyday terms. Difference between waning and waxing explained, but terms not evident in naming moon phases. Important keyword used is "seem."
The science content is current		x				Not mentioned that earth goes around sun in orbit. Mentioned subtly that moon is half lit all the time.
The level of difficulty is appropriate for the intended grade	x					More detail given, but in simple language appropriate for age and grade.
The content relates to the real world	x					Observation of different moon shapes is explained by looking at positions of sun, earth and moon.
The examples provided are appropriate		x				No new moon is shown in the moon cycle.
Cultural portrayal brings forth correct scientific adaptations					x	No cultural portrayals presented in the textbook.
Instructional Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Promotes engagement	x					Learners given activity to relate two dimensional drawings of moon shapes to position of sun, earth and moon.
Promotes active learning		x				Learners, in activity on pg. 149 question 5, are asked to draw what moon would look like given position of sun, earth and moon.
Suitable for intended purpose	x					Activities given help lead learners to intended outcomes.
Concepts clearly introduced	x					Concepts build on each other.
Concepts clearly developed	x					Developments of ideas are smooth. Explanations and illustration available where necessary. Explanations and examples are relevant.
Concepts clearly summarised	x					On pg. 154, there is a focused question, (Poster) which may form part of summary.
Linguistic level is appropriate for audience	x					Linguistic level is appropriate for age and grade of learner.
Non-technical vocabulary is appropriate	x					Language used is appropriate in explaining underlying concepts.
Technical terms are consistently explained/introduced					x	No technical terms used.
Activities are appropriate for level	x					Activities given appropriate for grade and age.

Technical Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
The relation between text and pictures is accurate		x				There is one omission: that of the new moon.
The textbook visual representation of the moon phases is accurate		x				Correct, but still new moon missing.
The illustrations/visuals are clear and unambiguous		x				One moon shape type is omitted within the illustrations.
Social Considerations	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Language use is appropriate	x					Language use is appropriate for the grade and age of learner.

Looking at the presented table 4.3c, it may seem judging from the ticks in the respective columns that the textbook does not have misconceptions. The fact that though there are ticks in the agree column as opposed to there being ticks in the strongly agree column, suggests that the content is not entirely correct.

In terms of technical design, the representation of the diagrams is accurate to a certain extent. There are only a few problematic items, but in general, the representations are good.

Looking at the data presented, it can be concluded that the quality of diagrams, and the explanations offered by the textbook, are good. Therefore the textbook is a good resource for learners to use to achieve conceptual change in terms of understanding the cause of moon phases.

It should be noted, however, that in terms of the textbook design, presenting moon phases and lunar eclipses in the same chapter is not beneficial. This is because placing these two concepts in the same chapter may cause confusion: that the inclusion of lunar eclipses may cause misconceptions surrounding the cause of the moon phases, and the cause of lunar eclipses.

The diagrams between pages 152 and 148 look very similar to one another (this is based entirely on the shape of the moon rather than the type of moon diagram shown: e.g. realistic diagram of the moon vs. black and white diagram of the moon), and there are only small differences in terms of how the pictures are represented. The concern therefore, is the fact that learners may tend to think that another possible explanation for the cause of moon phases is that the earth's shadow is cast on the moon, which is a common misconception as discussed in Chapter 2.

A **total eclipse** is when then view of the sun is totally blocked by the moon.

Although it was only about 8 a.m., the sky became darker and darker. Birds sang as they do in the evening, and flowers closed as they do at night time. Finally it became dark enough to see some of the brighter stars in the sky, which are usually invisible during the day because of the sun's bright light. People in Limpopo Province saw a **total eclipse**.

Compare Pic to that of pg 148 (Comment in this point mentioned in above paragraph.

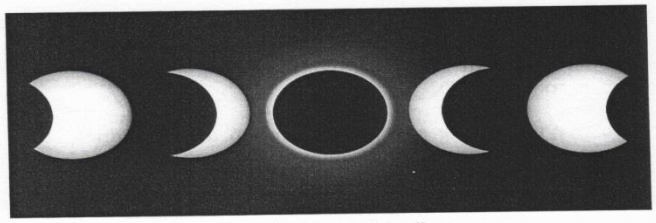


Figure 7: This is what you see during a total eclipse

A **partial eclipse** is when the view of the sun is only partly blocked by the moon.

People in other parts of South Africa did not see as much of a change as those in Limpopo Province. Figure 8 shows what people the rest of South Africa saw. These people saw a **partial eclipse**.

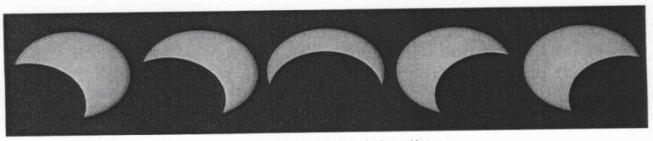


Figure 8: This what you see during a partial eclipse

Such amazing sights have been seen from time to time through the ages. These eclipses happen when the moon moves directly between the Earth and the sun in just the right way for the shadow of the moon to fall on part of the Earth. This is shown in Figure 9.

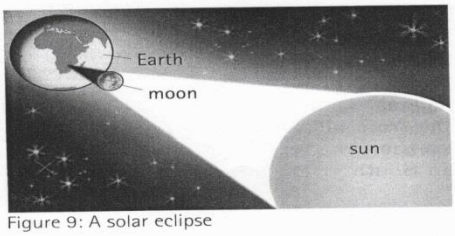


Figure 9: A solar eclipse

Anyone standing in the shadow will have their view of the sun blocked by the moon. Depending on where in the shadow they are standing, they will either see a partial or a total eclipse.

Figure 10 shows the shadow of the moon reaching the Earth. You can see that there are two parts to the shadow.

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4.3.4 Grade 7 Textbook II

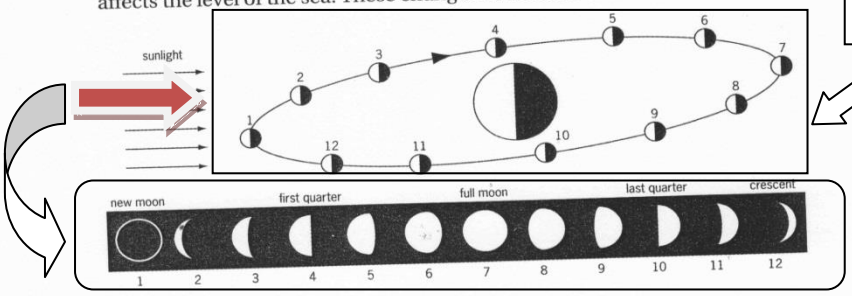
9 Tides and the phases of the Moon

When you look into the sky at night you sometimes see the Moon. The Moon shines because it reflects sunlight. At different times, you will see that the Moon appears to be a different shape or in a different phase. This is because you see different parts of the Moon lit up by the Sun, as the Moon orbits the Earth. The Moon takes 29,5 days to orbit the Earth. As it moves, the Moon affects the level of the sea. These changes in the level of the sea are called tides.

Comment 1

Comment 2

Comment 4



The phases of the Moon

You can't see the Moon when it is between the Sun and the Earth. This is called the new Moon. About a day later, you can see the first crescent, a small, thin slice of the Moon. In the southern hemisphere this thin crescent is on the left hand side of the Moon. This crescent Moon is visible just after sunset.

Comment 2

The slice of the Moon waxes or grows bigger until it reaches the first quarter and is when the Moon appears half lit. When the Moon is between first quarter and full, it is called a gibbous Moon. Once it has reached full Moon, the Moon wanes or the sunlit part of it becomes less until it reaches the last quarter. Finally the Moon becomes a thin crescent again, lit up on the right-hand side and is visible just before sunrise.

Comment 3

ACTIVITY 1

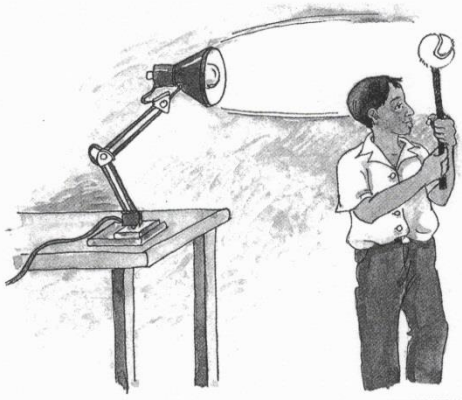
Groups / Use a model to experience the phases of the Moon (LO2 AS3)

You will need: an old cricket ball (or any other small ball), painted white; a small stick; Prestik; a bright light, such as an overhead projector light or desk lamp light.

1. Work in small groups to attach the ball to the short stick with the Prestik. Hold the stick at arm's length. Each group member must take a turn to do this.
2. Switch on the light and hold the ball between yourself and the light. The light represents the Sun, and the ball, which you cannot see clearly, the new Moon.

Integration – **Activity 1:** Mathematics LO3: works with space and shape; Social Sciences, Geography LO1: uses enquiry skills, LO2: demonstrates knowledge and understanding, LO3: exploring issues – makes informed decisions

3. Keeping your arm straight in front of you, turn slowly in a clockwise direction. You will see a thin crescent appearing on the left side of the ball. This will grow until it becomes a full Moon. You will now be between the light and the ball.
4. Carry on turning in a clockwise direction to see all the phases of the Moon that we described. Remember as you are turning, to slowly raise the ball so that your head doesn't get in the way at full Moon!

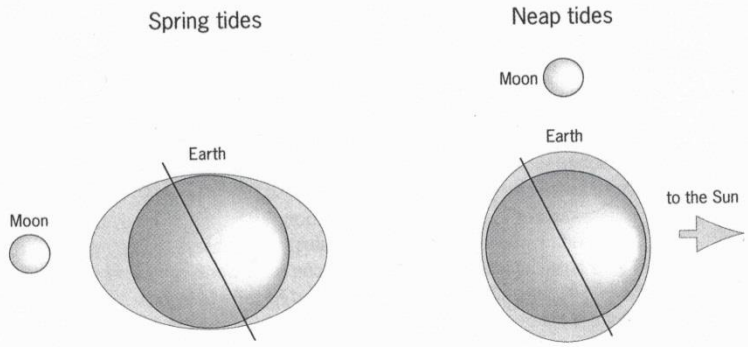


Comment 3

Tides

The Moon and the Sun both exert a force on the Earth and its seas. The pull of the Moon is larger than that of the Sun because the Moon is so much closer. At full Moon and new Moon, both the Sun and Moon pull in the same line so the tides of the sea are slightly higher than normal. They are called **spring tides**. Spring tides happen twice a month. Between the full and new Moon, the tides are not as high. When the Moon is in either the first or last quarter, the Sun and Moon are pulling at right angles to each other and the tides are slightly lower than normal. These are called **neap tides**. Because the Earth spins once a day there will be two high and two low tides each day.

Challenge: Why are there two tides each day?



The Moon has an effect on the tides.

Negative aspect of the textbook

Content

Comment 1

On page 90, it is mentioned that it takes the moon 29, 5 days to orbit the earth, which is approximately the time it takes for 1 calendar month. Thus, from a human perspective, the moon undergoes a new cycle every month. There is nothing wrong with such a statement, but it is also important to explain why it is that the moon takes 29, 5 days to orbit the earth and complete its cycle. If this is not mentioned, then such a statement can be considered a negative aspect of the textbook, as the information presented would be incomplete. To illustrate this further one could look at the scientific explanation of why the moon takes 29, 5 days to orbit the earth. The explanation is as follows: it takes the moon less time to orbit the earth once. It is estimated that it takes the moon 27, 3 days for one complete orbit. The reason we see the moon start a new cycle in 29, 5 days has to do with the fact that the earth also orbits around the sun at the same time that the moon is orbiting the earth, and this has an influence on how long it takes for the earth, sun and moon to be in line again for the formation of the new moon. (This is in reference of a solar cycle). It must again be highlighted that a possible omission of explaining why the moon undergoes 29, 5 days to orbit the earth is the possibility of the concept being difficult for learners at grade 7 level to understand.

Comment 2

Again on page 90, it is mentioned that the moon "grows bigger". This is incorrect as, in reality; the moon stays the same size. The moon only appears to be growing bigger. This again could cause the misconception that the moon changes in the actual size, where at one stage it gets smaller, and the next stage, it gets bigger.

What is of interest in the diagram though is that the half of the moon that is coloured white is facing the sun. The black part is not facing the sun. The latter is the other half that we cannot see, but the way it is represented suggests that the sun never shines on the other half of the moon.

Instructional Design

Comment 3

The instructional design is appropriate for the learners. The learners are encouraged to use models on page 90 to model out different shapes of the moon in relation to the position of the sun, earth and the moon. Such an activity would help in increasing understanding on what causes the different phases of the moon.

The fact that learners work in groups for this kind of activity means that learners can share their ideas, and this may force learners to reflect on their thinking if the group as a whole does not agree on a set positioning of the models. Such reflections foster critical thinking skills and problem solving skills. It helps learners also to value a group, and to learn to work with the group that they have.

The concepts are presented in a smooth and logical way by looking at the sequence. To illustrate this idea, it is seen from the textbook that the introduction of moon phases starts with the book explaining why we can see the moon. It goes on to say that different shapes are seen in different days because of the moon phases. A diagram is given, and moon phases are discussed in reference to the diagram. Lastly, it ends with learners given an activity to model some moon shapes. This illustrates good logic in the presentation of concepts, where the concepts are clearly developed. The activities thus are appropriate for the level of learners. Such activities can be carried out by learners at grade 7 level. No technical terms are used, and therefore the language presented is made simpler to understand by the use of straightforward English.

Technical design:

Comment 4

On page 90, there are 12 diagrams shown to represent the moon phases. When moon phases are discussed, texts usually mention eight moon phases with their respective names. Therefore, the diagrams on the page may cause confusion in terms of how many phases there are in total. This may actually be good, as learners are shown that the moon undergoes changes all the time, and that it is not restricted to changing only 8 times. A disadvantage of this representation is that it is not explained that the moon phases are not restricted in the way they undergo change (e.g. that there are only 8 phases). In fact, what is seen in the diagrams

may create the belief that the moon undergoes 12 changes in its cycle. What is of a great advantage though with the diagrams shown is that the diagrams show in summary what exactly the moon would look like at a given position.

Social Considerations

Language usage of the textbook is appropriate. There is no evidence of trendy language, profanity, prejudice terms, slang, or incorrect grammar.

Positive Aspect of the textbook

The textbook shows the relative positions of the sun, earth and the moon, and the appropriate picture or diagram for each position. The diagram alone summarises the main point that the cause of the moon phases is due to the relative positions of the sun, earth and the moon. What is also complementary to the summarised diagrams is the activity given to learners, where the learners use models to understand the cause of the moon phases, and most importantly, to observe the shape of the model moon in various positions.

Constructivist Promotion of the textbook

The textbook on page 90, taps into the learners' prior knowledge. The knowledge that the textbook taps into concerns what learners would notice when they look at the moon. It assumes that at one stage or another, the learners would have seen different shapes of the moon when they observe the moon in the evening or during the day sometimes. It is not an idea that is far-fetched as learners, irrespective of where they come from (rural or urban), have opportunities of seeing the different shapes of the moon. The textbook shifts to explaining why the different shapes of the moon are observed. This illustrates that there is a shift in the text focus, taking learners to the next level of thinking, by focusing on the cause of the different shapes of the moon.

The questions asked within the text are more rhetorical, which may cause learners to think about their past experiences of observing the moon. With this in mind, characteristic one is achieved.

Again, a 2-dimensional model is used to illustrate how it comes about that we have the different shapes of the moon.

This gives learners a mental picture of what is happening in reality, as we may not be able to physically see the relative movement of the earth, sun and the moon. The only things that we are able to observe are the effects of this movement. Therefore, having a 2-dimensional representation as the one represented in the textbook enables learners to understand the effects of what they observe. In this regard, as mentioned with the other 2-dimensional representations, characteristic two from Duban (2008) is achieved.

On page 90, the scientific word waxing (refer to comment 2) is used in the same line with the common language word *bigge*r, and again the scientific word waning is used in the same line with the everyday language word *less*: not much is explained by the choice of words within the text. Not explaining the scientific terms with everyday language may create misconceptions. In this case, the misconception may be that, physically, the moon gets bigger or smaller in its size. This in reality is not the case, as the moon remains the same size; the only difference is that as the moon in undergoing phase changes and appears as if the moon is getting bigger or smaller. In this regard, characteristic three in Duban (2008) is not achieved.

On page 90, besides the earth and the moon being given the same representation by the textbook, the diagrams presented clearly show the position of the sun, earth and moon, with the correct representation in terms of how the moon would be viewed on earth by humans.

On page 90- 91, an activity is given to learners to model the phases of the moon and to use observation to look out for the different phases of the moon as the moon undergoes its orbit around the earth. Group work for this activity is encouraged greatly. This fulfils characteristic 4 and 5 of Duban (2008).

In summary, 4 characteristics out of a total of 5 are achieved by the textbook. This means that the textbook has a very high percentage of it being used as a tool to promote constructivism.

Data Summary

Table 4.3d: Summary of data from textbook in respect to characteristics

Content	**SA**	**A**	**D**	**SD**	**NA**	Summary of findings
The science content is accurate			x			Text suggests that whole moon is lit at different times. Diagram of moon is used to represent earth. Text mentions seven phases moon undergoes, while picture shows 12 kinds of moon representations.
The science content is current	x					Information is current, as different positions of sun, earth moon are shown for different moon shapes.
The level of difficulty is appropriate for the intended grade		x				Level of difficulty is appropriate, but text and picture relation may cause confusion.
The content relates to the real world	x					There is a link with what is seen in night sky, and positions of sun, earth and the moon.
The examples provided are appropriate	x					Examples given appropriate for grade and age.
Cultural portrayal brings forth correct scientific adaptations					x	No cultural portrayal evident in book.
Instructional Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Promotes engagement	x					Activity on pg. 90 encourages modelling of moon phases.
Promotes active learning	x					Through modelling, learners may internalise cause of moon phases.
Suitable for intended purpose					x	No outcomes stated in textbook.
Concepts clearly introduced	x					Introduction of concepts is smooth and logical.
Concepts clearly developed	x					Explanations are available where necessary.
Concepts clearly summarised					x	No evidence of concepts being summarised.
Linguistic level is appropriate for audience	x					Linguistic level appropriate for grade and age.
Non-technical vocabulary is appropriate	x					Vocabulary is appropriate.
Technical terms are consistently explained/introduced					x	There are no technical terms used.
Activities are appropriate for level	x					Activities are realistic and appropriate.
Technical Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
The relation between text and pictures is accurate	x					Text and pictures relate to one another.
The textbook visual representation of the moon phases is accurate	x					The traditional 8 phases of the moon is not brought about the representations.
The illustrations/visuals are clear and unambiguous				x		Illustrations may be ambiguous for the fact that 12 moon phases are represented.
Social Considerations	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**

Social Considerations	SA	A	D	SD	NA	Summary of findings
Language use is appropriate	x					Language used is appropriate.

In terms of the content, it can be viewed from table 4.3d represented above that there is a small problem relating to the accuracy of the content presented in the textbook. Firstly, there is a statement on page 90 which is seen as incomplete, which impacts on the accuracy of the content. The rest of the characteristics under content are achieved by the textbook but, overall, the content represented in the textbook is of good quality

The technical design judging from table 4.3d proved to be beneficial as the only problem that arose was the ambiguous nature of the diagrams, where learners may think that there are 12 moon phases in total.

There are five names of the phases drawn above the diagrams of the moon phases, for example, new moon is mentioned above drawing number 1. Following the names, learners may assume that the new moon is representation number 1, 2 and 3. It is possible for this generalisation to be made, because in religious celebrations, the new moon is marked by the appearance of a crescent. The same could be said about the first quarter representing drawing number 4, 5 and 6.

The technical design of the book is good. The text relates to the pictures shown, but more should be explained about how the moon undergoes changes. The text should also make mention that the shapes of the moon are not restricted to be 8 or 12. Making this small change to the explanation would enhance the technical aspect of the textbook.

4.3.5 Grade 8 Textbook I

Activity 5

Phases of the Moon (groups)

LO1, AS: Conducts investigations and collects data; AS: Evaluates data and communicates findings.
LO2, AS: Recalls meaningful information; AS: Interprets information.
LO3, AS: Understands science as a human endeavour.

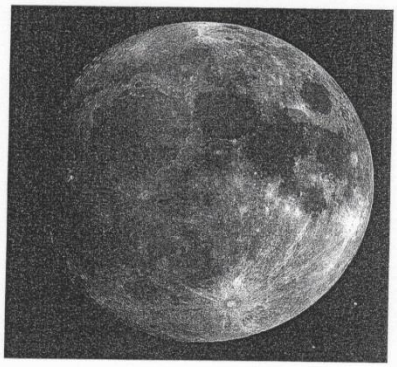
Comment 6

1. Thousands of years ago, many cultures held parties and festivals at Full Moon. (These still take place today in some cultures.) Why do you think these took place at Full Moon?
2. What traditions do people still have that are linked to Full Moon?

Comment 3

3. Do a Moon watch with a group of friends. Make a chart like the one below, where you draw the shape of the Moon you see each night. Try to do a Moon watch for one month.

Comment 4



Week 1	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Moon's shape							

Did you know?

The Moon was worshipped in some ancient religions and is still part of people's traditions in many parts of the world. Each culture links its own festivals and holidays to the Moon. In China, a holiday was established to honour the Moon. Every year, on the fifteenth day of the eighth **lunar month**, or during the Mid-Autumn or Harvest Moon, a 'Moon Festival' takes place. During this time, it is tradition for people to go to their rooftops, mountains or any other high place to view and honour the Moon.

Comment 3

Chapter 6: The universe 125

Activity 6

Shapes of the Moon (pairs)

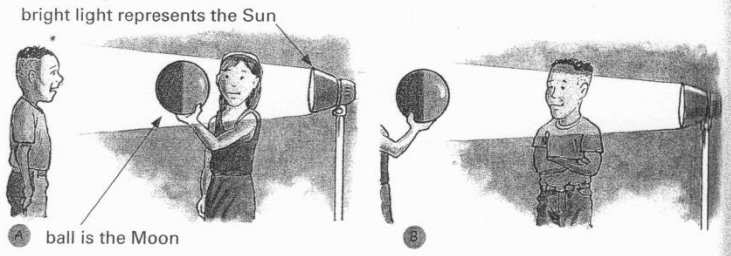
LO1, AS: Conducts investigations and collects data; AS: Evaluates data and communicates findings.

LO2, AS: Recalls meaningful information; AS: Interprets information.

You will need
• a dark room • a ball • a torch or bright lamp

Do this activity one week after you start your Moon watch. Imagine the bright light or torch is the Sun, the ball is the Moon and the person not holding the Moon-ball is the Earth.

1. Hold the ball as shown in picture A. Draw what you see.
2. Now hold the ball and the light as shown in picture B. Draw the shape of the illuminated part of the Moon. What shape do you see as the reader as you look at the Moon in the picture?
3. In between the positions shown in picture A and B you will see different views of the Moon, for example when the Sun and the Moon are at right angles to you. Draw some of these too.
4. Can you use this activity to explain why the Moon has a different shape at different times of the month?



Phases of the Moon

As you will see from the Moon watch table, the way you see the Moon changes shape slightly each night. The different shapes of the Moon are called the Moon's phases. The actual shape of the Moon does not change. Remember, you only see the part that is being lit up by the Sun.

The Moon takes about one month to orbit the Earth. The Sun lights up the half of the Moon that faces it. As the Moon moves around the Earth, you see a different amount of the lit-up half of the Moon.

In Activity 6, in position A, when the Sun illuminated the side of the Moon facing away from the Earth, you could not see the Moon. This is called the New Moon phase. In position B, the Sun was illuminating the same side of the Moon that was facing the Earth.

Comment 5

Comment 2

Comment 1

Negative aspects of the textbook

Content

Comment 1

On page 126, it states that "The moon takes about a month to orbit the earth". A month in a calendar consists of 30 and 31 days respectively, where the exception is February, where the month takes 28 days, and in a leap year (which happens once in every four years) it takes 29 days. Approximations can create problems, as learners may conclude that the moon orbits the earth in any of the above given days (30 or 31 days), which is inaccurate. It actually takes the moon less time to orbit the earth than is suggested.

Comment 2

On page 126, there seems to be a contradiction in the text. It states that the different shapes of the moon are called moon phases, and in the next sentence that the actual shape of the moon does not change. This can cause a lot of confusion as the two sentences contradict each other.

Comment 3

The textbook attempts to relate the moon to the real world by mentioning that there are religious celebrations that are held when the moon is full. The textbook also on page 125 makes mention of another culture where the existence of the moon is celebrated; however, in terms of looking at moon phases, and how the phases relate to the real world, there is no relation whatsoever.

On page 125, the activities given on cultural portrayal only deal with a particular phase of the moon: e.g. the full moon. This activity therefore would not bring out scientific concepts on the cause of moon phases.

Instructional design

The design of the textbook is adequate and would enhance learners' understanding. The activity given on page 125 (Refer to comment 4) of the textbook requires learners to draw the shapes of the moon over a period of one month. This type of activity increases learners' understanding that the moon undergoes different shape changes over a period of a month, and learners may therefore see the cycle starting to repeat. The moon thus completes its cycle around the earth in slightly less time than initially suggested. This activity may be very useful

if carried out over a period of a month containing 30 to 31 days, as learners would then see that the cycle repeats itself.

Comment 5

The learners on page 126 are given another activity which involves using models. Using models encourages learners to decide, and at the same time establish by means of using the models as to why the moon is a different shape at different times of the month. Such an activity encourages critical thinking and problem solving. This encourages learners to participate in active learning as they discover things for themselves when experimenting with models.

Most of the activities involve learners working either in groups or in pairs. This helps learners to compare their ideas with those of the rest of the group. It encourages self-reflection, and thus helps a learner to engage more with the ideas presented. This may help with the learning process as learners would be faced with explaining their misconceptions where the group, and later on the teacher, can help a learner realise the mistake in the leaners' thinking. There are therefore more benefits to working with a group, with an active teacher who has good content knowledge.

The textbook has intended outcomes, and makes these outcomes explicit to the learner at the beginning of the chapter of moon phases on page 125 (Refer to comment 6). Concepts are clearly introduced and developed, and there is a logical flow of ideas in the content presented; the textbook begins with cultural aspects of the textbook, goes on to shapes of the moon and phases of the moon, and ends the chapter with more information about the moon. From the sequence of these topics, one can see that there is a logical structure.

Within the content, there are no technical words evident, which make the text easier for learners to understand for the grade level. At the end of the chapter, there are focus questions (pg. 128) where learners are asked to make a list of things they have learnt in the chapter. This therefore serves as a summary of the chapter, and may help learners in future when they have to think of previous things that they have learnt.

Focus Question

Focus Question as highlighted in above paragraph

Assessment

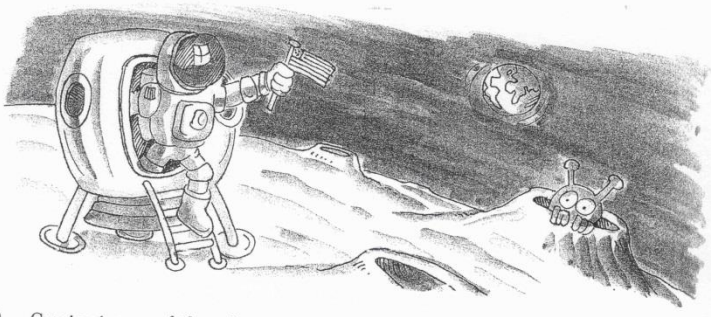


Make a list of all the things you have learnt about and learnt to do in this chapter. Compare your list with the list on page 111.

1. Draw the positions of the Earth, the Sun and the Moon when there is
   (a) a Full Moon
   (b) a New Moon
   (c) a first and last quarter of the Moon.
2. Working in pairs, use a drawing and notes to explain how spring tides are caused.
3. In your own words, describe the life cycle of a star.
4. Debate the question: Could there be life on other planets? Use different sources to support your arguments.

Assessment projects

1. Write a project about the first time humans landed on the Moon. Who was the first astronaut to walk on the Moon? What did those astronauts say about their experiences? What were the names of the spacecraft they travelled in? When did they land on the Moon?



2. Contact one of the observatories or universities in South Africa to find out more about a career in astronomy. You need to find out what astronomers in South Africa do and what subjects you need to study at school and university to follow a career in astronomy. You should also find out what bursaries are available to study astronomy. Perhaps the observatory or university will let you visit their facilities and see astronomy in action.

Technical design

The technical design of the book is adequate. The relationship between the text and pictures is accurate; the text explains the concepts, and the picture is there to help with the understanding of the concepts. The visual representation of the moon phases is accurate, unlike other textbooks. This textbook includes in the cycle a visual representation of a new moon. The illustrations are therefore clear for learners to understand what is occurring in the pictures given to them.

Social considerations

Language usage of the textbook is appropriate. There is no evidence of trendy language, profanity, prejudice terms, slang, or incorrect grammar.

Positive Aspect of the textbook

The activities given by the textbook promote engagement. An example can be seen on page 125 (Refer to comment 4) where learners are required to draw and observe the moon for a period of a month. This type of activity helps learners see the different shapes the moon can undergo in a period of a month, and thus is a good introduction to moon phases. On page 126, the concept of moon phases is further explored, as learners determine for themselves the cause of moon phases using models. E.g. "Can you use this activity to explain why the moon has a different shape at different times of the month?" The activities given would help learners to learn from each other, as they involve work carried out in groups or in pairs. There is thus a smooth transition and development of concepts, where what is observed is explored in greater detail.

Active learning is promoted as learners perform activities where they collect data, and use the data collected to explain moon phases and the different shapes associated with the moon phases, before theory is introduced.

The textbook also contains a set of objectives or outcomes that should be achieved by the learner at the end of the chapter (Refer to comment 6). The activities given help learners to achieve these intended outcomes. A further advantage of the textbook is that explanations and illustrations are offered after learners have done activities. This helps learners understand the value of the activities in allowing them to understand the concept of moon phases.

At the end of the chapter, concepts are clearly summarised by means of focus questions and end-of-chapter synthesis activities: e.g. on page 128 (Refer to comment on focus questions under comment 5). The text instructs learners to "make a list of all the things you have learnt to do in this chapter". This list is then compared to another list on page 111 which appears in earlier pages, in terms of what learners are expected to know after the chapter has been completed.

Constructivist Promotion of the textbook

The way in which the textbook is written assists in establishing what the learner already knows, in a creative way. The textbook on page 125 (Refer to comment 3) gives a very brief background on the fact that cultures hold celebrations in respect of the shape of the moon. The textbook aids in identifying what learners know about the moon and culture by asking why the learners think the celebrations take place. The textbook also gives a brief background about moon celebrations at the bottom of page 125 (See comment 3). The textbook thus only taps into the learners' previous knowledge about the moon and culture, and no attempt is made by the textbook to find out what learners know about the scientific aspect of what causes the phases of the moon. The textbook instead focuses on only one aspect of a moon phase: the full moon.

As far as characteristic one is concerned, it could be said that the characteristic is not achieved. Even though learners' previous knowledge is accessed, it can be safely said that the knowledge that is tested does not have to do with moon phases, but has to do with the full moon. No questions challenge learners' knowledge of the phases of the moon, and what causes these phases.

No analogies are used by the textbook to help learners understand the cause of moon phases. Instead, learners are given an activity to model the relative positions of the sun, earth and the moon. Learners are encouraged to look at the shape of the light being shone onto the model of the moon. A 2-dimensional picture is drawn in the textbook to illustrate how to go about doing the activity. After observation, the text then asks learners why they think the moon undergoes different phase changes. It is hoped from the activity that learners will understand that the different shapes of the moon are caused by the relevant positions of the sun, earth and the moon. This can be seen from the explanations provided by the textbook on page 126: "As the moon moves around the earth, you see different amounts of the lit - up half of the moon."

The activity, with the use of models, may help learners to develop a mental picture of what is happening in reality, as we may not physically be able to see the relative positions of the earth, sun and the moon. The only things that we are able to observe are the effects of this movement. Therefore, having an activity where learners independently model the positions and shapes of the moon that they observe, may enable learners to understand the effects of what they observe. In this regard, characteristic two from Duban (2008) is achieved.

On page 126, we see the first evidence of the relation between everyday language and the scientific way of thinking. It mentions on page 126 that "the actual shape of the moon does not change" (refer to comment 2). In everyday language, we do talk about the moon changing its shape. This may create the misconception that the moon is constantly changing shape each time, as opposed to learners understanding that the appearance of the moon is related to the position of the sun, earth and the moon, in respect to what is reflected to the people who are observing the moon on earth. It is quite useful that the textbook mentions this fact to spark debate amongst learners and teachers alike, so that they may come to an understanding of why it is said that the actual shape of the moon does not change.

It is extremely beneficial that the text indicates that we only see the half of the moon that is lit. The evidence is within the text, where it mentions that "as the moon moves around the earth, you see different amounts on the lit up half of the moon." This therefore may eliminate a possible misconception that when the moon is full, we see the "whole moon"

Almost immediately, the textbook tackles what learners should know about the moon as opposed to the everyday language, by supplying scientific facts, rather than making a comparison explicitly within the textbook. In this way presenting scientific facts may encourage learners to ask questions if the theory is not in line with their everyday understanding. It therefore can be supported that characteristic 3 of Duban (2008) is achieved.

Pictures are used in the textbook to complement the text written. This helps with the understanding of what the text is trying to convey. Enough pictures are used to convey the necessary concepts. Characteristic 4 of Duban (2008) is therefore achieved.

On page 125, in activity 5 and 6 it is encouraged that learners' work in groups and in pairs for the respective activities (e.g. in activity 5, it is encouraged that learners work in groups to collect data: the data consist of recording what the moon looks like on each day for a month).

This encourages learners to compare what they have with one another for validation purposes.

Again, on page 126, it is encouraged that learners work in pairs for modelling the relative positions of the sun, earth and the moon, so as to establish what moon phase occurs when different positions are modelled. Therefore, characteristic 5 of Duban (2008) is also achieved.

In summary, 4 characteristics out of a total of 5 are achieved. This therefore means that the textbook can be seen as a good conceptual tool to promote constructivism.

Data summary

Table 4.3e: Summary of data from textbook in respect to characteristics

Content	**SA**	**A**	**D**	**SD**	**NA**	Summary of findings
The science content is accurate			x			Number of days for complete cycle not accurate. Little is explained about actual shape of moon not changing.
The science content is current		x				No mention of earth orbiting the sun.
The level of difficulty is appropriate for the intended grade		x				Some text may be confusing to learners.
The content relates to the real world				x		Analogies used do not relate to real world.
The examples provided are appropriate		x				Not enough examples are given for 6 of the 8 moon phases.
Cultural portrayal brings forth correct scientific adaptations				x		Cultural activity brings forth non-scientific relation or adaptions.
Instructional Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Promotes engagement	x					Observation activity is given to learners. Activity also entails learners using models to explain moon phases.
Promotes active learning	x					Learners collect data and use data to explain moon phases.
Suitable for intended purpose	x					Suitable for the stated outcomes.
Concepts clearly introduced	x					Introduction of concepts is smooth and logical.
Concepts clearly developed		x				Explanations and illustrations are given after each activity. Illustrations and explanations are relevant.
Concepts clearly summarised	x					Concepts summarised by focus questions. At the end of chapter, there are synthesis activities.
Linguistic level is appropriate for audience	x					Linguistic level is appropriate as per grade and age.
Instructional Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**

Instructional Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Technical terms are consistently explained/introduced			x			There are no technical terms used.
Activities are appropriate for level	x					Activities are appropriate as per age and grade.
Technical Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
The relation between text and pictures is accurate	x					Text and picture relation are accurate.
The textbook visual representation of the moon phases is accurate	x					Visual representation of moon phases is accurate.
The illustrations/visuals are clear and unambiguous	x					Illustrations are clear and unambiguous.
Social Considerations	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Language use is appropriate	x					Language use is appropriate for grade and age of learner.

In terms of the content of the textbook, it can be seen from the summary presented by the table 4.3e that the content is satisfactory.

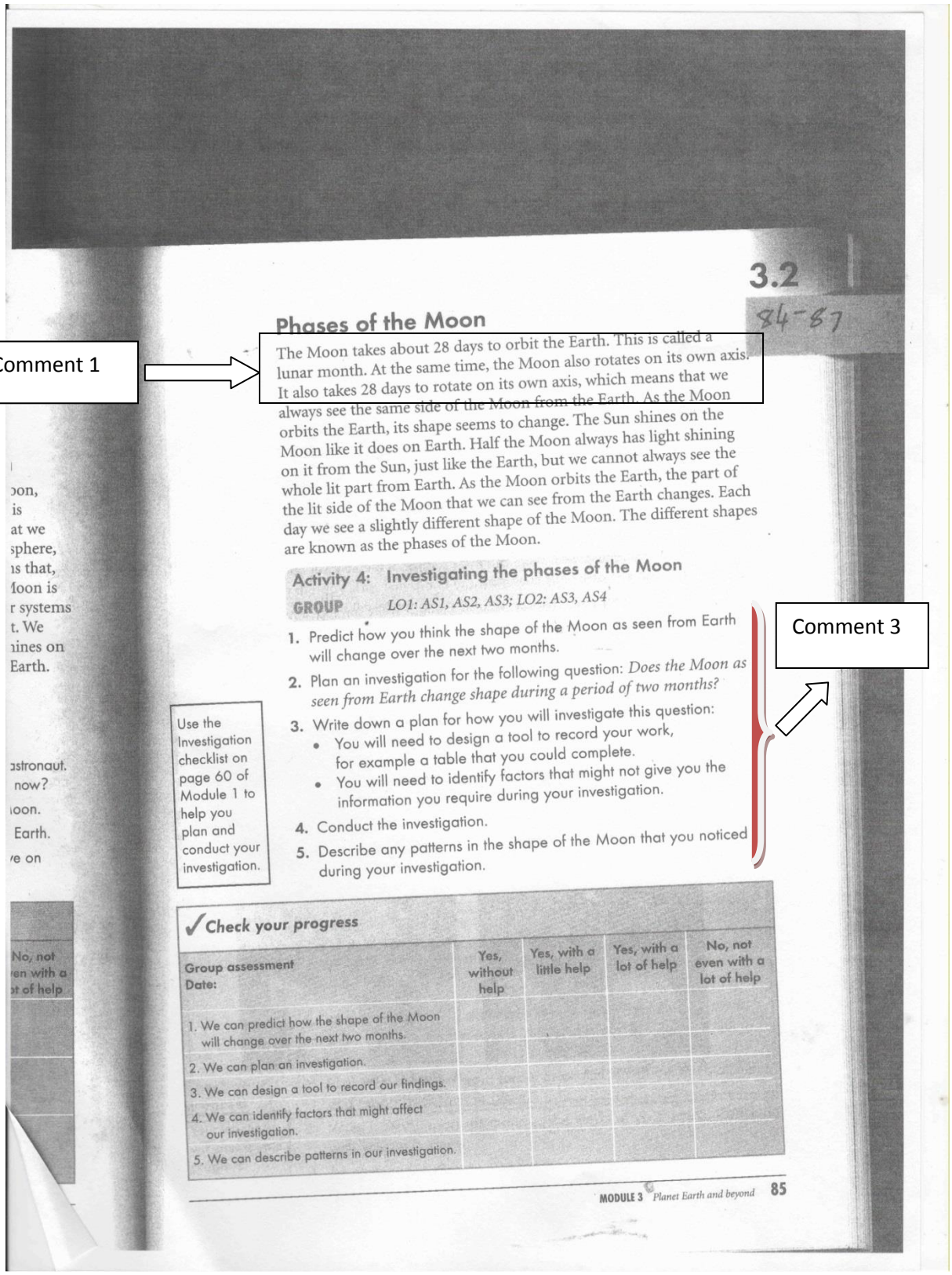
This is because of an inaccuracy brought forth by the textbook in relation to the time frame it takes for the completion of the moon phase. Other concerns include the completion of information, where within a text, there is relevant information left out as per detailed description above pertaining to the characteristic relating to how current the information is.

The contradiction or, rather, misconception in relation to the sun shining on the moon makes the textbook somewhat confusing to understand as it may also give the learners the idea that the other half of the moon which cannot be directly viewed on earth is not lit by the sun at all.

The textbook also lacks examples of the relative positions of the sun, earth and the moon for the other moon phases that take place. Also, cultural portrayals do not relate to moon phases at all, but instead only concentrate on one type of moon phase: the full moon.

The technical design, however, is good and this can also be seen according to the summary provided by the table above. It can be said that the quality of diagrams represented in the textbook is good because the written text relates to the pictures represented by the textbook. Even though the relative positions of the earth, sun and the moon are not shown in the drawings for the different moon phases, the correct sequence is shown in terms of the shapes that come after one another for the different phases. There is nothing ambiguous about the pictures shown, as opposed to other discussed textbooks: grade 6 and 7 Natural Science textbooks.

4.3.6 Grade 8 textbook II



3.2

84-87

Phases of the Moon

The Moon takes about 28 days to orbit the Earth. This is called a lunar month. At the same time, the Moon also rotates on its own axis. It also takes 28 days to rotate on its own axis, which means that we always see the same side of the Moon from the Earth. As the Moon orbits the Earth, its shape seems to change. The Sun shines on the Moon like it does on Earth. Half the Moon always has light shining on it from the Sun, just like the Earth, but we cannot always see the whole lit part from Earth. As the Moon orbits the Earth, the part of the lit side of the Moon that we can see from the Earth changes. Each day we see a slightly different shape of the Moon. The different shapes are known as the phases of the Moon.

Activity 4: Investigating the phases of the Moon

GROUP *LO1: AS1, AS2, AS3; LO2: AS3, AS4*

1. Predict how you think the shape of the Moon as seen from Earth will change over the next two months.
2. Plan an investigation for the following question: *Does the Moon as seen from Earth change shape during a period of two months?*
3. Write down a plan for how you will investigate this question:
   - You will need to design a tool to record your work, for example a table that you could complete.
   - You will need to identify factors that might not give you the information you require during your investigation.
4. Conduct the investigation.
5. Describe any patterns in the shape of the Moon that you noticed during your investigation.

Use the Investigation checklist on page 60 of Module 1 to help you plan and conduct your investigation.

✓Check your progress

Group assessment Date:	Yes, without help	Yes, with a little help	Yes, with a lot of help	No, not even with a lot of help
1. We can predict how the shape of the Moon will change over the next two months.				
2. We can plan an investigation.				
3. We can design a tool to record our findings.				
4. We can identify factors that might affect our investigation.				
5. We can describe patterns in our investigation.				

Comment 1

Comment 3

3.2

Cultures and the phases of the Moon

In earlier grades you have learned how many cultures and religions have used the phases of the Moon as a way to keep track of passing time. Different cultures have also created many stories to explain the phases of the Moon. Below you can read one such story.

The Angry Sun

A San story about the phases of the Moon



One night, the Sun saw the full Moon shining brightly down on Earth, and he became very angry.

The Sun was a jealous, fiery person, who brought warmth and light to the Earth during the day. The Sun didn't want the Moon to shine so brightly at night, so he followed the Moon to chase the Moon away. But the Moon wasn't frightened of the Sun and stayed right where he was. The Sun became very angry. How dare the Moon shine when he did! The Sun became so angry that he started slicing pieces off the Moon with his powerful Sun rays.

The Moon didn't want to die, so he begged the Sun: "Oh Sun, do not destroy me entirely! Let me keep my backbone for the children." So the Sun took pity on the Moon and stopped slicing him and left his backbone alone.

But the Moon was badly hurt, so he went away to hide his pain. When he felt better, he returned to the sky and grew and grew... until he was full again, lighting the dark night.

Again the Sun became jealous and angry... and started once more to slice pieces off the Moon with his powerful Sun rays.

And so the story continues until today.



Comment 2

Activity 5: Investigating the phases of the Moon

GROUP *LO3: AS1*

1. Discuss the following statement in your group: *Traditional myths and legends are as important as scientific explanations to explain natural phenomena.*
2. Explore the views of your family or community about this statement, and report back to your group.
3. Write a short report summarising the views of your group. Conclude with your own views.
4. Be prepared to discuss your findings and views with the whole class.

Check your progress ✓

Your teacher will assess your progress.

Negative aspect of the textbook

Content:

Comment 1

The point mentioned below is insignificant for the purpose of the study, but is worth mentioning as it falls within the section of moon phases in the textbook:

On page 85, two aspects are mentioned: the time taken for the moon to spin on its own axis, and the time taken for the moon to orbit the earth. What is of interest in the statement is the implication that it takes the same time for the moon to go around the earth as it does to spin on its own axis. The amount of time suggested is close to the correct scientific value, where according to science literature, it is estimated that the moon would take approximately 27, 3 days to spin on its own axis in that time period. What is important to note is that the time taken for the moon to spin on its own axis is not the time the moon takes to orbit the earth; in fact, it take a slightly longer period (29.5 days). Therefore, the textbook in this regard is not accurate in terms of the content presented.

Comment 2

On page 87, the cultural portrayal introduces the concept of waning and waxing, where the moon appears to be getting bigger and smaller. This cultural portrayal could help learners see that the moon undergoes different shapes, where the shapes are referred to as moon phases. However, the cultural portrayal does not explain the cause of the moon phases.

Instructional design

Comment 3

The instructional design is adequate. The learners are first of all given an activity on page 85 where they need to conduct an investigation over a period of 2 months. This investigation involves learners working in groups, and observing for the two months if the moon changes shape. The onus is left on the groups to decide how they are going to conduct the investigation given to them. This involves active learning as the group has to make decisions together on how they are going to tackle the activity. Group decision making involves skills such as critical thinking and problem solving.

Comment 4

In the next activity on page 86, learners are introduced to models. This helps learners to understand the cause of moon phases and, in a way, increase understanding on the concepts associated with moon phases. Concepts are clearly introduced and developed, as indicated by the sequence in which things are presented: Shapes of the moon, using models for shapes of the moon, and lastly the myths and legends surrounding moon phases and astrological phenomena. There are no technical terms evident in the text making the text easy to read and to understand.

Comment 4

3.2

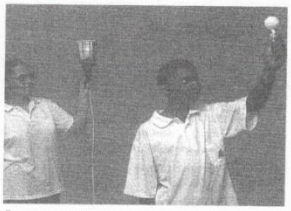
EXTENSION ACTIVITY

You can make a model as described below to help you understand the phases of the Moon better, as shown in the two photos below.

1. Darken the room so that shadows are clearly visible.
2. Set up a bright, uncovered light bulb. This represents your "Sun".
3. Stick a white ball (like a table tennis or styrofoam ball) on the end of a pencil. This is your "Moon". Hold the ball and pencil at arm's length.
4. Your head now represents the Earth, and your eyes are a person looking at the Moon from the Earth.
5. Begin by facing the "Sun". Note the shape of the "Moon" and whether you can see any of its lit-up part.
6. Keep holding your "Moon" at arm's length while turning slowly on the spot in an anticlockwise direction. Stop when you have completed a quarter-turn, as in photo A below.
7. Observe how much of the lit-up part of the "Moon" is visible.
8. Continue with another quarter-turn. The "Sun" will now be behind you.
9. Note how much of the "Moon" is visible now, as in photo B below.
10. After repeating this process for two more quarter-turns, you will be back with the "Moon" between you ("Earth") and your "Sun".
11. Now repeat this cycle using your model, but this time record your observations by sketching your "Moon" at each of the four stages in the cycle. Include a written explanation next to each sketch.
12. In small groups, discuss the strengths and weaknesses of this model. Record your ideas in your workbook.



A After a quarter turn



B After half a turn

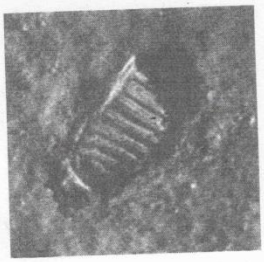
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Unit 2

Moon cycles

Reviewing our knowledge of the Moon



A footprint that an astronaut left on the surface of the Moon.

In Grades 4–6 you already learned about the Moon, which is the Earth's natural satellite. (A satellite is something that orbits a planet.) Let's review what we know about the Moon. The Moon has no atmosphere, so it has no air, no rain and no wind. This means that, unlike Earth, it does not support any life. The Moon is quite small compared to the Earth. Suns in solar systems generate their own light, but the Moon does not. We can only see the Moon because when the Sun shines on the Moon, the sunlight is reflected towards the Earth.

Comment 5

Activity 3: Knowledge of the Moon

INDIVIDUAL *LO2: AS3, AS4*

1. Above is a photograph of a footprint left on the Moon by an astronaut. Why do you think it will still be visible thousands of years from now?
2. a. Write down one difference between the Sun and the Moon.
   b. Write down one difference between the Moon and the Earth.
3. What would you need to take with you if you wanted to live on the Moon?

Use the Investigatio checklist on page 60 of Module 1 t help you plan and conduct yo investigatio

✓ Check your progress

Self-assessment Date:	Yes, without help	Yes, with a little help	Yes, with a lot of help	No, not even with a lot of help
1. I could explain why the footprint will still be visible after a thousand years.				
2. I could write down one difference between the Sun and the Moon.				
3. I could work out what I would need to take to the Moon to live there.				

✓ Check

Group asse Date:

1. We can p will chang
2. We can p
3. We can d
4. We can i our invest
5. We can c

Technical design

Moon phases and the cause of the moon phases are discussed, but there are no pictures indicated in the book to relate to the text. The only picture shown is based on an activity on how to go about conducting the activity using models.

Social considerations

Language usage of the textbook is appropriate. There is no evidence of trendy language, profanity, prejudice terms, slang, or incorrect grammar.

Positive Aspect of the textbook

The activities in the textbook promote active learning. Learners on pages 85 -87 explore the shape of the moon, the cause of the moon phases, and looking at cultural myths. These activities help develop concepts surrounding moon phases.

Using models is encouraged in the activities to help learners see the relative position of the sun, earth and the moon, by observing the shape of the moon. Such activities help learners realise the cause of the moon phases.

Constructivist Promotion of the textbook

Comment 5

On page 84, there is a small section before the commencement of the chapter, on what the learners are required to know already about the moon. What is quite good is that it gives the learners an idea on when they would have learnt the content from the previous grades: i.e. grades 4- 6. This may then help learners to think of lessons that were taught to them in previous grades.

The knowledge that the textbook looks at is based on the characteristics of the moon, and why we are able to see the moon. The activity that follows on the same page reinforces what characteristics learners are to know by means of questions and statements. An example is, "What would you need to take with you to live on the moon?" and " why learners would think that a footprint of an astronaut would be visible after 1000 years" This kind of question looks at whether the learner is able to remember certain traits of the moon, e.g. no air, no rain, no wind etc. What is expected for students master and know is further emphasised on

the bottom of page 84, where there is a checklist for what learners ought to know before the commencement of the chapter.

The only information that would serve much purpose as a foundation for moon phases is that of the reflection of the sun from the moon, mentioned in the section "Reviewing our knowledge of the moon," on page 84.

It can be said that characteristic 1, as mentioned by Duban (2008), is achieved, but there are points to consider. Looking at the text, instead of having conceptual change, the text rather emphasises the importance of what was learnt previously. The text serves the purpose of re-emphasising concepts learnt. There is very little text on an important aspect of pre-knowledge for the foundation of moon phases (that being the sun's reflection off the moon). Rather, characteristics that do not help in understanding moon phases are given more space in the textbook. Characteristic two of Duban (2008) is therefore not achieved.

No analogies are used; instead, learners are given an activity on page 86 (Refer to comment 4) to model the relative movement of the sun, earth and the moon. Giving the exercise alone, without including pictures of the moon phases in the textbook, leaves learners at a disadvantage, as learners might not know precisely which shapes to look out for, (except for the moon shapes that the textbook wants to concentrate on) and similarly, see the relative positions of the sun, earth and the moon with those shapes viewed.

It can be said that this exercise could possibly help learners to understand the cause of the moon phases. The disadvantage of the textbook is that learners may not know the shapes of the moon that fall in-between the quarter turns as given by the activity.

There is no evidence in the text that relates everyday spoken language to concepts that are dealt with in the scientific community. To illustrate this point, one could look at the text relating to cultural stories on page 87 (Refer to comment). An example of a story is given, where the story could be related to the phases of the moon, specifically, the concept of the moon waning and waxing. No text follows to show clearly how the story relates to the science of the moon phases.

An activity is given where learners are to discuss the importance of traditional myths and legends, but the activity is broad in terms of the wording. Focus could thus be shifted by instructing the learners to look at general myths and legends that do not pertain to the phases of the moon. Characteristic 3 from Duban (2008) is again not achieved.

The only drawing present in the section of moon phases in the textbook is a picture of a footprint left by an astronaut on the moon, and a picture to illustrate how learners should stand when modelling the relative positions of the sun, earth and the moon to see moon shapes at different positions. Even though the section is based on moon phases, no picture is present to show the different phases of the moon, and what they are called. Since there is a lack of relevant pictures, Characteristic 4 from Duban (2008) is also not achieved.

In the section of moon phases, out of the 4 activities given, 3 of the activities require learners to work in groups. This allows learners to share their views in the different kinds of activities given, and to work together at the same time, to tackle the obstacles offered by each activity. Therefore, characteristic 5 of Duban (2008) is achieved.

In summary, out of the 5 characteristics that make the textbook a constructivist tool for learners to use to develop their understanding of moon phases, only 2 characteristics are achieved, making the textbook a poor tool for learners to use to enhance their learning.

Data Summary

Table 4.3f: Summary of data from textbook in respect to characteristics

Content	**SA**	**A**	**D**	**SD**	**NA**	Summary of findings
The science content is accurate			x			Number of days for complete moon cycle is inaccurate. Description of moon phases is also inaccurate.
The science content is current	x					Fundamental aspects of the cause of moon phases are not made explicitly clear.
The level of difficulty is appropriate for the intended grade	x					Content is easy for learners to be able to understand.
The content relates to the real world		x				Not stated that what is seen by us on earth is due to the relative position of the sun, earth and the moon.
The examples provided are appropriate					x	No examples given by the textbook
Cultural portrayal brings forth correct scientific adaptations			x			Only content covered by the cultural story is waxing and waning of the moon. Cultural adaptions bring forth incorrect scientific adaptions.
Instructional Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Promotes engagement		x				Learners get to plan an investigation on the different shapes of the moon. There is an activity given to learners in terms of using models.
Promotes active learning	x					Learners are encouraged to work in groups.
Instructional Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**

Instructional Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Concepts clearly introduced	x					Sequences in which concepts are introduced are logical and smooth.
Concepts clearly developed		x				Concepts are clearly developed.
Concepts clearly summarised					x	No evidence of summary in the textbook.
Linguistic level is appropriate for audience	x					Linguistic level is appropriate for learner.
Non-technical vocabulary is appropriate	x					The non-technical vocabulary is appropriate for the learner as per grade and age.
Technical terms are consistently explained/introduced					x	No technical terms used.
Activities are appropriate for level	x					Activities are appropriate.
Technical Design	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
The relation between text and pictures is accurate					x	No picture present for comparison.
The textbook visual representation of the moon phases is accurate					x	No moon phases are indicated by the moon in terms of visual representation of moon phases.
The illustrations/visuals are clear and unambiguous		x				Illustration as per activity is clear, but that is the only place where there are visuals.
Social Considerations	**SA**	**A**	**D**	**SD**	**NA**	**Summary of findings**
Language use is appropriate	x					Language used is appropriate.

The table 4.3f represented above summarise aspects of the content, and quality of pictures offered by the textbook. In terms of the content, the parts dealing with strongly agree and agree, deal with the characteristic of how current the content is, whether the level of difficulty of the textbook is appropriate for learners in grade 8, and whether the content relates to the real world. However, there is a disagreement on the accuracy of the textbook in terms of the scientific content. More detail was mentioned above on what aspects of the content were not accurate. Therefore, it terms of the first research question, one can conclude that the science content is inaccurate; there are misconceptions in the textbook which impact on the quality of explanations offered by the textbook. Therefore, the textbook is a problematic tool to begin with.

In terms of the technical design, which looks at the quality of diagrams, no comparisons can be made, as there are no pictures present which relate to moon phases, except for the pictures which show learners how to go about modelling the relative positions of the sun, earth and the moon for certain moon phases. Therefore, one could conclude that the textbook contains poor text; in this instance, text is poor when no topic specific pictures are shown.

From the presented textbooks, it can be seen that no textbook was free from content that was in accurate. Besides the content, various aspects of the textbook have also been commented on: e.g. the instructional design, technical design and social consideration. These characteristics helped to look at the following aspects:

- The engagement level that the textbook promotes
- Whether the textbook encourages active learning
- Whether concepts regarding the moon phases are clearly developed and summarised
- The relation of pictures to the text presented by the textbook
- Whether the language used was appropriate for learners at the grade level
- Whether technical terms were explained

All these aspects aided in determining on what the quality of the textbooks were. Even though the textbook was interrogated for accuracy, and negative aspects were reported on, positive aspects despite the negative points, were also mentioned to highlight important contributions that each of the textbooks made. Table 4.3g supplies a summary of the positive and negative aspects that each of the textbooks had:

Table 4.3g: Summary of all the textbooks

Grade 6 Textbook 1	
Negative Aspects	**Positive Aspects**
Inaccurate content present. Cultural meanings attached to specific moon shapes do not promote learning of moon phases. Visual representations of moon phases are not accurate	Activities in the textbook promote engagement. Language used in text is appropriate for learners. The pictures relate to the text.
Grade 6 Textbook 2	
Negative Aspects	**Positive Aspects**
Inaccurate content present. No relation is made in the textbook with cultural stories and the science behind them. Visual representation of the moon phases is not accurate.	Language used is appropriate for the grade level. Cultural stories in textbook convey important scientific applications. Activities promote active engagement.

Grade 7 Textbook 1	
Negative Aspects	**Positive Aspects**
Inaccurate content present. Presents a summary of moon phases and eclipses together (this may cause confusion). There is an omission of a new moon in the sequence of moon phases.	Language use of the textbook is appropriate. Textbook uses keyword 'looks like' to emphasise something that is not true. Activities promote active engagement. Textbook sets explicit goals that learners are to achieve after the chapter.
Grade 7 Textbook 2	
Negative Aspects	**Positive Aspects**
Inaccurate content present.	Activities promote active engagement. Language use of the textbook is appropriate. Concepts are presented in a smooth and logical way.
Grade 8 Textbook 1	
Negative Aspects	**Positive Aspects**
Inaccurate content present.	Activities promote active engagement. The textbook makes intended outcomes explicit at the beginning of the chapter. Language used in the textbook is appropriate.
Grade 8 Textbook 2	
Negative Aspects	**Positive Aspects**
Inaccurate content present. No pictures that relate to the text.	Activities promote active engagement. Language used by the textbook is appropriate.

In general, the content accuracy tended to increase the higher the grade level of the textbook. In terms of the picture illustration of the moon phases, the two grade 7 textbooks provided moon phase diagrams that would aid learners in understanding the causes of the phases of the moon, as the diagrams showed the relative positions of the sun, earth and the moon for the different shapes the moon can undertake during its cycle.

4.4. Misconceptions

Not all textbooks were free from misconceptions. Even the textbooks which were deemed to be good textbooks had a misconception in one way or another. Below is a summary of the misconceptions picked out in the textbooks on the section of moon phases. The table also contains the scientific explanation of the misconception, so as to compare and understand why certain concepts covered by the content were deemed to be misconceptions:

Table 4.4a: Summary of identified content that could lead to misconceptions

Misconception	Scientific conceptions
Grade 6 Textbook 1	
The dark part of the moon we cannot see is in shadow. (pg. 94)	The dark part is where the sun is not shining on that part for it to be reflected back.
Representation suggest that the moon undergoes phase change every 7^{th} day.	The change of the moon in terms of shape is an on-going process.
At the beginning of each calendar month, the moon may look like a crescent.	At beginning of month, the moon may take any shape, depending on where it is in the cycle (Can refer to moon phase calendar).
Beginning of moon cycle is marked by a crescent moon.	Beginning of moon cycle is marked by a new moon.
Grade 6 Textbook 2	
We can only see parts of the moon which are in sunshine.	Other part of the moon that is lit all the time by the sun we cannot see, as that side is not facing us.
The part we cannot see of the moon is in shadow. (pg. 107)	The dark part is where the sun is not shining on that part for it to be reflected.
The moon is a small world that moves around the earth.	The moon is natural satellite
The moon picture of "last crescent" is wrong. (pg. 107)	The moon represented is that of a gibbous moon. (pg. 107)
Grade 7 Textbook 1	
New moon is omitted in the cycle	The cycle begins with a new moon
Grade 7 Textbook 2	
The moon grows bigger	The moon remains the same size. What we see depends on the amount of light shining on the moon. So in actual fact, the moon appears to be growing bigger or small for that matter.
Grade 8 Textbook 1	
Moon takes a month to orbit the earth	It may take a fewer days as a month varies between 30 – 31 days except for February
Grade 8 Textbook 2	
It takes 28 days for the moon to spin on its own axis and to orbit the earth.	It takes the moon approximately 27, 3 days to spin on its own axis and approximately 29, 5 days to orbit the earth.

4.5. Summary

The present study set out to find what the quality of explanations was, and the quality of diagrams presented by the textbook in the topic *moon phases*. The textbooks analysed in the chapter brought about findings that would help answer the first research question.

It is mentioned in chapter 2 that the theoretical stance taken for the present study is that of constructivism. Looking at literature, Driver, Guesne & Tiberghien (1985) make mention that people usually construct their own meanings of knowledge presented to them. With learners exposed to multimedia, different meanings can come about on concepts presented by content. Such meanings affect how learners attain new knowledge, as in constructivism, it is said that constructivism is achieved by the "gradual re-crafting of existing knowledge" (Smith, DiSessa & Roschelle, 1993, p. 123). In chapter 2, it was identified that a textbook could be used as a tool to aid conceptual change, provided that the textbook is presented in such a way that it encourages constructivism. Duban (2008) identified a list of characteristics that one could use to identify whether a textbook promoted constructivism. These characteristics were used in the analysis of the six Natural Science textbooks. Out of the 6 textbooks analysed, one textbook design was not in line with a constructivist approach, and proved to be a poor textbook to use for the purpose of learning. The remainder of the five textbooks proved to be effective tools to use to help learners achieve conceptual change in the topic of moon phases. The grade 8 textbook used by learners involved in the case study in the present study, proved to be one of the five textbooks identified as textbooks that promote constructivism.

In terms of content, it can be seen by the summary presented in table 4.4a that there was not even one textbook that was free from content problems. The table presented text that could be considered as misconceptions in the topic *moon phases*. The table also presented content that could potentially lead learners to have misconceptions, and that is why such content is also presented in the table 4.4a presented above. The identified text that was picked up in the textbooks was as follows:

- The moon grows bigger
- The dark part of the moon we cannot see is in shadow
- The moon is a small world that moves around the earth
- The moon may undergo a phase change every seventh day

In terms of the diagrams presented on the phases of the moon, results reveal that one textbook did not have diagrams of the phases of the moon to be used to compare the quality thereof (This was Grade 8 textbook 2). This is revealed by table 4.3f under the characteristic *technical design.* This textbook was not used by the case study group involved in the current study. Instead, grade 8 textbook 1 was used to teach grade 8 learners about moon phases as the textbook contained diagrams of the different shapes of the moon as the moon undergoes its phase changes. Upon analysis, the following findings were made:

- Grade 6 textbook 1 contained black and white diagrams of 4 shapes of the moon
- Grade 6 textbook 2 contained black and white diagrams of 7 shapes of the moon. The last crescent illustration of the moon is incorrect
- Grade 7 textbook 1 contained 7 realistic shapes of the moon. Included is another diagram showing the relative position of the sun, earth and the moon to illustrate how the moon moves (Refer to diagram under comment 2 in grade 7 textbook 2)
- Grade 7 textbook 2 contained 12 black and white moon shapes, showing the relative position of the sun, earth and the moon, and the type of moon shape that one would observe based on the positions of the sun, earth and the moon.
- Grade 8 textbook 1 contained 8 black and white shapes of the moon.
- Grade 8 textbook 2 did not have any shape of the moon

Upon analysis, it was therefore found that the grade 7 textbook diagrams of the moon phases were of better quality than the two grade 6 textbooks, and the 1 grade 8 textbook, as the diagrams of the grade 7 textbooks showed by means of diagram representations on why the moon undergoes the different changes in shapes. The other textbooks just merely showed the different shapes the moon may have when undergoing the different phases of the moon.

Overall, it can be said that the quality of explanations tend to increase the higher the grade of the textbook. It can also be said that the quality of diagrams seem to be better in grade 7 textbooks, as opposed to the other textbooks in the respective grades.

This chapter looked at data presented by the textbook. Information relating to the textbook was summarised by means of tables, from table 4.3a – table 4.3f. The misconceptions that came out of the content was further summarised in table 4.4a. The next chapter looks at whether the textbooks had an effect on learners, in terms of understanding the cause of the moon phases.

Chapter 5

Analysis of Case Study Group

5.1 Introduction

In this chapter, I am going to concentrate on the second phase of the study: Grade 8 learners' ideas on what causes the moon phases. First I will explain the process used to elicit learners' ideas about the moon phases. I will then present the results from the interview and, finally, I will relate my findings back to theory. The instrument used as a guide to elicit learners' ideas about moon phases was used to answer question 2 of my research questions: How do grade 8 learners interpret textbook diagrams of moon phases in relation to the physical model? I will also present issues emanating from the study.

5.2 Data Analysis

An interview schedule was used to obtain responses from interviewees. The purpose of an interview is to explore why participants answered the way they did in specific questions (Opie, 2004). The reason for using an interview for the purpose of my research was to determine whether learners were able to explain why they represent textbook illustrations using models given to them. The models consisted of objects which represented the sun, earth and the moon.

Learners were asked to manipulate these models to represent what they saw occurring in the illustrations provided from textbook 2-dimensional picture representations of the different phases of the moon.



Figure 5.2a: Interview Model

In Figure 5.2a, starting from the left, the white hockey ball was used to represent the moon, the yellow globe was used to represent the sun, and the model of the earth was used to represent planet earth. The models used were chosen carefully for their similarities in colour to the actual moon, earth and the sun. The models used, however, were not according to the right scale.

For the purpose of the interview, fifteen grade eight learners from the same class were pre-selected by the educator teaching the class, according to three performance categories. The categories included: above average performers, average performers and below average performers. The learners were selected on the basis of their performance in Natural Science in their class. Five learners were selected from each category. Even though there was a total of 15 learners, results of only 8 learners are presented: those of 4 learners from the above average category and results of 4 learners from the below average category. Only 8 learners' results are presented because the learners in the average category obtained the same results in the interview as the learners in the below average category.

The interview schedule used by Trundle *et al*. (2002) was adapted to determine learners' ideas of the moon phases. Presented below is the interview schedule, and it is shown in this chapter, so as to illustrate what was used from the instrument for the purpose of the interview:

Trundle 2007 Interview Schedule:

> **These model components represent the sun, earth, and moon. For practical reasons, they are not to scale in size or relative distances from each other. I want you to use this model to explain to me, and show me while you are explaning what you think causes the phases of the moon.**If the student says that clouds cause the phases of the moon, a piece of cotton will be provided for the cloud component
>
> (Drawing provided to show what the full moon phase looks like. Orange areas represent what we see of the moon at that moon phase.)**Take the model and arrange it so that we would see a full moon. Why would the moon appear like this drawing?**
>
> (Drawing provided to show what the new moon the new moon phase looks like.)**Now arrange them so that we would have a new moon. Why would the moon appear like this drawing?**
>
> (Drawing provided to show what the crescent moon phase looks like. Show the drawing.) **Could we see a moon that looks like this? If so, arrange the model so**

that we would be able to see a moon that looks like this drawing. Why would the moon appear like this drawing? If not, why not?

(Drawing provided to show what the gibbous phase looks like.) **Could we see a moon that looks like this? If so, arrange the model so that we would be able to see a moon that looks like this drawing. Why would the moon appear like this drawing? If not, why not?**

(Drawing provided to show what the "false gibbous"phase looks like.)**Could we see a moon that looks like this? If so, arrange the model so that we would be able to see a moon that looks like this drawing. Why would the moon appear like this drawing? If not, why not?**

Use the model to show me what happens as the moon goes through one complete cycle of phases.

The models used for the purpose of the interview are different from those of the interview schedule. From the interview schedule, only 3 drawings were given to the learners for the manipulation of the models: that of the full moon, a crescent and a gibbous moon. The last question was also used to ask learners to show what happens as the moon cycles through its phases. Lastly, my own question was added to the interview. I arranged the models myself, in such a way that the position of the sun, earth and the moon represented a gibbous moon, and asked learners what kind of moon they would see if they were standing in the northern hemisphere.

5.3 Interview Results

Learner Number 1 (Above average learner):

The learner had the correct understanding of the positions of the earth, sun and the moon for the representation of the full moon. Even though the positioning was not accurate, the learner knew the relative positions required for a full moon:

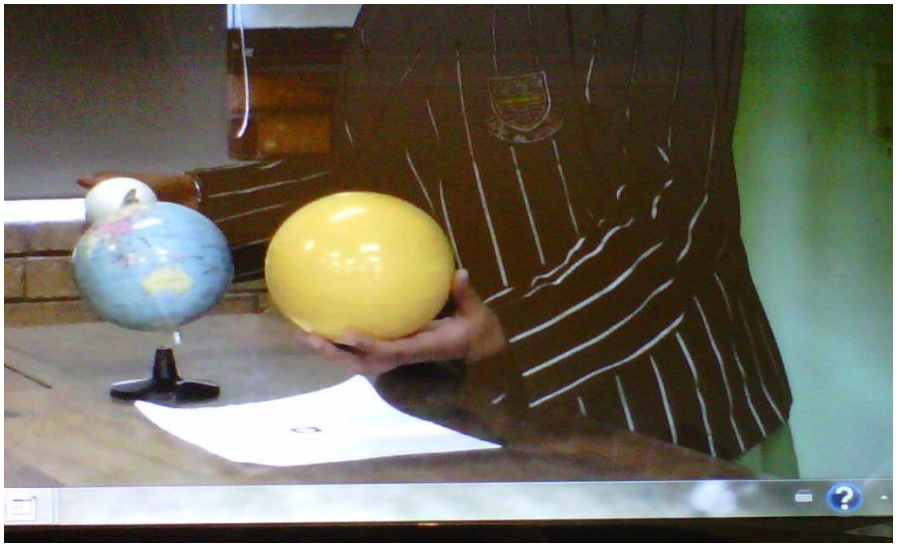


Figure 5.3a: Demonstration of a Full Moon by Learner

The representation shown on figure 5.3a is an incorrect representation, as the learner was asked to show a representation of the full moon. The learner in relation to the model representation shows actually how a gibbous moon would look like. What was quite interesting to observe was that the learner did not seem to realise that she was showing a gibbous moon representation. What was also interesting was that even though the learner had the wrong representation by the use of the models, the learner understood how it came about for us to observe a full moon. Evidence of understanding of the orientation could be picked up in the learner's explanation:

> **Learner:** Well, the sun is here, so the, it will just, the whole sunlight will hit the surface of the moon that we see from the earth.
>
> **Teacher:** Oh, ok, alright; so that is your general explanation of it?
>
> **Learner:** Yes.
>
> **Teacher:** Alright, so why will we see then the moon appearing like that?It's because of what's happening with the sun …
>
> **Learner:** Well, ya, all the sunlight will hit directly the whole face of the moon

What was of interest in this brief discussion was that at no point did the learner mention that it is the sun's light that is reflected from the moon, which enables us to see the moon. Instead, to emphasise the fact that the arrangement is that of a full moon, the learner mentioned that it is "the whole sunlight". This raises an important question: does the learner think that if only

parts of the sun hit the moon, then we will only see the moon partially because of the sun, rather than the moon only reflecting part of the sun's rays?

The second drawing of the crescent moon was represented incorrectly by the learner:



Figure 5.3b: Demonstration of a Crescent Moon by the Learner

The learner's arrangement of the model was incorrect. The arrangement looks like a representation of a quarter moon. The learner, however, was aware that for a person to see a crescent, only part of the moon will have light shining on it. This can be seen in the conversation below:

The learner's explanation of the orientation was as follows:

> **Learner:** The sunlight will only hit, like, the crescent shape of the moon, not the whole moon.
>
> **Teacher:** Oh ok, so what do you mean by the crescent shape?
>
> **Learner:** Well, it will only hit, like, this part of the moon.
>
> (The learner shows by means of the model of the moon, which part the sun will hit for light to be reflected.)

Again, the learner's response does not refer to the fact that light will be reflected off the moon but, rather, that the sun will hit parts of the moon.

In terms of the third question, where the learner was given a picture of the gibbous moon, the learner was able to give the correct representation of the relative positions of the sun, earth and the moon.

It seems that from the learner's response, one could make the generalisation that the learner may think that the sun is mostly responsible for the different shapes of the moon. The reason for this is that, in all explanations thus far, including the representation of the gibbous moon, the learner stated that the sun shone on certain parts of the moon:

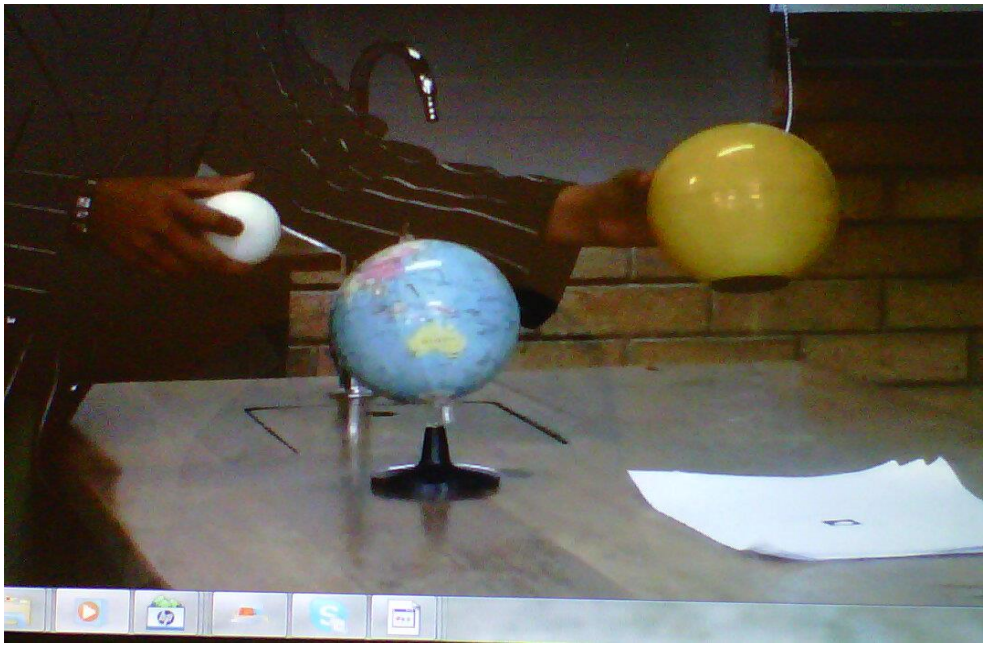


Figure 5.3 c: Demonstration of a Gibbous Moon by the Learner

Gibbous moon explanation:

> **Learner:** You see three quarters of the moon because the sun will shine on three quarters.

The learner was successfully able to show how the moon would be moving for us to see the different phases of the moon. The learner kept the sun and the earth in one fixed position, where the earth was in line with the sun. The learner then proceeded to show how the moon would move around the earth to illustrate the different moon phases.

Figure 5.3d below displays the orientation that was shown to all learners so that they could draw what they would observe if they were situated in the Northern hemisphere, and had to look at the moon. Learners were given a piece of paper and pen to draw what they thought they would see. There were, however, learners who did not draw anything because they thought the orientation illustrated below was not possible for there to be a viewing of the moon. These learners will be explored later on.

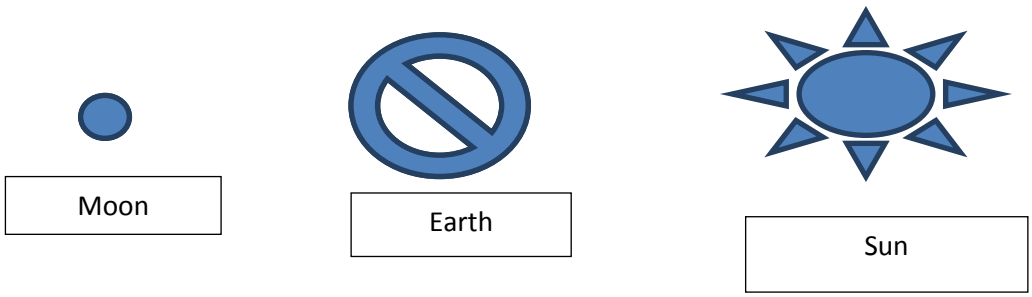


Figure 5.3d: Demonstration of a gibbous moon by the researcher

Learner 1 drew a crescent moon, as she believed that the sun will only hit parts of the moon.

In summary, the learner was not able to show the orientation of a crescent moon correctly. The learner was mistaken about how the sun, earth and moon should be positioned to achieve this type of moon. This confusion could further be seen in the last question, where the teacher provided an orientation for the learner to observe, which the learner thought was an orientation of a crescent moon. Further, it may seem that the learner thought that the sun was responsible for the different shapes of the moon, as the learner constantly referred to the part of the sun shining on the surface of the moon.

> *(From learner 2 onwards, the arrangement of the learners' models is presented as a top-view representation of how they arranged the models, for the purpose of space: The following sun, earth and moon representations will be used.)*



Learner number 2(Above average learner)

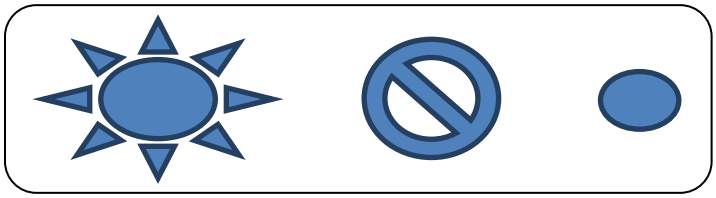


Figure 5.3.1a: Drawing Number 1 Representation

For the first representation, the learner was able to represent the orientation of the full moon correctly. The learner, from the onset, knew that the moon orbited the earth, and the fact that this movement was responsible for the different phase changes:

> **Learner:** Well, I chose this 'cause as the moon uh rotates around the earth**.** And it gets to this point, the sun reflects its light to the moon which reflects it back onto the earth. (The learner gives this explanation while referring to the models.)

What is significant here, as opposed to learner number 1, is that the learner knew that the suns' light got reflected from the moon towards earth.

For the second drawing, what was of interest was that the learner said we would not be able to get a crescent moon:

> **Teacher:** Is it possible for us to have a crescent represented like this?
>
> **Learner:** Uh, I don't think so.
>
> **Teacher:** Ok, so we won't be able to see this type of a moon?
>
> **Learner:** No.
>
> **Teacher:** Alright, thank you.

This could suggest that the learner was unsure about how the orientation of the crescent moon would look. The same could be said about the gibbous moon, as can be seen by the discussion below when the learner was asked if it was possible to get a gibbous moon:

> **Teacher:** Alright, is it possible for us to see this type of a moon?
>
> **Learner:** Um, no.
>
> **Teacher:** Ok, why would you say so?
>
> **Learner:** (Silence): Ok, I think we would.
>
> **Teacher:** Ok, uhh, then why did you suddenly change your mind?

Learner: Because I just then thought of it, pictured it.

What could have caused the learner to change her mind was that the gibbous moon looked more or less like a full moon, with a missing part. The learner could correctly arrange what a full moon would look like, thus allowing her to guess what a gibbous moon would look like.

Therefore, it can be seen from the conversation that the learner was likely thinking about the orientation of the sun, earth and the moon, as opposed to thinking that a crescent or a gibbous moon does not exist.

In terms of the cycle of the moon, the learner struggled to explain the cause of the moon phases. The learner first explained the concept of day and night, to say that people would see the moon in the evening as opposed to the day:

Learner: Well, I think it's going to rotate around the, well this rotates (The learner refers to the model of the earth to show that it is spinning on its own axis.)

Teacher: Yes.

Learner: So as it rotates, this, the different countries are going to be having their different moon, their night, they will be able to see the moon.

In this context of day and night, it could be seen that the learner was thinking that the moon rises and sets just as the sun would rise and set (this stems from everyday language for explaining why it is night or day).The reason for this is that the learner talks about the position of the moon as being either high or low:

Teacher: Ok, so, is the moon, I see you holding the moon there, will the moon remain there?

Learner: Um, I think it will, it will go higher and lower.

Teacher: Ok, what do you mean by higher and lower?

Learner: Um, because, um, as it, as the earth rotates around the orbit, it's, it's, going higher and lower in a way.

Later though, with much probing, the learner could correctly explain to a certain extent the cause of the moon phases, as she was moving the model of the moon around the earth:

Learner: Ok, it is from the full moon there (The learner is using the models to explain the cause of the moon phases.)

Teacher: Yes.

Learner: And it moves just a little bit, then it's, that part is just slightly covered, so that's, um , that's now it's a half shape, and as it moves, this side here is now facing that way, and the sun is just facing this side, and it is just a little bit of reflection, and then as it moves closer and closer, and when it gets to this point, the sun is only hitting this side and not that side.

Teacher: urhur???

Learner: So it's just only a half. And then when you get here there is no, there is no moon. The reflection is hitting this part and not the other. And then as it moves this side, it is only getting the sun, and that side isn't, and then it keeps moving, and then this side, half, half-moon reflects. And then does that.

The learner could only explain the cause of the moon phases after much probing.

An analysis of the learner's description of the cause of the phases of the moon reveals the alternative, everyday wording of what a new moon is described as: what is of interest is that the learner refers to new moon as there being no moon. This can be attributed to what is seen in the night sky, as a new moon is not visible to the naked eye.

For the last question, which deals with the gibbous moon, the learner drew a crescent for the orientation. This was expected, as earlier on, the learner could not produce an orientation that would yield a gibbous moon.

In summary, the learner could give the correct orientation of what a full moon would look like, but struggled with the orientation of the gibbous and crescent moons. The learner originally thought that it was not possible to have an orientation that would yield a crescent or gibbous moon. At the end, the modelling of the position of the earth, moon and the sun to yield a gibbous and crescent moon was incorrect. One could conclude that the learner has very little knowledge of the relationship between moon phases, and the orientation of the sun, earth and the moon to get the different shapes, as the learner also answered the last question incorrectly, which dealt with models and the shape of the moon.

With regard to the cause of the moon phases, the learner seemed to be confused about what occurs for moon phases to take place, and the day and night cycle. A possible explanation for the learner's confusion is the fact that the learner thinks of the moon in the same way as she would think of the sun.

To expand this idea, it is usually said that the sun rises in the east and sets in the west. As the sun sets, one is usually able to see the moon in the sky. The learner talks of the moon being

higher and lower, which may suggest that the learner may think that the moon also rises in the evening, and sets in the morning.

Learner Number 3(Above average learner):

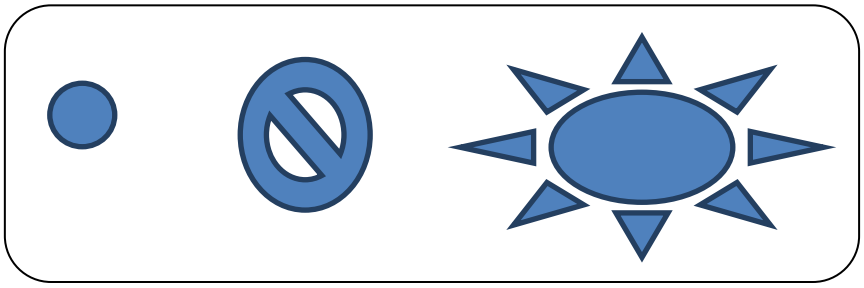


Figure 5.3.1b: Drawing Number 1 Representation

For the orientation of the full moon, the learner was able to rearrange the models correctly. What was quite interesting was that the learner brought up the issue of scale when referring to the earth and the sun. It seems, from the discussion, that the learner thinks that the size of the sun influences how the sun shines on the moon:

> **Learner:** Ok, so the sun is bigger than the earth so that when is shines it gets around and it reflects off the moon so we can see the whole surface.

The learner understands the fact that the light is reflected off the moon, but the learner brings another aspect to the explanation by saying that the light gets around the earth. By bringing in scale, however, the learner does not seem to consider the role that distance plays in the relationship between the sun, earth and the moon.

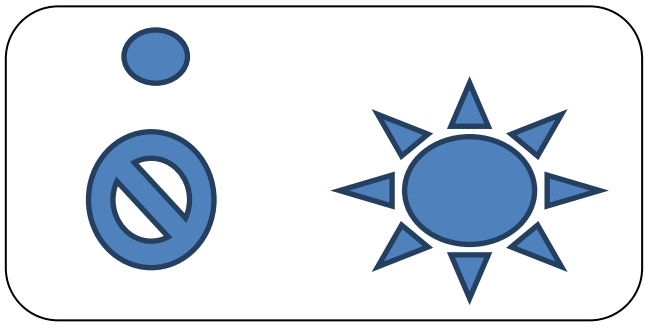


Figure 5.3.1c: Drawing Number 2 Representation

The orientation of the crescent moon was an incorrect representation. The arrangement given by the learner looks like a first quarter. Even though it was an incorrect orientation, the

learner understood that for there to be a crescent moon, a small amount of light is reflected off the moon:

> **Learner:** It's like here, so then, and then it hits like here and shines a bit of it so that you can see that part over there.

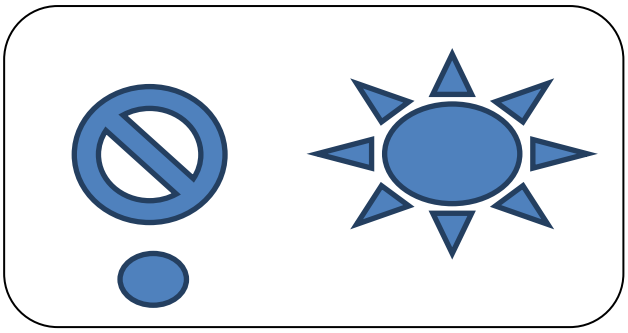


Figure 5.3.1d: Drawing Number 3 Representation

The orientation of the gibbous moon was incorrectly illustrated. The illustration looks like that of a last quarter representation. The explanation offered by the learner though showed that the learner understood that most light is reflected off the moon for one to have a gibbous moon.

> **Learner:** So then, the sun shines on most of the moon except for the part over here (The learner shows which part will not shine)

In terms of the cause of the moon phases, the learner was able to move the moon model correctly to show how the moon phases take place.

Looking at the gibbous moon orientation I provided, the learner was not able to draw the correct shape. The learner drew a last quarter moon. The learner seems to understand that most of the light would be reflected off the moon, as she drew a picture of half a moon.

In summary, the learner takes size into consideration in terms of the influence the sun has in shining its light. What the learner failed to see was that, if scale is taken into consideration, one needs to include the relative distances of the sun, earth and the moon. The learner also does understand that the type of moon that one would see is dependent on the amount of sun reflected off the surface of the moon.

Learner number 4 (Above average learner):

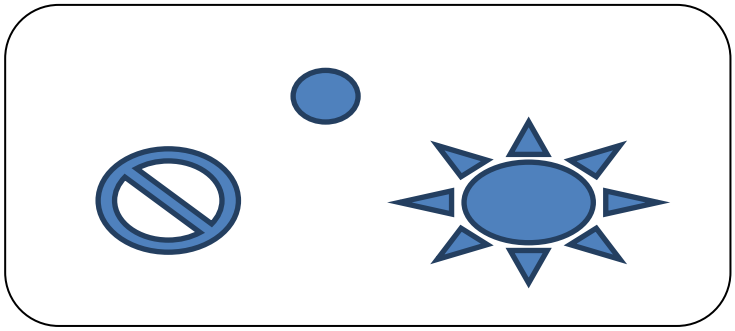


Figure 5.3.2a: Drawing Number 1 Representation

The learner was not able to correctly represent the full moon. What was very interesting was that the learner believed that light penetrates the back of the moon, so as to light up the moon. The reason for this statement was that the learner positioned the models in a manner that suggests a new moon. One could possibly in this instance think of a transparent light bulb and a light fitting analogy to try to explain how the learner thought of the situation. If the light bulb shines behind a light fitting, the light fitting still shines and one therefore can see the outline and shape of the light fitting:

> **Learner:** The sun will shine the light on the moon, and we will see that part of the moon; you will see that part of the outline

What also stood out in the learner's statement is that the learner mentions that we see an outline of the moon, rather than the light of the sun on the surface of the moon being reflected.

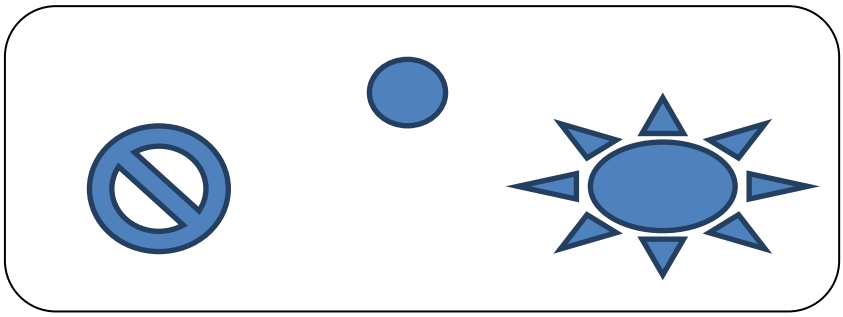


Figure 5.3.2b: Drawing Number 2 Representation

The learner provided the correct orientation for a crescent moon. The learner understood that from a crescent moon, one could see a small piece of light being shone onto the moon.

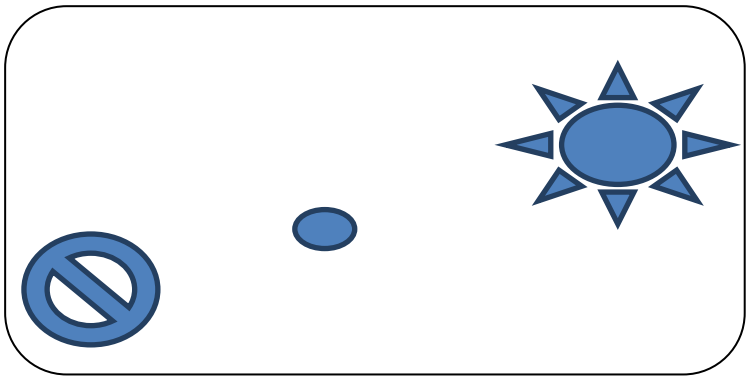


Figure 5.3.2c: Drawing Number 3 Representation

The learner was not able to show the orientation of a gibbous moon correctly. The arrangement of the models depicted a new moon again.

In terms of the moon phases the learner struggled to explain what causes the moon phases. The confusion became clear when she mentioned that both the sun and the moon are in constant motion with each other. Despite this, when the learner made the sun and the earth stationary at one fixed position, she was able to show successfully how the moon moved to cause the moon phases.

For the final question, the learner was not able to draw the moon correctly with the orientation of the models. The learner mentioned that the kind of moon that they drew was that of half a moon. But the diagram that the learner drew though looks more like a waning crescent moon. Besides the drawing, the fact that the learner mentions that one would get a half a moon with the orientation of the models by the teacher shows that the learner understands that more light would be shone onto the surface of the moon for the person on the Northern hemisphere to see.

In summary, the learner thought that the sun penetrates the moon from the back, which allows us to see an outline of the moon. This idea is carried through to the crescent shape of the moon: the learner mentions still that light covers most of the back side of the moon, that the reason we are able to see the crescent moon is because only a small amount of light is shining on the back side of the moon. The learner was not able to arrange the models correctly for the gibbous moon, and consequently, could not draw the correct moon representation for the last question, which also dealt with the gibbous moon. The learner was only able to answer successfully how the moon achieves its different shapes when the models of the earth and the sun were made to be stationary.

Learner number 5(Below average learner):

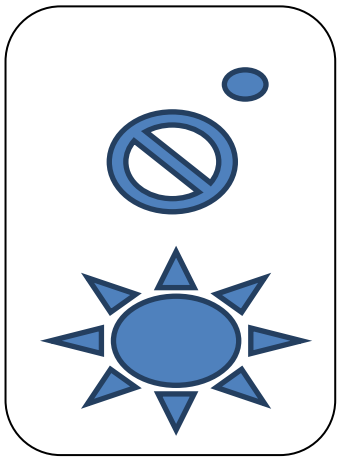


Figure 5.3.3a: Drawing Number 1 Representation

For the orientation of the full moon, the learner gave an incorrect representation. The learner thought that the moon needed to be higher than the other models of the earth and the sun. By higher, it is meant that the learner elevated the model of the moon upwards, so that the model stood above the other models of the sun and the earth. The diagram example shows how the learner arranged the models in such a way that the moon was in a higher position:

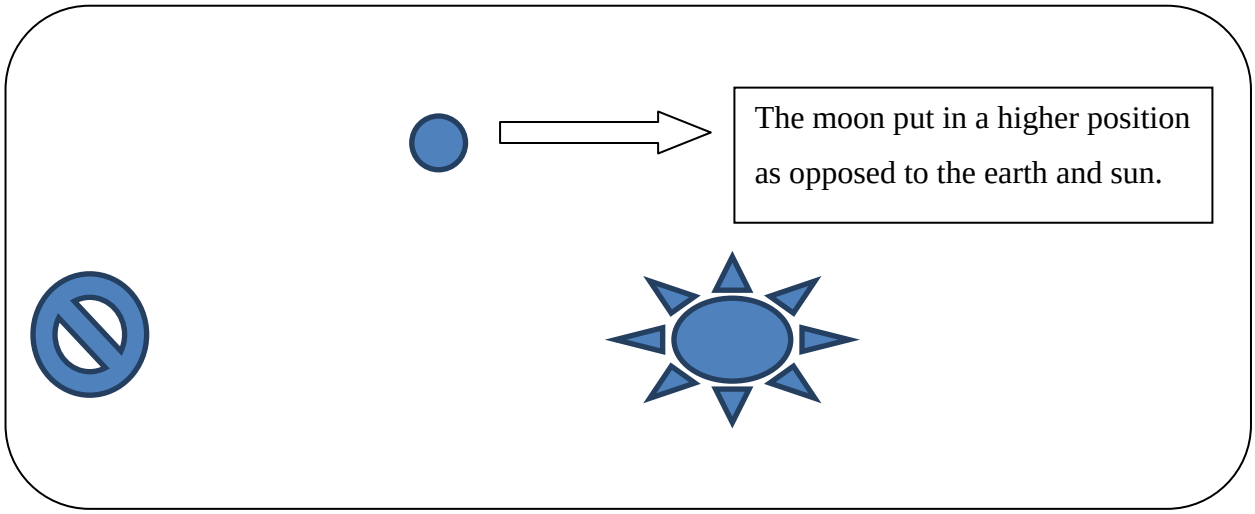


Fig 5.3.3b: Illustration on how the learner elevated the moon

This may be due to the understanding that when one looks at the night sky, the moon is high in the sky and, hence, it also needed to be high for the model representation:

> **Learner:** Ok, doesn't this need to be up…

The up that the statement is made was referring to the position of the moon, and that it needed to be elevated above the earth.

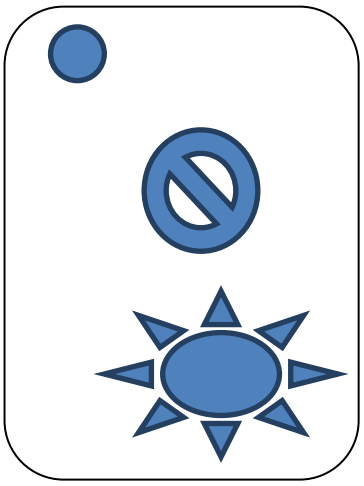


Figure 5.3.3c: Drawing Number 2 Representation

With the crescent moon, the learner gave an orientation that was incorrect and her reasoning did not fit the description of a crescent. The learner said the representation would show half a moon as opposed to the crescent. This may suggest that the learner would associate the shape of a crescent as a half moon.

> **Learner:** Ok, like, you, the sun is going to reflect here and it is like only going to show like half of the moon.

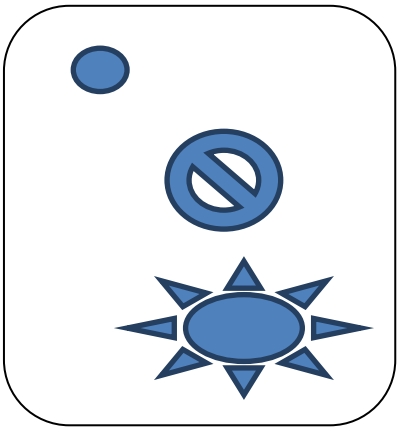


Figure 5.3.3d: Drawing Number 3 Representation

The learner provided the correct representation of the gibbous moon, but the learner's explanation for the gibbous moon did not show that she understood why her orientation would yield a gibbous moon. The learner, in fact, had the same orientation as that of the crescent moon. By looking at the learner's body language for the crescent in the previous question, the learner may have been unsure of the orientation, and guessed the position of the crescent moon and, subsequently, the gibbous moon:

In terms of the phases of the moon, the learner showed the moon and the earth moving around the sun. This may suggest the learner does not know the cause of the moon phases.

For the final question, the learner also drew the incorrect drawing. Her response to the orientation also suggests that the learner initially was confused, as seen from her drawing, as she drew a full moon.

In summary, the learner was not able to answer the majority of the questions accurately, as she seemed to be confused during the process of the whole interview.

Learner number 6(Below average learner):

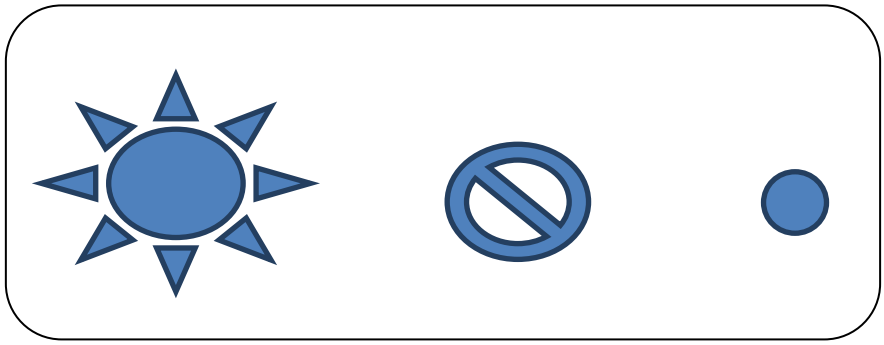


Figure 5.3.4a: Drawing Number 1 Representation

The first orientation was correct by the learner, but she did not offer an explanation that showed she understood why the orientation yields a full moon. The learner talked about the sun reflecting, rather than the sun shining, on the moon, and the light from the moon reflecting onto earth:

> **Learner:** Um, sir, 'cause I think the sun would be, um, the sun is like reflecting on that area, and the moon is reflecting more on the earth. I think.

This statement may suggest that the learner thinks the moon has its own light which it reflects onto the earth.

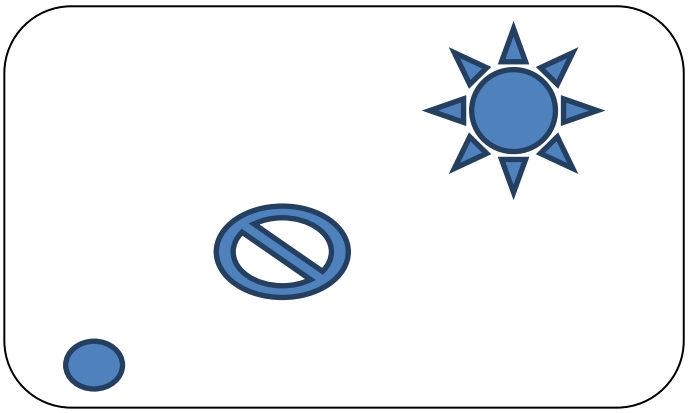


Figure 5.3.4b: Drawing Number 2 Representation

The crescent representation again proved to be problematic. The learner put the models at different angles, but the orientation of the sun, earth and the moon was presented in a straight line. This learner also thought that the moon has its own light, because the learner talked about the sun's light being more dominant the moon's light.

> **Learner:** Um sir, because like the sun is reflecting more onto earth, rather than the moon, I think.

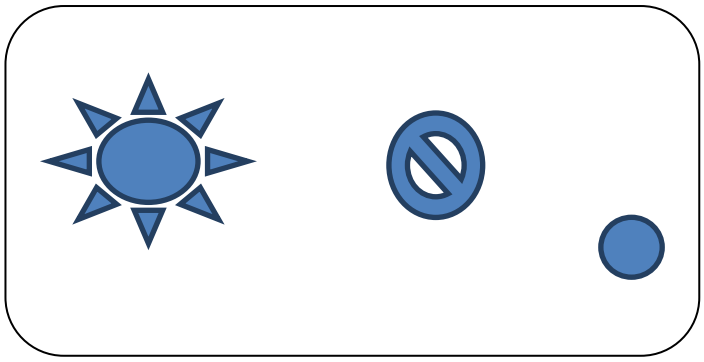


Figure 5.3.4c: Drawing Number 3 Representation

For the gibbous moon, the orientation was correct, but the response again showed that the learner did not understand what she was explaining to the teacher. The learner talks about the moon and the sun's light being reflected:

> **Learner:** Um sir, because like, like half of the like, half of the moon is reflecting to the earth, the earth and not a lot of the sun is, ya, reflecting sir.

In terms of the moon phases, the learner was thinking of what happens in order for us to experience day and night. The learner was moving the sun and the moon, and explained that for people to witness the moon phases there needs to be day and night. The learner's explanation showed that she was not sure about what causes the phases of the moon.

For the orientation that the teacher showed, the learner made mention that it was not possible for there to be such an orientation. The main argument was that the sun and the moon cannot both be showing at the same time. This explains why the learner referred to what would rather happen in a typical day and night when answering the question about moon phases:

> **Learner:** Um, sir, 'cause like wouldn't it be like, wouldn't it be like both reflecting to the same thing like…
>
> **Teacher:** Ok, so explain a bit more what you mean by both?
>
> **Learner:** Like, during like day time, wouldn't the moon be like the same time as the sun?

In summary, the learner thinks that both the sun and the moon have their own light which is reflected. Therefore, the bigger the moon is in size, the more light it shines.

Learner number 7(Below average learner):

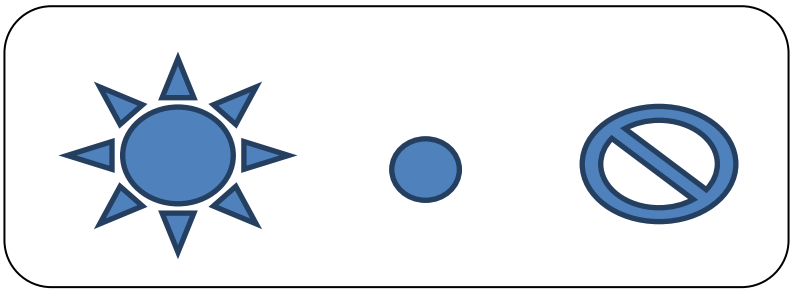


Figure 5.3.5a: Drawing Number 1 Representation

The learner had an incorrect representation for the full moon. The representation that the learner had was more typical of a new moon. What is of interest is that the learner took the size of the models into consideration when arranging the different orientations.

> **Learner:** Ok, I put the sun here so that, um this moon in the middle, so that the light of the moon could show properly.

The learner therefore thought that if the moon was not in the middle, then the moon would not be seen because of either the sun, or the earth blocking the sight of the moon.

> **Learner:** Um, the reason why I say so is because, um, the sun could be big, and maybe if it is in the middle, it will like close the moon, but then if I move the small one, maybe the full moon will show.

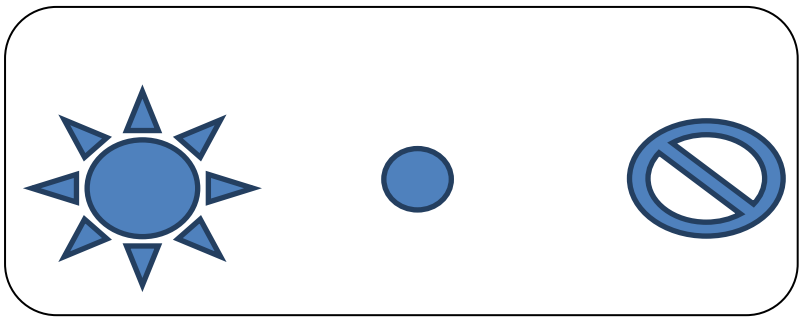


Figure 5.3.5b: Drawing Number 2 Representation

For the crescent, the learner was again unable to provide a correct representation. From the previous orientation, the learner changed where the earth would be, but the orientation still yielded a new moon. The learner still insisted that the moon needed to be in the middle for it to be seen.

> **Learner**: Ok, um, the reason why I move it like this, the sun to the side, is because if like the sun is in the middle and then it would be on the way for the moon and you would not be able to see the moon fully like that.

Another interesting comment by the learner for the first and second picture was that she said one cannot have the sun in the centre as it would block the view of the moon. This may also suggest that the learner was thinking about eclipses rather than moon phases.

For the gibbous moon, the learner said it is not possible for a person on earth to see such a moon. The learner was therefore not asked to show an orientation based on her response:

> **Teacher:** Is it possible to see a moon like this?
>
> **Learner:** Um, no.
>
> **Teacher:** Ok, why?
>
> **Learner:** The reason why I say so, maybe it's because, if you um, you can't like really see the moon fully like that.
>
> **Teacher:** Alright, thank you.

For the phases of the moon, the learner was not able to use the models to show what causes the moon phases as the learner did not know how to do this:

> **Teacher:** So I'm not saying that individually stop, I'm just saying how would the moon be moving for us to see the different shapes?
>
> **Learner**: I don't know.

Lastly, the learner thought that the orientation that the teacher provided would not enable one to see the moon, but would enable the person to see the sun. This may suggest that the learner is thinking about night and day, and that one cannot view the moon if the sun is shining.

In summary, the learner thinks that the size of the models influences how one would see the moon; the learner believed that the sun or earth could block the moon from being seen. The learner could not answer two questions, as the learner did not know how to go about explaining the questions posed to her.

Learner number 8(Below average learner):

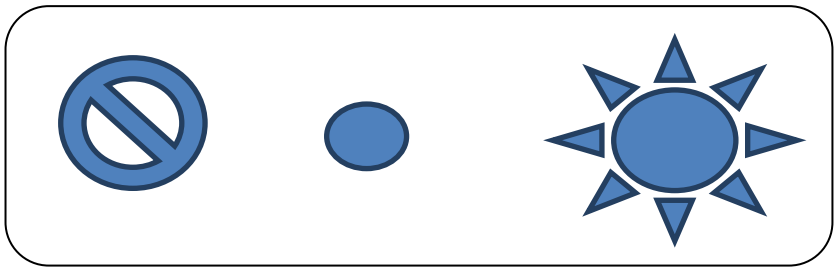


Figure 5.3.6a: Drawing Number 1 Representation

For the full moon drawing, the learner gave an incorrect orientation. The orientation given was that of a new moon as opposed to a full moon.

The learner mentioned that the reflection of the sun comes from behind the moon for us to see the moon.

> **Learner:** Um, ok like the sun is directly behind the moon, so then, so um, so like we on earth can see um can see the moon, the whole moon fully because the reflection of the sun is coming from behind the moon.

One can once again use the analogy of the light bulb and the light fitting, to try to understand how the learner was thinking about the moon.

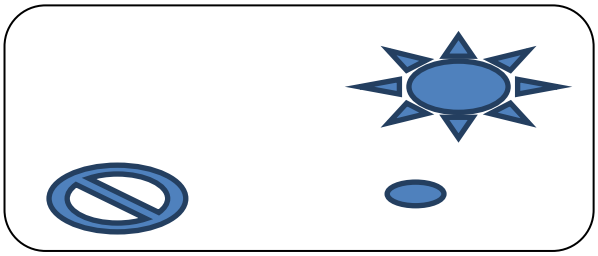


Figure 5.3.6b: Drawing Number 2 Representation

For the crescent moon, the orientation was correct. The learner still thought that the reflection was from behind the moon, as she mentions in her explanation that the reflection takes place at an angle from behind the moon:

> **Learner:** Um, I am thinking ok because like the shape of the moon is kind of showing by the corner, so the reflection of the sun would reflect the moon from the side, from a vertical side, so the um the shade would be near the sun, and the moon would shine on the vertical side, I think.

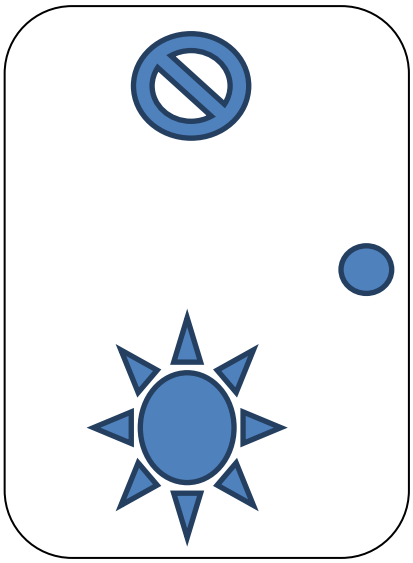


Figure 5.3.6c: Drawing Number 3 Representation

For the gibbous moon representation, the learner again had the wrong representation. The learner's explanation showed that she did not understand her orientation, as she referred to her previous orientation, explaining that it is the same, but in an opposite way:

> **Learner:** Um, I think it is just like the other one but in the opposite way. Because, if um the sun is a bit closer to the earth, then, um, the piece that is at the bottom like that one will be shaded, and the top side would be like not shaded.

The learner made mention that there is also a top and bottom side of the moon, where shading would take place. I was not sure what that meant for interpretation purposes, but from analysing the position of the sun, earth and the moon, this could be attributed to the fact that the moon model was lower in position than the sun and the earth.

For the moon phases, the learner first showed the sun moving around the earth and the moon. When asked to explain why the sun moved, the learner retracted her statement, saying the moon would be moving. When she was asked to demonstrate, the learner showed the earth

moving around the moon and sun, while the sun was "spinning on its axis". The learner was very confused and did not arrive at the correct explanation of the cause of the moon phases.

For the final question, the learner drew an incorrect representation. The learner drew an illustration of a waning crescent. But based on the learner's previous answers, it is possible the learner guessed what the moon would look like given the orientations.

In summary, the learner thought that the light of the sun could penetrate from behind the moon for us to be able to see the moon. The learner, though she gave some correct answers, seemed to be confused with orientation in general of the different shapes of the moon. Evidence of this came about when the learner could not fully explain what caused the different shapes of the moon.

5.4 Summary of Learners Responses

Below, the theory used to analyse learners' responses to questions in the interview is briefly explained. Further, a summary of the learners' responses is put into table form and coded. The coding of the learners responses is explained below when introducing the theory used for analysis purposes.

5.4a Theory

The theory used to analyse learners' responses was discussed in detail in Chapter Two. Only a summary is provided below, so as to briefly understand how the coding was developed.

Below is a schematic diagram that summarises the mental model theory developed by Chi & Roscoe (2002):

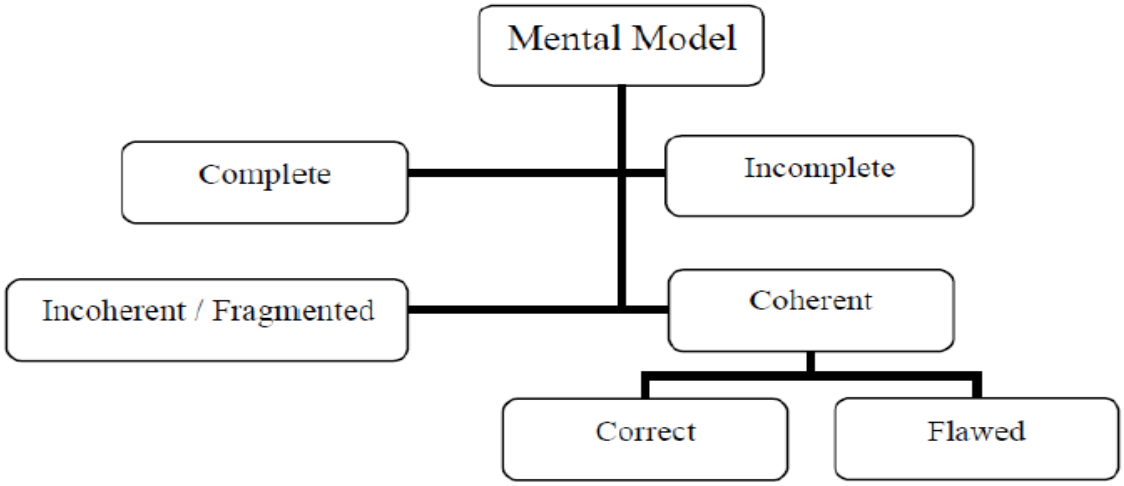


Figure 1. The mental model categorization by Chi and Roscoe (2002)

To explain the model briefly, a table below has been developed to give insight into the meanings of the words in the schematic diagram:

Table 5.4: Table showing the difference between coherent and incoherent mental models

Coherent Can be classified further into 2 *Coherent Correct Coherent Flawed*	**Incoherent**
Propositions are related to one another in an organised manner.	Propositions are not interconnected in some systematic way.
Generate explanations, make predictions and answer questions in a consistent and systematic fashion.	Cannot offer consistent and predictable explanations about phenomena.
	Lack complete understanding of concepts.

Learners' responses to questions relating to the moon phases can be classified as either coherent or incoherent. Within the heading of coherent, it was mentioned in the theory by Chi & Roscoe (2002) that learners could provide explanations that were coherent, but not

scientifically correct. This is why a subsection was developed, so as to classify explanations that were coherent but incorrect.

The new subsection where responses were coherent but incorrect was labelled as *coherent flawed*. From their headings, codes were developed to summarise learners' responses to questions. These codes are as follow:

CC – Coherent and Correct

CF – Coherent but Flawed

I – Incoherent

Results from the learners' responses in terms of the different codes can thus help to summarise whether a child had a complete or an incomplete mental model. Below, the terms are explained based on the theory by Chi & Roscoe (2002):

Complete Mental Model: Majority of the conceptions are correct

Incomplete Mental Model: Majority of the conceptions are incorrect

For the purpose of accurately answering the research question pertaining to the case study group, I have considered the code CF to fall more in the region of an incomplete mental model. The reason for this is based on observation of the learners' body language and responses to questions posed to them by the teacher. I discovered that if learners are able to position the sun, earth and the moon correctly, but offer an incorrect answer for why the position is that way, it is likely that the learners are guessing the position, which may then show a misunderstanding of the concepts of the orientation of the models and moon phases as a whole.

Below in section 5.4, the results are presented.

5.4a: Summary in Tables for Each Learner:

Learner 1 (*Above average learner)*

Table 5.4a: Summary Table 1

Question	Orientation	Reason	Coding
1	Right	The whole sunlight will hit the surface of the moon (The learner, though, does not talk about the fact that light is reflected from the moon).	CF
2	Wrong	The orientation is that of a gibbous moon. The learner makes mention that only parts of the moon will be reflected.	CF
3	Right	We see three quarters of the moon because the sun will shine on three quarters of the moon.	CC
4	Right	The moon orbits the earth.	CC
5	Wrong	The learner thought it would be a crescent moon.	CF

The learner has a total of 3 out of 5 questions answered in the CC region. Even though the learner answered 2 out of 5 questions which fell in the CF region, it can be said that the learner has a complete mental model to a certain extent.

The reason for this is that, even though the learner did not get the positioning of the sun, earth and the moon correct, the learner is aware of how the sun works in relation to the amount of light that can be viewed in the night sky by observers on earth. The learner thus has a good background in terms of understanding concepts pertaining to the phases of the moon.

Learner 2 (*Above average learner)*

Table 5.4b: Summary Table 2

Question	Orientation	Reason	Coding
1	Right	The learner knows that the moon rotates around the earth. The learner also makes mention that at a specific point there would be a full moon.	CC
2	Wrong	It was the second time round that the learner had an orientation of the moon. Interestingly enough, the learner said one would not be able to get a crescent moon. I think the learner was thinking that it was not possible to do an orientation to get a crescent moon, as opposed to there being no crescent at all.	I
3	Wrong	The sun is not facing directly; it is just facing a small part of the moon.	I
4	Wrong/right	First, the learner talks about earth spinning on its own axis. When this happens, different countries experience light and day. The learner also mentions that the moon will be moving higher and lower, in the same way that the sun rises and sets. The learner mentions that if the moon is behind the earth, one will not be able to see the reflection of the light, but if it is at a different angle, one will be able to see the different shapes. Only after much probing, was the learner able to show how the moon orbits the earth	CF
5	Wrong	The learner thought the shape would be that of a crescent moon.	I

Learner 2 only managed to answer one question correctly. The majority of the other questions answered, and the manner in which they were answered, shows that the learner had difficulty in establishing how to use the models, and the correct orientation for the different moon types.

Part of the problem may stem from the fact that the learner does not have a good foundational understanding of what causes the phases of the moon. From the data, it therefore can be said that the learner has an incomplete mental model.

Learner 3 *(Above average learner)*

Table 5.4c: Summary Table 3

Question	Orientation	Reason	Coding
1	Right	The learner considers the size of the sun and earth (The learner says that the sun is bigger than earth.) It is interesting that the learner mentions that when the sun shines, it gets around the earth, and that light is reflected.	CF
2	Wrong	The sun shines a little bit of the moon and gets reflected back onto earth.	I
3	Right	The sun shines on most parts of the moon except here, small part.	CC
4	Right	Full moon, moves till no moon and cycle repeats itself.	CC
5	Wrong	The learner thought there would be a half a moon.	I

Learner 3 has a basic understanding of what takes place when the moon undergoes different phase changes. The learner's understanding contains gaps which may indicate that the learner does not fully understand, and may need guidance to steer her in the right direction. Based on the classification of the understanding of concepts, the learner leans more towards possessing an incomplete mental model, as opposed to a complete mental model.

Learner 4 (*Above average learner)*

Table 5.4 d: Summary Table 4

Question	Orientation	Reason	Coding
1	Wrong	The learner mentions that when the sun is shining from the back of the moon, that we see a whole outline of the moon (Referring to shapes maybe from the textbook: relation to what is being seen).	I
2	Right	The light of the sun would be mostly covering the back side of the moon. We can only see a small piece which the sun is covering.	CF
3	Wrong	The light of the sun makes us see parts of the moon.	I
4	Right	The moon will be moving around the earth.	CC
5	Wrong	The learner thought that the moon would be a half moon.	I

Most of learner 4's mistakes in answering questions posed were based on the learner's understanding of the interaction of the sun with the moon.

The learner stated that the sun shines from the back of the moon, and all other question were answered from this point of view. The learner therefore falls in the region of having an incomplete mental model.

Learner 5 (*Below average learner)*

Table 5.4e: Summary Table 5

Question	Orientation	Reason	Coding
1	Wrong	The learner mentions that the sun's light will be reflected from the side of the moon. The learner holds the moon in a higher position or orientation. This suggests that the learner thinks of the moon seen in the evening, as opposed to the correct orientation.	I
2	Wrong	With the sun's reflection, only half of the moon is shown.	I

Question	Orientation	Reason	Coding
3	Right	We can only see part of the moon.	CF
4	Wrong	The earth goes around the sun; the moon follows. (What is interesting is that with the learner's demonstration, the moon is made to go around the earth, while the earth is moving around the sun.)	I
5	Wrong	The learner drew a full moon.	I

From the data, it can be seen that the learner has a vague understanding of the concepts of the moon. Even though the learners would have used a textbook and received teaching of the concepts, the learner's responses showed that instruction and the textbook had failed her. The learner therefore falls in the region of having an incomplete mental model.

Learner 6 (*Below average learner)*

Table 5.4f: Summary Table 6

Question	Orientation	Reason	Coding
1	Right	The learner talks about the sun reflecting away from the earth, while the moon is reflecting towards the earth. There seems to be no connection made by the learner to the role of the sun, as opposed to the moon.	CF
2	Wrong	The sun is reflecting more on the earth than the moon.	I
3	Right	Half of the moon is reflecting to earth, and not a lot of the sun is reflecting.	CF
4	Wrong	(The learner makes the moon and the sun move at the same time). The moon is going around, and day goes from morning to night, so the moon glows.	I
5	N/A	It is not possible to have an orientation. Both the sun and the moon would be reflecting onto the same area. The moon will be out at the same time as the sun.	I

The learner managed to position the sun, earth and the moon correctly for 2 out of 5 questions posed.

The reasons provided for the positioning of these models was flawed which may suggest that the learner guessed the orientation of the models for the different moon types. Based on the statistics of percentage per question asked, the learner leans towards the position of having an incomplete mental model.

Learner 7 *(Below average learner)*

Table 5.4g: Summary Table 7

Question	Orientation	Reason	Coding
1	Wrong	The learner says that the moon is put in the middle and the sun on the right so that the moon could show properly. I suppose that the learner imagines that the sun will block the moon so that it cannot be seen, because of the size of the earth and moon. Later the leaner also mentions that the big models (the earth and sun) are placed at the sides. This shows that the learner also may think that the earth will block the moon and that we would not be able to see it. Again, learner thinks if the sun is in the middle, it will block the moon from being viewed.	I
2	Wrong	If the sun is in the middle, it will be in the way. So one will not be able to see the moon in the middle.	I
3	N/A	The learner said one cannot get a gibbous moon because if one is on earth, one will not be able to see such a moon.	I
4	N/A	The learner does not know.	I
5	Wrong	The learner thinks we will be able to see the sun and not the moon.	I

Of the questions posed, learner 7 answered most incorrectly. On the orientation table, for questions 3 and 4, N/A is written as no comment or analysis could be made on the learner's response; the learner said she did not know the answer to the question asked. Based on this analysis and data, the learner therefore has an incomplete mental model.

Learner 8 (*Below average learner)*

Table 5.4 h: Summary Table 8

Question	Orientation	Reason	Coding
1	Wrong	The reflection of the sun comes from behind the moon.	I
2	Right	The moon shines on the vertical side. The shade will be near the sun.	CF
3	Wrong	If sun is closer to earth, a portion at the bottom will be shaded and top side will not be shaded.	I
4	Wrong	Perhaps the moon will rotate around the sun and the earth. The earth will move around the sun and the moon, while the sun stands still. The earth and the moon follow each other at different times. (First, the learner showed the sun moving round the earth and the moon.)	I
5	Wrong	The learner drew a crescent moon.	I

Learner 8 managed to arrange the models correctly only for question 2. Based on the other questions, it could be inferred that there was a strong possibility that the learner was guessing the orientation in question 2, as the learner was not able to answer correctly the rest of the questions asked. It can also thus be concluded from the data, that the learner contains an incomplete mental model.

5.4 c Summaries for All Learners

Table 5.4i below shows a summary of the mental models for all learners.

Table 5.4i: Summary of mental models for the 8 learners

Learner	Q 1	Q 2	Q 3	Q 4	Q 5
1	CF	CF	CC	CC	CF
2	CC	I	I	CF	I

Learner	**Q 1**	**Q 2**	**Q 3**	**Q 4**	**Q 5**
3	CF	I	CC	CC	I
4	I	CF	I	CC	I
5	I	I	CF	I	I
6	CF	I	CF	I	I
7	I	I	I	I	I
8	I	CF	I	I	I

In summary, 8 out of a total of 8 learners have an incomplete mental model, but in light of the data presented in table 5.4c, it must be acknowledged that some learners answered certain questions better. Based in the data provided, it can be said that most of the learners have little understanding of concepts relating to the moon phases. Mualem & Nussbaum (2002) suggests that for individuals to understand concepts in moon phases, they would need to possess the correct spatial perception. It was evident from the learners' use of the models to explain the cause of the moon phases and why the moon appeared as it did, that learners did not possess this kind of spatial perception. This led to learners having a poor understanding of the concepts relating to the moon phases.

In terms of learner ability, all the learners had difficulties in answering the majority of the questions posed to them by the researcher correctly, as can be seen by the summary provided by table 5.4c. What is of interest, was that learners which were in the category above average, who were considered as learners who achieved good grades for the subject (80% and above for Natural Science subject), they too irrespective of their ability found themselves in the position where they were confused, and offered responses which were incorrect at most times.

Table 5.4j below shows the total amount of responses per category of CC, CF and I:

Table 5.4j: Responses per category

Above Average Learners
I = 9; CC = 6; CF = 5
Below Average Learner
I = 16; CC = 0; CF = 4

The difference that can be seen is that the above average learners were able to supply a total of 6 responses between the four of them correctly. In terms of the categories of I, and CF, the above average learners are not far off compared to the learners in the below average category. This shows that all learners had difficulty in demonstrating and explaining the positioning of the earth, sun and the moon in relation to moon shapes during the duration of the moon cycle. This could be because of the lack of personal engagement with the modelling activity from the textbook that could have limited the learner's ability to model an understanding of moon phases.

5.5 Relationship between textbook and learners

Learners were prescribed the grade 8 textbook 1 that was analysed in Chapter 4 to help them understand the content involved in the subject. All the learners in grade 8 were using this textbook as it was a selected textbook by the Head of Department of Natural Science in the school. As can be seen by the in-depth analysis of the textbook, the textbook contained satisfactory content, with slight errors. Despite the errors, the textbook had the correct sequence and moon shapes within the cycle. Again, the textbook proved to be a constructivist tool, which meant that the textbook had sufficient content and activities to help learners understand moon phases, and the cause of the moon phases. The activity which would have had the biggest impact in understanding the cause of moon phases is activity 6 in the textbook, which involved using models to explain why the moon has different shapes at different times of the month.

The learners, despite having the tool at their disposal, still had difficulty explaining concepts involving moon shapes, and the cause of moon phases. This therefore shows that there is an

indirect relationship between the content presented about the moon phases and the learners' understanding of the moon.

5.6 Issues Emerging from Results

Presented in this section are individual cases worth examining as they may inform us on other meanings that learners may attach to the phases of the moon. Firstly, the majority of the learners are aware that the sun shines its light onto the moon, and the moon reflects its light onto earth, which we observe. It was striking that learner 6 believed that the moon had its own shining light. This may be because, generally, when it is day, the sun shines, and when it is night, we observe the moon. This is one possible misconception that may exist in other learners from other schools.

When one looks at the night sky, the moon stands higher in the sky as the time of night progresses. The reason for mentioning this point is that learner 5 felt that the moon needed to be at a greater height than all the other models. This may become a general misconception that the moon is directly above the earth.

Another point is that scale or size of the sun, earth and moon models influences much of how learners think about concepts. One example worth highlighting is that from learner 7, as the learner thought that since the model of the earth and sun were much bigger, that putting the moon behind the earth or the sun would hinder our view of the moon. Therefore, for the moon shapes, the learner had an orientation of a new moon: the learner felt that such an arrangement would help us see the moon, as neither the sun nor earth would hinder this view.

Chapter 5 has presented results obtained from the interviewing of learners to find out their thoughts on aspects surrounding the phases of the moon. The next chapter presents conclusions in the light of the results obtained.

Chapter 6

Conclusion

6.1. Introduction

The study conducted sought to investigate the quality of textbooks prescribed by the Gauteng Department of Education for the RNCS syllabi, in which such textbooks are potentially used in South African Gauteng schools. The study was particularly interested in the quality of content, and the pictures depicted under the topic moon phases. Further, the study investigated the influence of one of the textbooks at grade eight level had after the teaching of the topic. 15 Learners were used to investigate this effect, where 8 learners' responses were looked at in detail. The reason for scaling down the learners was due to the similarity of answers given by the other participants not included in the study. The study therefore sought to answer the following research questions:

What is the quality of diagrams and explanations of moon phases offered by grade

6 – 8 Natural Science textbooks?

a) What misconceptions can be identified by the content presented by textbook?
b) What structure is presented in relation to conceptual development (Does the structure in which content is present, build on concepts to aid conceptual development: i.e. concrete or abstract)?

How do grade 8 learners interpret textbook diagrams of moon phases in relation to a physical model?

In chapter 4 and 5, results of the data was presented to address the research questions mentioned in 6.1.1 and 6.1.2

In this chapter, I will respond to the research problem and questions, by drawing from findings from the data obtained in chapter 4 and 5. I will also draw conclusions from the findings of these chapters. Further, I will reflect on the study undertaken and discuss the limitations to the study. I will also share recommendations emanating from the current study.

6.2. Research Problems and Questions

6.2.1. The Research Problem

In chapter 1, I mentioned that there were very few studies that looked at the relationship between the textbooks used at schools by teachers in reference to the 2-dimensional diagrams used in the textbook, and how it influences learning of a 3-dimensional concept. This study looks at this relationship.

Upon analysis of the textbooks, it was interesting to see the majority of the textbooks had commonalities in terms of how the content was presented. The commonality was that the content presented the different shapes of the moon with accompanying 2-dimensional diagrams, and there was an activity offered to model out the phases of the moon. To elaborate more on the activities which involved the modelling of the moon phases, learners were asked to use specific objects to represent the sun, earth and the moon. Learners then had to use the objects (e.g. A lamp to represent the sun, a white ball to represent a moon, and a person posing as the earth) to show the relevant positions of the sun, earth and the moon as the moon undergoes its changes in shape. Below, table 6.2.1 provides a summary to illustrate the common structure of the textbook to make the mentioned statement clearer:

Table 6.2.1: Table showing a common structure of the 6 Natural Science textbooks

Text book	**Presentation**
Grade 6 textbook 1	Two dimensional shapes of the moon Modelling of the moon phases activity
Grade 6 Textbook 2	Two dimensional shapes of the moon No modelling activity
Grade 7 Textbook 1	Two dimensional shapes showing relative position of sun, earth and the moon Modelling of the moon phases activity
Grade 7 Textbook 2	Two dimensional shapes showing relative position of sun, earth and the moon Modelling of the moon phases activity
Grade 8 Textbook 1	Two dimensional shapes Modelling of the moon phases activity

Text book	Presentation
Grade 8 Textbook 2	No moon shapes drawn Modelling activity

Even though the content presented in the textbooks was problematic, one needs to acknowledge that the modelling activities in the textbooks were good activities to help learners understand about the causes of the phases of the moon. The grade 8 learners' selected to participate in the study used the grade 8 textbook 1, which had an activity where learners were to draw the different shapes of the moon over a period of a month, and also model out the different shapes. Due to time constraints, the teacher explained the phases of the moon, and referred the learners to the shapes drawn in the textbook. The teacher used the activity of modelling, so as to enhance the learners understanding of the concept. Despite using the modelling as a demonstration, and learners having the textbook at their disposal to help them understand the content, it still proved to be difficult for learners to relate models to shapes of the moon. The difficulty that learners demonstrated to relate models to the shapes of the moon showed that learners still lacked understanding on the cause of the phases of the moon.

6.2.2. The First Research Question

What is the quality of diagrams and explanations of moon phases offered by grade 6-8 Natural Science Textbooks?

All the textbooks had misconceptions, and these misconceptions were summarised in chapter 4 regarding which textbook contained which misconception. The identified misconceptions from the content presented by the textbooks were as follows:

1. The moon grows bigger
    - The dark part of the moon we cannot see is in shadow.
    - The moon is a small world that moves around the earth
    - The moon may undergo a phase change every seventh day

The first misconception is not a common misconception from the literature that was reviewed, but it can be understood how it comes about for this misconception to be seen inside a textbook.

The textbook puts the words “grows bigger” to enhance explanation of the technical term waxing. This is one way of explaining the waxing process in terms of what can be viewed in the evening sky. Certainly when the moon is observed in the evening, as it goes through its phases, it does appear as if the moon is getting bigger and smaller. Such a misconception can also be transmitted to learners using the textbook as a source material, as it is not explained further on why the term “grows bigger” is used as an alternative word. This may lead to learners thinking that the moon grows bigger and smaller in size all the time, where this is not the case. If textbooks have this misconception in their books, this may be passed onto learners who use the textbook as a source material into understanding content. This supports the point mentioned by Callison & Wright (1993), who made mention that these common misconceptions that learners have may be disseminated from textbooks when learners use these textbooks as a learning tool.

The three points that follow after the 1st misconception are put in bullet form as they were not picked up as stated misconceptions in the textbook. Rather, the way these statements are put in the text of the textbooks, may lead learners to develop misconceptions in the section of the phases of the moon.

The first bullet point can be regarded as correct in some ways. Looking at shadows in everyday life, they are caused by a light source, and most of the time, the light source being that of the sun. Certainly, shadows can also be seen when there are bright lights like those that shine in a stadium for evening games, or light that comes from a bright torch. For there to be a shadow, it is caused by light (coming from a light source) not being able to reach by the part of the object not being lit due to some obstruction by an object. Certainly, there is a direct link with what happens when it comes to the phases of the moon. The fact that for an example that we get a half moon, is because the sun’s light is not able to reflect on the half part of the moon we cannot see because of the positioning of the sun, earth and the moon. That is why it can be said that the part that we cannot see of the moon is in shadow. The positioning therefore of the sun earth and the moon provides the hindrance of the sun’s light not being able to be reflected on the whole side of the moon facing the earth.

The problem though comes about the interpretation of the statement of “the dark part of the moon we cannot see is in shadow” Problems may therefore arise when learners would try to establish on what causes the shadow (the dark part of the moon we cannot see) of the moon.

When learners start learning about the lunar eclipse, it is then when learners can come with misconceptions on the source of the shadows. When this happens, then learners may have another misconception, that the fact that the moon undergoes phase changes are because of the objects responsible for the shadows, e.g. the earth when looking at lunar eclipses as an example. This may thus explain why there is a common misconception of earth's shadow being the cause of the phases of the moon. It can therefore be seen that the concept of shadows can lead learners to come with misconceptions, especially looking at objects that would be responsible for the shadow that the moon has. Looking certainly at literature, misconceptions arising on the cause of the phases of the moon are based on the sources that may be responsible for shadows of the moon. An example can be seen in Stahly et al. (1999) & Baxter (1989) when they presented common misconceptions held about the cause of the phases of the moon. As a reminder, the common held misconceptions were:

1. Clouds cover the part of the moon we cannot see
2. Planets cast shadows on the part of the moon that we cannot see
3. The shadow of the sun falls on the moon, blocking our view of it all
4. The shadow of the earth falls on the moon, blocking our view

(Stahly et al., 1999, p. 160)

Looking at the 4 points, it can be noted that the clouds, planets, sun and earth are the objects mentioned as being the sources of the shadows we see on the moon, and thus, the ones that cause the different shapes of the moon as it undergoes its phase changes. It can therefore be understood where learners obtain this misconception from.

In terms of the second bullet point, the moon is not considered as a small world, but rather as a natural satellite. Even though the current study is concerned more about the correctness of content in terms of the phases of the moon and what causes these phases, it is considered here because in the textbook, it is put in a sentence where the cause of the moon phases are explained, e.g. "the moon is a small world that moves around the earth" The content where it talks about them moon moving around the earth is correct, but learners may still pick up another misconception within the sentence.

The last bullet point is also considered, because of the nature of the sentence construction, which may lead learners to have a misconception. In the last bullet point, the sentence uses

the word “may” so as to get across the fact that the statement is not necessarily true all the time (this sentence is from Grade 6 textbook 1, page 94). But this may not be clear to learners. Only four examples are shown of the cycle of the moon. Learners therefore may assume that phase changes take place every seventh day, and that there are only 4 noticeable moon phases. This misconception is further emphasised by the statement “the shapes we see in these four figures are called phases of the moon” on the same page of the textbook.

Another problem that may stem from the diagrams in relation to the content alongside the diagrams is that learners may also assume that in the 1^{st}, 7^{th}, 14^{th}, and 21^{st} day that the shapes of the moon in each month may look like the illustrated diagrams in the textbook.

Such clumsy textbook writing may therefore lead teachers and learners alike to develop poor ideas in relation to the phases of the moon. Cohen and Lucas (1999) makes mention that misconceptions may arise based on the 2 dimensional diagrams drawn about the textbook. What they did not note though, is that the text that goes alongside the 2 dimensional diagrams may bring about more confusion, and cement ideas that would prove to be problematic in understanding the scientific cause of the phases, and the duration the phases take place in one complete cycle.

None of the textbooks were free from misconceptions, or factors that could lead learners and teachers alike to have misconceptions. This suggests that the authors of the textbooks may have also come across difficulty in conveying correct scientific knowledge to learners in the Intermediate Phase of schooling. The fact that the books are not free from misconceptions, links with King’s (2010) and Leite’s (1999) possible explanation on why there are misconceptions in textbooks: that misconceptions are there due to “the authors limited understanding, from poor attempts to simplify ideas for their pupil readers, or by inadequate attempts to coach their writing to address the views of science that pupils are likely to have” (King, 2010, p. 584). Leite (1999) also provides a similar possible reason for misconceptions in textbooks, by mentioning that incorrect content and contradictions are due to an author’s difficulty in dealing with content.

In terms of the structure of the textbook, Duban’s (2008) characteristics were used to establish whether the presentation of the textbook was sufficient to be used as a constructivist tool to aid in the development of the learners’ conceptual knowledge about the phases of the moon.

As mentioned in Chapter 2, the characteristics used were as follows:

- Books should pay attention to students' prior knowledge and help to change the prior knowledge. Therefore, books should contain conceptual change texts. In these texts, through questions, students' prior knowledge should be activated
- To provide students' conceptual change, texts with analogies should be used because analogy-based thinking consists of the definition and transfer of constructive information from the known system to the new and relative system.
- To eliminate misconceptions originating from daily spoken language, the differences between concepts and relations should be defined well to students and these differences and relations should be mentioned often within texts.
- In the course books, visual components should be used often. In a good science course book, not only writing and formulae, but also many visual components such as pictures, figures, and graphics should be used.
- Learning develops through individuals' interaction with others, since individuals share their perspectives, exchange information and solve problems on the basis of collaboration. Therefore, in the science course books; there should be activities that will encourage students to work in collaboration by doing group work with their peers.

(Duban, 2008, p. 394)

These characteristics were further used to establish whether the textbook used by the grade 8 learners involved with the study was a good textbook to use to help learners build their knowledge about the phases of the moon.

Out of the 6 textbooks analysed, only 1 textbook scored poorly when using Duban's (2008) characteristics as a checklist. The textbook that was poor was grade 6 textbook 2. All other textbooks proved to be good constructivist tools to use to enhance the learning of the phases of the moon by the learners. The fact that the textbooks are good constructivist tools meant that they were supposed to be good tools to aid conceptual change in learners knowledge by means of text and diagrams used in the textbook. Looking at text, it has been noted that no textbooks are free from misconceptions. It then becomes problematic for learners to construct knowledge that is scientifically correct by means of using the textbook. This means that the

process of assimilation noted by Piaget (2003) would hinder learners in internalising new knowledge that is incorrect. This situation leads to learners to develop new misconceptions, where those misconceptions may be difficult to eradicate at a later stage if learners do get introduced to content that is scientifically correct.

In terms of the diagrams presented by the textbook, table 6.2.2 below forms a summary when looking at the quality of diagrams presented about the phases of the moon:

Table 6.2.2: Table showing quality of diagrams of the phases of the moon

Textbook	**Diagrams Observed**
Grade 6 Textbook 1	Only 4 diagrams of the moon phases are shown where each phase is 7 days apart. Phase not in correct sequence Illustrations are ambiguous Diagrams are in black and white
Grade 6 Textbook 2	Sequence of the moon shapes is incorrect as 2 moon shapes are omitted. Diagrams are in black and white
Grade 7 Textbook 1	In the sequence, the new moon has been omitted. 2d Realistic diagrams shown Diagrams explaining cause of moon phases show relative position of sun, earth and the moon
Grade 7 Textbook 2	Diagram shows the relative position of the sun, earth and the moon, and what the moon would look like in the relative positions shown.
Grade 8 Textbook 1	Black and white pictures of 8 known phases of the moon.
Grade 8 Textbook 2	No pictures or diagrams shown of the different shape of the moon in a cycle.

In summary, the 2 grade 6 textbooks contain black and white diagrams of the different shapes of the moon in a moon cycle. In both textbooks, certain moon shapes are not included.

Out of the 8 common known shapes in a moon cycle, 4 shapes are not shown in textbook 1 and 2 shapes are not shown in textbook 2. With the omission of these shapes in the two textbooks, it makes it difficult to follow a sequence in the correct order, in terms of the moon either waning or waxing. Using these textbook therefore may not enable learners to know of the 8 commonly known moon shapes in a moon cycle.

The 2 grade 7 textbooks diagrams focus more on the relative positions of the sun, earth and the moon. The purpose from the observed diagrams is to explain the cause of the different shapes that the moon has as it is going through its cycle. Even though the two textbooks have got the same type of diagrams (the relative position of the sun, earth and the moon), upon closer analysis, these diagrams are used differently. The grade 7 textbook 1 firstly introduces the different shapes that the moon undergoes, and the diagram of the relative positions of the sun, earth and the moon is used for learners to try and determine by means of an activity, on what the moon would look like in each position the moon is relative to the earth and sun. The grade 7 textbook 2 uses this type of the diagram to explain what happens as the moon waxes and wanes. It also shows at each position what the moon would look like. Therefore, the purpose is not for learners to find out what the moon looks like in each position, but to explain why the moon has different shapes, and ultimately, what causes the phases of the moon.

In the grade 8 textbooks, grade 8 textbook 1 just shows the 8 commonly known phases of the moon, with the name of the moon beneath each moon diagram. The textbook shows thus the correct sequence of the shapes of the moon as the moon is waxing and waning. The grade 8 textbook 2 however does not have diagrams showing the different shapes the moon undergoes as it is going through its cycle.

The two grade 6 textbooks and the one grade 8 textbook (grade 8 textbook 1) present diagrams where only the shapes of the moon are shown. Where there is an increase in the quality of diagrams, can be observed in the two grade 7 textbooks, as the diagrams helps one understand what causes the different phases of the moon. Comparing the two grade 7 textbooks, grade 7 textbook 2 provided the best diagram illustration of the moon phases. With such a diagram, one can see a variety of concepts portrayed by the diagram; what the moon

looks like in the different positions, how the moon orbits the earth, and showing thus what causes the different shapes that can be observed in the night sky.

Maulem & Nussbaum (2002) and Yair & Litvak (2001) make mention that learners require spatial perception in understanding concepts involving the phases of the moon. In light of the textbooks investigated in terms of the diagrams presented, only the two grade 7 textbooks attempts to address the issue of spatial perception, by arranging the diagrams in such a way, that the moon phases are shown in relation to the relative position of the sun, earth and the moon. There is therefore a strong possibility that learners that would have used the grade 7 textbooks would understand more on the relative positions of the sun, earth and the moon given a shape of the moon. Since learners in the case study group were using a prescribed grade 8 textbook, the focus shifted in determining whether diagrams presented in the grade 8 textbook (grade 8 textbook 1) would enable learners to conceptually understand the phases of the moon.

The grade 8 textbook used was the textbook that was considered a constructivist textbook under Duban's (2008) characteristics of what makes a constructivist textbook. Analysing the diagrams presented shows the textbook competently showing the common 8 moon shapes. The diagrams presented in this textbook are 2-dimensional, whereas in reality, the moon phases occur 3-dimensionally. Since the grade 8 textbook did not show the relative positions of the sun, earth and the moon, the hypothesis was therefore made that such a textbook would fail learners in understanding the shapes of the moon in relation to the position of the sun, earth and the moon.

In light of what is presented about the misconceptions found in the textbooks, and the quality of diagrams, the following is observed in response to the first research question:

- One finds that there are more misconceptions that are found in the content of grade 6 textbooks and the number of misconceptions that can be found decreases in the grade 7, and grade 8 textbooks.
- The grade 7 textbooks show better quality moon diagrams as opposed to the grade 6 and grade 8 textbooks, as these diagrams shown in the grade 7 textbooks may help aid learners in finding out the cause of the different phases of the moon

It can therefore be said that the quality of explanations of the topic moon phases increases the higher the grade, as it can be seen that textbooks provide more correct scientific content the higher the grade.

In reference to the quality of diagrams, it was quite interesting to find out that the two grade 7 textbooks provided better quality diagrams as opposed to the other textbooks. The difference of the grade 7 textbooks as compared to the 2 grade 6 textbooks, and grade 8 textbook 1 can be attributed to the fact that the grade 7 textbooks diagrams provided more detail in terms of the moon phase: by more detail, it is meant that the diagrams of the two grade 7 textbooks showed in summary, on what causes the moon phases (e.g. relative positions of the sun, earth and the moon). This was shown by both the grade 7 textbooks. Further, grade 7 textbook 2 went on to also show at what positions will the moon get its relative shapes. In grade 7 textbook 1, the learners had to find this out by themselves by means of an activity given to them. Finally, both textbooks provided the names of the different shapes of the moon. The only shortfall was that in the grade 7 textbook 2, not all the names of the 8 common moon phases were mentioned.

The two grade 6 textbooks and the grade 8 textbook 1 did not provide such detail. Only certain shapes were put as diagrams. In the grade 6 textbook 1, only 4 shapes were illustrated, where only one name was mentioned in terms of a moon shape, that being the crescent moon. In the grade 6 textbook 2, shapes with their corresponding names were given, where there was an omission of 2 moon shapes, and incorrect representation of a waning crescent.

6.2.3. The Second Research Question

How do grade 8 learners interpret textbook diagrams of moon phases in relation to a physical model?

Literature makes mention that before instruction; teachers and learners have limited understanding on the cause of moon phases. In terms of teachers, studies conducted by Dai & Capie (1990) and Callison & Wright (1993) confirm this notion. Most of the studies conducted on teacher/learner understanding confirm that the main misconception that teachers' and learners' had was that the cause of the phases of the moon was due to the earth casting a shadow onto the moon. The present study did not concentrate on learners' conceptions before instruction; rather, the main focus was to solely look at how the textbook influences the learning on the phases of the moon. However, measures were taken to prevent

such a notion being transmitted through instruction, by the researcher sitting with the teacher who was to present the lesson, on how one would go about teaching the cause of the phases of the moon. Due to time constraints, it was agreed by the researcher and the teacher, that models would be used as a demonstration to explain what the cause of the moon phases were, that learners observe in their textbooks. Since the study was based on textbook influence on learners' understanding of the moon phases, tests by means of a structured interview were taken after instruction.

For the purpose of this question, the textbook diagrams given for learners to interpret were taken from page 127 of the Grade 8 textbook 1. This is the textbook that learners were using as a source material for their Natural Science subject. The page was photocopied, and three shapes were cut out, namely that of the full moon, the crescent moon and the gibbous moon. Learners were asked to use physical models, and to demonstrate the relative positions of these models to get the three shapes of the moon mentioned. With the models, a yellow globe was used to represent the sun, a white hockey ball was used to represent the moon, and a model of the earth, borrowed from the schools social science department was also used to represent the earth.

All the learners had difficulty with the exercise of correctly arranging the models to the desired textbook shape. In some cases, learners correctly arranged the models, but their explanations on why they arranged the models the way they did, proved to be flawed, showing that the learners lacked understanding in terms of their arrangement of the models.

There is however, one difference between learners that were considered above average and below average. This difference comes about the answering of question 4 in the interview schedule. In respect to question 4, learners were asked to show by using models given to them of the sun, earth and the moon, on what causes the phases of the moon. With respect to the learners in the above average category, 3 out of 4 learners were able to successfully explain using the models on the cause of the moon phases. The learners that were in the below average category, all the learners were not able to successfully explain using models on what caused the moon phases. This was the only distinctive difference between the different group/categories of learners.

Theory mentions that learners tend to have little understanding on the cause of moon phases. This can be seen by studies conducted by (Trundle et al., 2010; Brunsell & Marks, 2007; and Rider, 2002) as mentioned in Chapter 2, when looking particularly at learners in the Middle

School Phase of study (same age group of learners involved in this study). The learners in the respective studies had misconceptions surrounding what the cause of the moon phases were.

The general misconception was that the cause of the moon phases was because of the earth casting a shadow onto the moon. In terms of the learners in the case study group, none of the learners seem to have this particular misconception. Instead, the problem that learners had was describing how the models of the sun, earth and the moon would move relative to one another.

To further investigate on the learners' ability on understanding what shapes come about with different positioning of the sun, earth and the moon, I arranged the models in such a way that they represented a gibbous moon, and asked learners to draw what they would see in they were a person standing on the Northern hemisphere, looking at the moon. This exercise was done to test the spatial ability of the learners. Testing the spatial ability of learners would therefore provide light on the reasons why the learners arranged models the way they did when being interviewed.

None of the learners managed to draw a correct representation of the moon, given the positions relative to the sun and the earth. This question therefore showed and confirmed that all learners seem to have a general problem in spatial perception. When learners cannot think spatially, then they will struggle to imagine the correct shapes of the moon given the relative positions of the sun and the earth.

In general, all learners struggled to interpret textbook diagrams of the moon phases in relation to a physical model. The results obtained from the semi-structured interview can be explained using the theoretical framework employed for the case study group. According to Chi & Roscoe (2002), how learners represent knowledge can be interpreted by a concept known as mental models. As a reminder of the theory explained in detail in Chapter 2, Chi and Roscoe (2002) made mention that learners can be viewed as having complete (majority of the learners conceptions are correct) and incomplete (majority of the learners conceptions are incorrect) mental models. The fact that all learners struggled to interpret textbook diagrams in relation to a physical model meant that learners possess an incomplete mental model. In relation to the case study group, this meant that learners found it difficult to arrange models correctly of the sun, earth and the moon, to represent the shape that learners were given to model out. This can only mean that the textbook alone is not a sufficient tool for learners to

use to develop spatial perceptions that learners would require to understand the concept of phases of the moon.

6.3. Conclusions

The study revealed the following information in relation to textbooks, and learner understanding of moon phases in relation to a physical model:

1. Cultural stories were only found in grade 6 textbooks. The cultural stories shared in these grade 6 textbooks could only help explain the phenomena of the waxing and waning of the moon. None of the other stories could be linked to understanding the cause of the phases of the moon.
2. The relationship to everyday life with the moon did not help either to explain the cause of the phases of the moon. The relation to everyday life was communicated by looking at various festivities that take place in religions when the full moon is sighted. What was interesting was the fact that in everyday language, the crescent shape of the moon is referred as the new moon.
3. All the textbooks had misconceptions in relation to the content presented. It was found however that generally, that the quality of explanations about the phases of the moon seemed to increase the higher the grade. More detail in terms of what causes the phases of the moon was observed in the 2 grade 7 textbooks.
4. It was also observed in the textbooks, that an omission of shapes in the cycle, when explaining the phases of the moon, may cause more confusion, where misconceptions can arise. Such an example can be seen in the grade 6 textbook 1, where only four shapes are shown, with a text explaining that after a period of seven days, the moon may change its shape. With such an example, learners may assume that the moon changes its shape every 7^{th} day.
5. The textbooks observed had very good activities. These activities involved learners using models to determine what causes the different shapes observed from the moon. With learners given enough time to explore these activities, these activities may help learners better understand concepts of the phases of the moon.

6. In terms of the learners, it was discovered that all learners had a problem with using models to represent the moon shapes provided by the researcher, which came directly from the learners' textbook page. The fact that learners had this difficulty, meant that they had an incomplete mental model about the concepts underlying the moon phases. It was discovered that the fact that learners were struggling to represent the moon shapes using models, meant that learners had limited spatial perceptions.
7. It was also found however, that the majority of the learners in the above average category understood the fact that the moon orbited the earth, and that this orbit could explain why the moon had different shapes. Learners in this category could further demonstrate this using the models given to them. On the other hand, learners that were in the below average category, failed to explain what was responsible for the different shapes of the moon using the provided models.

It is mentioned by Cohen & Lucas (1999) that misconceptions may arise based on 2-dimensional diagrams drawn about the moon. It was noted that it was only the grade 7 textbooks that provided a more detailed diagram of what causes the phases of the moon. The other diagrams drawn by the textbooks just showed the mere shapes of the moon as it goes through the cycle. Looking at the Grade 8 textbook used by the case study group, the common know eight shapes where drawn next to each other, where one could see the waning and waxing part of the moon. Such a diagram caused a misconception with a learner from the case study group; that being the moon growing bigger. Such a misconception could have been due to how the moon cycle was illustrated in the textbook, as by mere observation, it does appear in the textbook as if the moon is growing bigger and smaller.

The textbooks observed all had misconceptions, or statements written in the text that would cause misconceptions to occur. Likewise, learners in the case study group were also observed to have misconceptions regarding the phases of the moon. Such an observation shows the validity of the claim mentioned by Callison and Wright (1993) that it is possible that misconceptions held by learners may be passed on by the textbooks that the learners use.

Brunsell & Marks (2007) and Rider (2002) conducted research involving learners that are in the Middle school to determine their ideas about the phases of the moon. Their research showed that there was a small amount of learners that were able to correctly explain the cause

of the phases of the moon. A similar question was asked to the learners involved in the case study group, where learners had to explain by means of using the model of the sun, earth and the moon on the causes of the phases of the moon. In terms of results, a high number of learners in the above average classification (3 out of 4) were able to correctly answer this question. What was different in terms of findings was that the learners in Brunsell & Marks (2007) and Rider (2002) cited the most common misconception, that being the earth casting a shadow on the moon. Learners involved in this case study group though did not mention this common misconception as they attempted to explain the cause of the phases of the moon.

In summary, it can be said that textbooks do contain misconceptions, and that the textbook alone cannot help learners to understand the concept of the phases of the moon. In previous studies, there were interventions that took place to help learners enhance the learning and understanding of the phases of the moon. Studies conducted by Vosniadou (1991) and Trundle et al. (2007a) which helped the learning of fundamental concepts had a framework underlying the study, that being the framework of conceptual change. The framework as a reminder was underpinned by 4 characteristics:

1. Conditions are created in which students evaluate empirical evidence that is contrary to their beliefs;
2. Instruction provides clear explanations of scientific concepts, preferably through conceptual models or analogies;
3. Instruction utilises demonstrations that show the scientific models and explanations which are superior to non-scientific conceptions and explanatory frameworks;
4. Instruction promotes intentional learning, which is viewed by the learner as being purposeful and is characterised by a high level of meta- cognitive awareness and self-regulation.

In the current study, it was hoped that the textbook would help achieve characteristic 2. This though proved not to be successful due to the nature of the textbooks containing misconceptions, and learners still not understanding moon phases after the use of the textbook. Therefore, more time needs to be devoted in the learning of the phases of the moon for all 4 characteristics to be achieved by means of instruction and use of a good source material for learners to thoroughly understand the concept.

6.4. Implications

Looking at the new CAPS document, where the curriculum is expected to be carried out in schools by the year 2014, it is seen that moon phases is part of the grade 8 syllabi for Natural Science. In order for learners to understand moon phases, it is important that instruction addresses problems associated with understanding the phases of the moon.

Literature makes mention that learning occurs through the process is of re-crafting of existing knowledge (Smith, DiSessa &Roschelle, 1993: 123). This would mean that instruction needs to include finding out what learners know about the phases of the moon. If there are any misconceptions around the topic, then instruction should try and address the misconceptions held by the learners. It is not a task that is easily achievable, as there is no guarantee that learners will change the misconceptions held, but it is a starting point towards achieving a possible conceptual change amongst learners. Literature acknowledges the challenges faced in achieving conceptual change e.g. (in the sense that the "re-crafting of knowledge may despite many intermediate difficulties, be eventually successful") (Smith, DiSessa & Roschelle, 1993: 123), but it would thus mean that the teacher needs to develop an array of activities that would help learners change ideas that are not scientifically correct.

In relation to successful instruction that would cause learners to achieve conceptual change, previous studies that were able to achieve conceptual change were those studies conducted by Vosniadou (1993, 2003) and Trundle et al (2007a). These studies had a common concept: the concept of conceptual change (changing incorrect non-scientific ideas to be scientific). The success of this instruction was based on four characteristics.

The detail of the characteristics is discussed in Chapter 2, but to recall in summary form, the characteristics were as follows:

- Evaluation of empirical evidence by learners
- Instruction using models or analogies
- Demonstrations used in teaching
- Instruction promotes intentional learning

(Vosniadou, 1991; 2003; in Trundle *et al*., 2007a, p. 305)

Therefore, for instruction to help learners achieve conceptual change, the characteristics highlighted need to be taken into consideration.

In order for teachers to create instruction that would favour conceptual change, teachers as well need to have enough content knowledge to deal with challenges involved in helping learners change their non-scientific views about the phases of the moon. This would mean that there needs to be intervention done with teachers to help them understand the content. It can be seen in some literature, e.g. King (2001) who conducted a survey amongst 150 teachers and found that the content knowledge of teachers was weak. Such a problem can be curbed at universities training future teachers.

In relation to in-service teachers', various means could be adopted to also help the in-service teachers' improve their content knowledge. Some suggestions include:

- Publishers of textbooks offering workshops to support teachers with the content presented in their books.
- Provincial education departments offering more support to teachers by means of self-study guides, or even workshops on content that is seen as being difficult: specifically the concept behind the phases of the moon.
- Universities offering short courses to teachers to help them master these difficult concepts.

Having a variety of options that teachers could take in improving their content knowledge may be a better way in curbing the rebelling nature of some teachers, as they now may have a choice; rather than be forced to attend a compulsory workshop for an example.

King (2001) noted that teachers who usually had weak content knowledge, tended to focus more on what the textbooks presented as correct scientific knowledge. Therefore, to minimise further problems, much needs to be done by government in the education division in providing textbooks that are accurate in content. This means that it would be more advisable to take textbooks that are provided to learners, to specialists to be edited in terms of content. In that way, having textbooks which contains content that is scientifically correct and free of misconceptions, helps learners and teachers alike to develop content knowledge that is not flawed.

6.5. Reflections

There were a variety of Natural Science textbooks from the grade 6 - 8 level that have been published in South Africa for learners to use as a source material. Interestingly, not all the textbooks had the same content in the section Planet Earth and Beyond; this meant that not all textbooks in grade 6 – 8 had content that related to the phases of the moon. A criterion therefore had to be set in choosing the textbooks that were to be used for the purpose of the research. The criterion was that a textbook had to have a section where it only concentrated on the phases of the moon. Out of all the textbooks observed, only 7 met the criterion. One textbook was dropped so as to have an equal spread of textbooks per grade.

After choosing the appropriate textbooks to analyse, the next step was to look for a suitable instrument to analyse the content presented by the textbooks. It was initially difficult to establish an instrument that would assist in collecting the necessary data for the textbook analysis. The starting point commenced by searching for other instruments that were developed for the analysis of textbooks. The search led one to find a textbook instrument developed by Swanepoel (2010), who developed an instrument to analyse textbooks as part of her PhD work. The instrument analysed a variety of characteristics, ranging from content to language used in the textbook. Swanepoel's instrument was adapted, where only the content part of her instrument was used. The instrument contained a checklist when looking for the correct content. The checklist had a rating scale. When using this instrument, it was discovered that the instrument only provided a numerical value of the quality of the content. Not much could be explained with the rating scale as to what problems the content contained. This instrument therefore was discarded as the results did not provide data that was rich and sufficient to answer the first research question.

It was through the guidance of my supervisor, that a more suitable instrument was established, from the British Columbia Ministry of Education (2002, 2008). This ministry of education also developed an instrument to analyse source materials to be used by teachers. Adapting the ministry's instrument meant that only suitable characteristics were chosen, so as to fit in with the purpose of the research, that being to determine the quality of diagrams and content presented by the textbooks. This instrument helped in collecting the necessary data for the research project.

Reflecting back, it would have been easier if there was an instrument readily available that would focus directly on checking the correctness of content in Astronomy education. In that way, teachers may also learn from this instrument on the necessary correct scientific knowledge they would need to convey to their learners when teaching any topic that falls in astronomy education at schools.

Looking at the learners, content about the phases of the moon were taught to the learners involved in the case study. Initially, 15 learners were chosen to participate under the categories: above average, average and below average. The learners were chosen in terms of performance in the subject. The number was scaled down, due to learners' obtaining similar results. This strategy was also used as a means on finishing the project in a shorter time period, as it was discovered that the size of the project was much bigger than anticipated, given the time necessary to complete such a research project.

The learners involved in the case study were taught for 2 periods, where each period was 40 minutes long. Due to time constraints on delivering the necessary content, this was the only time that the teacher needed to use before going onto the next topic. Perhaps, when more time could be given in terms of learners doing the activities mentioned given by the textbooks on their own (especially the activity dealing with drawing the shape of the moon for a period of a month, and using models to explain the different shapes of the moon), and getting the chance to discuss these activities with learners within the class, and the teacher, the outcome might have been different, as learners would have had the opportunity via the activities to reinforce important concepts underlying the phases of the moon.

It was found by the researcher that the interview schedule was not followed word by word. This way of conducting the interview, lead the interview to be from a structured interview, to be a semi-structured interview. What worked well with this strategy though is that it allowed the researcher to probe more with the responses of the interviewees, and to reword the questions if the person being interviewed did not understand the question.

During the process of analysing the textbooks, it was found that the textbooks contained errors. The errors that were picked up not only related to the 2-dimensional diagrams of the shapes of the moon, but also the content. This brought about the realisation that if teachers were to teach the content as it is written in the textbooks, it would impact on learners' learning some incorrect content that could lead to them having further misconceptions. It therefore would be more worthwhile to communicate the findings of this study to the

publishers of these textbooks, so that errors could be corrected for the current textbooks that are in print. In this way, correcting the textbook errors would go a long way in ensuring that the basics taught to learners about the phases of the moon are at least correct.

6.6. Research Limitations

The second phase of the research followed a case study approach; only 15 learners were interviewed in one government school, which happened to be an all-girls school. The results of only 8 girls were presented.

This means that the results cannot be generalised, and that generalisation is restricted to this group only. But this generalisation can be used as an insight in what learners do not understand about the phases of the moon. A much larger sample, looking at private and government schools may supply much richer results, and better inform teachers on problems they need to watch out for when teaching this topic.

Due to time constraints, only one topic under the umbrella planet earth and beyond could be studied thoroughly and investigated.

6.7. Recommendations Emanating from the Study

More emphasis in providing the correct content therefore should be paid to the textbooks in the lower grades, so that learners from the onset have the correct scientific view of what causes the moon phases. This may help learners as they go through higher school grades to have fewer misconceptions about the cause of moon phases.

Teachers need to also be aware on the limitations of a textbook. The one way that teachers can be aware of the limitations is by teachers possessing correct content knowledge, and an increased level of pedagogical content knowledge.

This can be achieved by teachers visiting museums or science centres like the Planetarium to advance their knowledge. Teachers could at the same time take learners out on educational outings, so that learners may have a chance to experience content that they are taught in a practical way. Having such educational outings would contribute to the development of correct scientific knowledge that a textbook may fail to provide.

In terms of further research, all topics in prescribed textbooks suggested by the department of education dealing with topics related to Astronomy Education need to be analysed in terms of the correctness of the content presented by specialist in the field of Astronomy Education, so that textbooks supplied to learners have relevant correct information which is free from misconceptions.

Further research needs to also be done in developing an instrument that would test if a textbook contains scientifically correct knowledge. In this way, such an instrument may be made available to teachers planning to use a tool, to see if it contains correct content. This may help teachers also establish misconceptions that they have so as they can correct themselves before teaching a topic.

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Appendix A: Final Instrument used for Data Analysis for Textbooks

Evaluation Form

For each of the following statements, tick the relevant box that best reflects your judgment of the resource. Use the space following each item for comments, including relevant page numbers.

SA – Strongly Agree A – Agree SD – Strongly Disagree

D – Disagree NA – Not Applicable

Content	**SA**	**A**	**D**	**SD**	**NA**	**Comment**
The science content is accurate:						
The science content is current						
The level of difficulty is appropriate for the intended grade						
The content relates to the real world						
The examples provided are appropriate						
Cultural portrayal in textbooks brings forth correct scientific adaptations to explain moon phases						
Instructional Design	**SA**	**A**	**D**	**SD**	**NA**	**Comment**
Promotes engagement						
Promotes active learning						
Suitable for intended purpose						
Concepts clearly introduced						
Concepts clearly developed						
Concepts clearly summarized						
Linguistic level is appropriate for audience						
Non-technical vocabulary is appropriate						
Technical terms are consistently explained/introduced						
Activities are appropriate for level						
Technical Design Relation to pic	**SA**	**A**	**D**	**SD**	**NA**	**Comment**
The relation between text and pictures is accurate						
The textbook visual						

representation of the moon phases are accurate						
The illustrations/visuals are clear and unambiguous						
Social Considerations						
Language use is appropriate						

Appendix B 1: Ministry of Education British Columbia instrument adapted 2002:

BRITISH COLUMBIA
Province of British Columbia

Ministry of Education

Print Evaluation Form

Title

SA - Strongly Agree
SD - Strongly Disagree
N/A - Not applicable

For each of the following statements, check the circle which best reflects your judgement of the resource. If the statement is not applicable, check the circle marked N/A on the right hand side. Use the space following each item for comments, including relevant page numbers.

SA	SD		CONTENT	Comments	N/A
○	○	1.	Content is current		○
○	○	2.	Content is accurate		○
○	○	3.	Supports BC curriculum		○
○	○	4.	Scope (range) and depth of topics are appropriate to student needs		○
○	○	5.	Material has significant Canadian content		○
○	○	6.	Level of difficulty is appropriate for intended audience		○
○	○	7.	Content integrates "real-world" experiences		○
			INSTRUCTIONAL DESIGN		
○	○	8.	Instructional goals and learner objectives are clearly stated		○
○	○	9.	Suitable for a wide range of learning/teaching styles		○
○	○	10.	Promotes student engagement		○
○	○	11.	Promotes active learning		○
○	○	12.	Promotes communication skills		○
○	○	13.	Encourages group interaction		○
○	○	14.	Encourages student creativity		○
○	○	15.	Allows/encourages students to work independently		○
○	○	16.	Suitable for intended purpose		○
○	○	17.	Materials are well organized and structured		○
○	○	18.	Materials have unity/congruency		○
○	○	19.	Concepts are clearly introduced		○
○	○	20.	Concepts are clearly developed		○
○	○	21.	Concepts are clearly summarized		○
○	○	22.	Integration across curriculum subjects is supported		○
○	○	23.	Non-technical vocabulary is appropriate		○
○	○	24.	Technical terms are consistently explained/introduced		○
○	○	25.	Pedagogy is innovative		○
○	○	26.	Adequate/appropriate pre-teaching and follow-up activities are provided		○
○	○	27.	Adequate/appropriate evaluation tools are provided		○
			TECHNICAL DESIGN		
○	○	28.	Text relates to visuals		○
○	○	29.	Appropriate support materials are provided		○
○	○	30.	Visual design is interesting/effective		○
○	○	31.	Illustrations/visuals are effective/appropriate		○
○	○	32.	Character size/typeface is appropriate		○
○	○	33.	Layout is logical and consistent		○
○	○	34.	Users can easily employ the resource		○
○	○	35.	Packaging/design is suitable for the classroom		○
○	○	36.	Makes effective use of the medium		○

S - Suitable or appropriate
NS - Not suitable or appropriate
N/A - Not applicable

For each of the following statements, consider whether the resource addresses the following issues appropriately. If the statement is not applicable, check the circle marked N/A on the right hand side. Use the space following each item for comments and page references, or include comments and notes on a separate sheet.

S	NS	SOCIAL CONSIDERATIONS	Comments	N/A
○	○	37. Gender equity/Role portrayals of the sexes		○
○	○	38. Portrayal of sexual orientation		○
○	○	39. References to belief systems		○
○	○	40. Age portrayals		○
○	○	41. Socio-economic references		○
○	○	42. Political issues bias		○
○	○	43. Regional bias		○
○	○	44. Multiculturalism and anti-racism content		○
○	○	45. Aboriginal culture/roles		○
○	○	46. Portrayal of special needs		○
○	○	47. Ethical/legal issues		○
○	○	48. Language use		○
○	○	49. Portrayal of violence		○
○	○	50. Safety standards compliance		○

Describe the major reasons for recommendation for inclusion in the grade collection	List any components of this package which are not considered essential for inclusion in the grade collection

Describe the major reasons for non-recommendation for inclusion in the grade collection

SUMMARY

Shortlisted for grade collection ○

(choose one)

Comprehensive resource ○

Additional resource ○

Not shortlisted for grade collection ○

(choose one)

Does not meet ministry evaluation criteria ○

Not eligible for grade collection ○

Evaluator: _____ Date: _____

Evaluator: _____ Date: _____

Appendix B 2: Ministry of Education British Columbia instrument adapted 2008:

Learning Resource Evaluation **Revised: 2008/06/16**

ERAC
Educational Resource Acquisition Consortium

Title of Resource: _____

Evaluator: _____ **Evaluator**: _____

SECTION 1. CURRICULUM FIT

0= Not at all 2= Moderately
1= Slightly 3= Extensively

To what degree:	0	1	2	3	**References**
CF-1: does the resource support the philosophy, pedagogy, Rationale and goals of this BC curriculum? (Refer to the 'Introduction', 'Prescribed Learning Outcomes' and/or 'Achievement Indicators' sections of the Integrated Resource Package.) Consider:					
CF-1.1. does the resource support the rationale and goals of this BC curriculum?	☐	☐	☐	☐	
CF-1.2. is the resource consistent with the pedagogy suggested in this BC curriculum?	☐	☐	☐	☐	
CF-1.3. does the resource support active learning?	☐	☐	☐	☐	
CF-1.4. does the resource support a variety of learning styles?	☐	☐	☐	☐	
CF-1.5. does the resource support group interaction and independent learning?	☐	☐	☐	☐	
CF-1.6. does the resource support the development of critical thinking skills?	☐	☐	☐	☐	
CF-1.7. does the resource support the development of communication skills?	☐	☐	☐	☐	
CF-1.8. does the resource encourage and promote creativity?	☐	☐	☐	☐	
CF-2: does the resource address the Prescribed Learning Outcomes of this BC curriculum?	☐	☐	☐	☐	

Summary

0= Not at all 2= Moderately
1= Slightly 3= Extensively

Having considered the above questions, to what degree does the resource support these aspects of this BC curriculum?	0	1	2	3
	☐	☐	☐	☐

Note: If the resource scores a 0 or 1 on the summary <u>for this section</u>, the resource is rejected. If so, complete comments below, then proceed directly to the last page of this evaluation form.

If the resource does not support the BC curriculum, please explain why, with specific references and examples.

_____

_____

_____

Additional comments, if applicable. _____

SECTION 2. CONTENT

0= Not at all 2= Moderately
1= Slightly 3= Extensively
N/A= Not Applicable

To what degree:	0	1	2	3	N/A	References
CO-1: does the resource have a BC/Canadian perspective?	☐	☐	☐	☐	☐	
CO-2: is the content accurate?	☐	☐	☐	☐	☐	
CO-3: is the content relevant and does it deal with real world experiences?	☐	☐	☐	☐	☐	
CO-4: is the scope and depth of content appropriate for the cognitive and linguistic levels of the intended audience, and consistent with the intent of the Prescribed Learning Outcomes?	☐	☐	☐	☐	☐	

Summary

0= Not at all 2= Moderately
1= Slightly 3= Extensively

0	1	2	3
☐	☐	☐	☐

Having considered the above questions, to what degree is the content suitable for use in BC classrooms?

Note: If the resource scores a 0 or 1 on the summary <u>for this section</u>, the resource is rejected. If so, complete comments below, then proceed directly to the last page of this evaluation form.

If the content is not suitable for use in BC classrooms, please explain why, with specific references and examples.

_____

_____

_____

Additional comments, if applicable. _____

_____

_____

SECTION 3. INSTRUCTIONAL DESIGN

0= Not at all 2= Moderately
1= Slightly 3= Extensively
N/A= Not Applicable

To what degree:	0	1	2	3	N/A	References
ID-1: does the resource support instruction and assessment? Consider:						
ID-1.1. are instructional goals and purpose clearly stated?	☐	☐	☐	☐	☐	
ID-1.2. are learner objectives clearly stated?	☐	☐	☐	☐	☐	
ID-1.3. are the concepts clearly introduced?	☐	☐	☐	☐	☐	
ID-1.4. are the concepts clearly developed?	☐	☐	☐	☐	☐	
ID-1.5. are the concepts clearly summarized?	☐	☐	☐	☐	☐	
ID-1.6. are pre-teaching activities provided?	☐	☐	☐	☐	☐	
ID-1.7. are follow-up activities provided?	☐	☐	☐	☐	☐	
ID-1.8. are assessment opportunities provided, consistent with the Prescribed Learning Outcomes and Achievement Indicators?	☐	☐	☐	☐	☐	
ID-1.9. are technical terms consistently explained/ introduced?	☐	☐	☐	☐	☐	
ID-2: is the resource suitable for a wide range of learning and teaching styles?	☐	☐	☐	☐	☐	
ID-3: does the resource reflect a logical and consistent approach to the Prescribed Learning Outcomes and Achievement Indicators? Consider:						
ID-3.1. is the resource well organized, sequenced and structured?	☐	☐	☐	☐	☐	
ID-3.3. do the activities meet the intended goals and purpose?	☐	☐	☐	☐	☐	
ID-4: do the ancillary materials contribute to the overall effectiveness of the resource?	☐	☐	☐	☐	☐	

Summary

0= Not at all 2= Moderately
1= Slightly 3= Extensively

0	1	2	3
☐	☐	☐	☐

Having considered the above questions, to what degree would the instructional design support student learning?

Note: If the resource scores a 0 or 1 on the summary <u>for this section</u>, the resource is rejected. If so, complete comments below, then proceed directly to the last page of this evaluation form.

If the instructional design is an obstacle to student learning, please explain why, with specific references and examples.

_____

_____

_____

Additional comments, if applicable. _____

_____

_____

SECTION 4. TECHNICAL DESIGN

0= Not at all 2= Moderately
1= Slightly 3= Extensively
N/A= Not Applicable

To what degree:	0	1	2	3	N/A	References
TD-1. does the visual presentation and layout support student learning? Consider:						
TD-1.1: are the illustrations clear, effective and appropriately placed to support the text?	☐	☐	☐	☐	☐	
TD-1.2: is the visual design interesting and engaging?	☐	☐	☐	☐	☐	
TD-1.3: is the presentation logical, consistent and well-organized?	☐	☐	☐	☐	☐	
TD-1.4: are the font and type face appropriate for the intended audience?	☐	☐	☐	☐	☐	
TD-2. if there are various components to the resource, are these components organized in a clear, logical, user-friendly manner?	☐	☐	☐	☐	☐	

Summary

0= Not at all 2= Moderately
1= Slightly 3= Extensively

0	1	2	3
☐	☐	☐	☐

Having considered the above questions, to what degree would the technical design support student learning?

Note: If the resource scores a 0 or 1 on the summary <u>for this section</u>, the resource is rejected. If so, complete comments below, then proceed directly to the last page of this evaluation form.

If the technical design is an obstacle to student learning, please explain why, with specific references and examples.

_____

_____

_____

Additional comments, if applicable. _____

_____

_____

SECTION 5. SOCIAL CONSIDERATIONS

Social Considerations Criteria = Criteria that evaluators must consider when evaluating and shortlisting resources for student and teacher use to ensure that all references, including visuals, promote respect for and understanding of the diversity of Canadian society, and respects rights protected under the **Human Rights Code, RSBC 1996, C.210**

Evaluators must refer to the Guidelines - Social Considerations document for detailed descriptions of each general and specific criterion.

Evaluation ratings: The following evaluation ratings will be used for Social Considerations criteria:

A = Acceptable
U = Unacceptable
N/A = Not Applicable (Used for criteria that are not relevant for a specific context or curriculum)

C = Consideration Required (Used to indicate that teachers should consider use of other resources or teaching strategies to address a specific social consideration identified in this resource.)

O = Omission (Used to identify an omission related to the specific criterion. If the resource is Acceptable, teachers should consider use of other resources or teaching strategies to address this deficiency in this resource.)

- For each of the following statements, you **must** check either **A**, **U** or **N/A**, whichever best reflects your overall judgment of the resource. In addition, you **may** check a criterion with **C** and/or **O**.
- For any criteria marked **U** or **C,** specific examples with page numbers must be documented using the space following each item.
- For any criteria marked **O,** the specific omission must be documented using the space following each item.

A	U	N/A	Criteria	Comments/Reasons/ References	C	O
			SC-1 Age			
			SC-2 Gender Roles			
			SC-3 Aboriginal Peoples			
			SC-4 Multiculturalism			
			SC-5 Gender Identity and Sexual Orientation			
			SC-6 Ability - Disability			
			SC-7 Belief System			
			SC-8 Socio-Economic			

A	U	N/A	Criteria	Comments/Reasons/ References	C	O
			SC- 9 Violence			
			SC-10 Ethical and Legal			
			SC-11 Humour			
			SC-12 Safety			
			SC-13 Language			

Summary

0= Not at all 2= Moderately
1= Slightly 3= Extensively

Having considered the above criteria, to what degree would the cumulative social considerations support student learning?

0	1	2	3
☐	☐	☐	☐

Note: If the resource scores a 0 or 1 on the summary for this section, the resource is rejected. If so, complete comments below, then proceed directly to the last page of this evaluation form.

If the social considerations are an obstacle to student learning, please explain why, with specific references and/or examples.

_____

_____

_____

Additional comments, if applicable. _____

_____

_____

SECTION 6. EVALUATION DECISION

This resource has been rejected in one or more of the following areas.

Please check one or more of the boxes below, as applicable.

	Rejected	Not Considered (only applicable if a resource was already rejected for deficiencies in another Section)
1. Curriculum Fit	☐	
2. Content	☐	☐
3. Instructional Design	☐	☐
4. Technical Design	☐	☐
5. Social Considerations	☐	☐

_____ _____
Evaluator Signature Date

_____ _____
Evaluator Signature Date

OR

This resource has been shortlisted and forwarded for:

Consideration for A) Grade Collection and Ministerial order ☐

OR

B) Local approval ☐

_____ _____
Evaluator Signature Date

_____ _____
Evaluator Signature Date

IRP: _____ **Course** _____

Grade(s)	K	1	2	3	4	5	6	7	8	9	10	11	12
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Choose: Comprehensive resource	☐	OR	Additional resource	☐
Choose: Student resource	☐	AND / OR	Teacher resource	☐

Please respond to the following statements to assist in the development of the final annotation for this shortlisted resource.

Describe the strengths of this resource that teachers should consider when making a decision to use it with their students. _____

_____

_____

_____

Describe any weaknesses of this resource that would require specific teacher intervention and / or use of additional support material. _____

_____

_____

_____

Describe any social considerations identified in this resource that teachers should consider when making a decision to use it with their students.

_____

_____

_____

The **Curriculum Correlation Form for <<curriculum>>**, submitted by the Supplier, has been reviewed and revised by the evaluators, as required:

Signed: _____ Signed: _____

Name: _____ Name: _____

Curriculum Correlation, by Organizer

Please indicate if this resource provides:

satisfactory to good support for the **majority** of the learning outcomes within the curriculum organizer **OR**

support for **one or more** learning outcomes within the curriculum organizer

Please check all that apply.

SAMPLE – MODIFIED FOR EACH CURRICULUM

Organizers	Courses				
	Course – Grade 8	Course – Grade 9	Course – Grade 10	Course – Grade 11	Course – Grade 12
Organizer 1	Majority O One of more O	Majority O One of more O	Majority O One of more O	Majority O One of more O	Majority O One of more O
Organizer 2	Majority O One of more O	Majority O One of more O	Majority O One of more O	Majority O One of more O	Majority O One of more O
Organizer 3	Majority O One of more O	Majority O One of more O	Majority O One of more O	Majority O One of more O	Majority O One of more O

RECORD EVALUATION TIME: _____ min.

Appendix C: Table Summary of Instrument used for the current study

Characteristic	Checklist
Content	
The science content is accurate	Check for: ➢ Outdated information. ➢ Factual Errors. ➢ Improper use of statistics. ➢ Inaccurate graphs or displays. ➢ Invalid or oversimplified models, examples or simulations. ➢ Errors in spelling or grammar.
The science content is current	Check if the resource is not dated in its: ➢ Content. ➢ Language. ➢ Visuals.
The level of difficulty is appropriate for the intended grade	Appropriateness of: ➢ Concepts. ➢ Visuals. ➢ Vocabulary. ➢ Structure.
The content relates to the real world	Content that supports the integration of: ➢ Personal. ➢ Familial. ➢ Cultural context of society. ➢ Links with real world activities are incorporated. ➢ There is provision for hands on experiences.
The examples provided are appropriate	Appropriateness in terms of: ➢ Age and grade. ➢ Developmental level of a learner.

Characteristic	Checklist
Cultural portrayal in textbooks brings forth correct scientific adaptions to explain moon phases	
Instructional design	
Promotes engagement	➢ Questions should encourage reflection. ➢ Questions and activities should attract attention and increase understanding.
Promotes active learning	The following things should be promoted: ➢ Critical thinking. ➢ Problem solving. ➢ Group decision making.
Suitable for intended purpose	➢ Resource offers a means to an end. ➢ Content, methodology and means of evaluation correspond to the overall purpose.
Concepts clearly introduced	➢ Presentation of the concepts is smooth and logical. ➢ New concepts are identified in a clear and consistent manner.
Concepts clearly developed	Definitions, explanations, illustrations and examples are available where necessary and are relevant to the point under discussion: ➢ There are links to previously acquired knowledge. ➢ Examples and counter examples are offered. ➢ Examples can be broken down into sequential components.
Concepts clearly summarised	A summary may come in different forms, e.g. ➢ List. ➢ Synthesis activity.

Characteristic	Checklist
	➢ Post lesson quiz. ➢ Focussed Questions.
Linguistic level is appropriate for audience	Is the language used in the text appropriate for the grade and age of the learners?
Non-technical vocabulary is appropriate	Consider: ➢ Overall vocabulary load. ➢ Purpose for reading. ➢ Sophistication of ideas presented. ➢ The context. ➢ Level of concreteness/abstraction. ➢ Use of idiom or dialect (can increase comprehension difficulty and/or enrich meaning). ➢ User support (e.g. examples, illustrations, and glossaries).
Technical terms are consistently explained/introduced	Consider: ➢ Consistent presentation (e.g. in boldface; pause for explanation accompanied by illustrative examples). ➢ Learner support (e.g. glossaries, an index, advance organizers, post lesson summary).
Activities are appropriate for level	Are the activities given appropriate for the grade level and the age of learners?
Technical Design	
The relation between text and pictures is accurate	➢ What is said or written should clearly correspond to what is shown. ➢ Captions should be clear and relevant. ➢ Visuals should be placed to effectively support textual content and not interfere with reading or

Characteristic	Checklist
	viewing.
The textbook visual representation of the moon phases are accurate	Look at how the moon is represented for each phase.
The illustrations/ visuals are clear and unambiguous	Look if the illustrations do not confuse learners.
Social Considerations	
Language use is appropriate	Consider the use of the following: ➢ Trendy language ➢ Profanity ➢ Racist, sexist, homophobic, and other pejorative terms. ➢ Slang, jargon or dialect. ➢ Incorrect grammar ➢ Gender biased language

Appendix D: Transcript of Leaner Responses per Interview

Transcript for learners for research purposes

Learner number 1

Researcher: Alright, Um, on the table there you've got uhh three specific models, ok, so the yellow globe represents the sun, uh, the white ball represents the moon, and then the model of the earth then just represents the earth. Ok, now the idea is for me to give you a picture uh of the moon, alright, an then from that picture I'd like to see how you actually arrange the model so that we could be able to see the moon that you were able to then be able then to look at in the picture, is that fine?

The learner agrees by saying yes

Researcher: Ok, so, the first picture is as follows

The Researcher gives the learner the picture of the moon phase as per textbook they used to learn this section.

Researcher: Ok, so, could you please arrange your models so that we are able then to see um that picture representation.

The learner arranges the models in such a way that the earth, sun and the moon are in a straight line, where within that straight line, the earth being at the centre.

The moon being on the centre: the moon an sun being on either side of planet earth

Researcher: Ok, so explain your arrangement

Learner: Well, the sun is hear, so the, it will just, the whole sunlight will hit the surface of the moon that we see from the earth

Researcher: Oh, ok, alright, so that is your general explanation of it?

Learner: Yes

Researcher: Alright, so why will we see then the moon appearing like that, it's because of what's happening with the sun …

Learner: well, ya, all the sunlight will hit directly the whole face of the moon

Researcher: Ok, alright, thank you.

The Researcher after the learner's response gives the learner the second drawing as per the textbook.

Researcher: So now I am just giving you the second um, picture representation. Right, um, are we able to see the moon that is like that (Researcher points to the picture on a moon phase that was given to the learner).

Learner: it will be something like this.

(The learner arranges the models by moving them in a position that the learner thinks the sun, earth and the moon will be).

Researcher: Ok, sooo, can you please explain why that arrangement would be the way that we see it like that.

Learner: The sunlight will only hit like the crescent shape of the moon, not the whole moon.

Researcher: Oh ok, so what do you mean by the crescent shape?

Learner: Well, it will only hit like this part of the moon

(the learners shows by means of

Researcher: Ok, and that's the part that we will be able to see then

Learner: Yes

Researcher: Ok

Researcher: Alright

(The Researcher hands the learner another picture of a moon phase).

Researcher: Could we see a moon that is like that (the Researcher points at the picture given to the learner of a moon phase)

Learner: You see three quarters of the moon because the sun will shine on three quarters

Researcher: Oh, ok, alright.

So could you just maybe shift, um, in this direction so that we can see the representation, because we can't uh see the moon. (The Researcher shows the direction in which he would like the learner to move)

Ok, So come this side, alright.

Ok, explain it again please.

Learner: The sun, the sunlight will hit like a quarter of, three quarters of the moon and we will see three quarters from the surface of the earth you will see a quarter of it won't have any light on it

(The Researcher then gives the learner another drawing to look at)

Researcher: Ok

Over here, it is just a sequence in terms of the different shapes the moon can undergo while it is undergoing its cycle. Ok, so could you demonstrate it to me if the moon if going through

different phases, how would it be moving. So it does not have to be individual items, just I'm more interested how the moon would be moving.

Learner: Ok, it would go like this ways around

(The learner demonstrates the movement

Researcher: Ok, why would it be moving around

Learner: Because it orbits the earth

Researcher: Alright, thanks

Researcher: Alright, can I just take the models.

(the Researcher takes the models, positions the models, and ask the learner what kind of moon would be observed with the arrange of the models presented)

Alright, Say this is the sun, ok, and this is the moon, alright, is it possible for us to have an orientation like this? (The Researcher showing the learner yet again the model of the sun and the moon)

Learner: Um, um yes I think so

Researcher: Ok Yes, alright, so if itS is possible for us to have an orientation like this, could you pleae then draw for me what we will be able to see, so…

(The Researcher goes to go fetch a piece of prestick and a matchstick)

Researcher: Imagine that you are this person on a matchstick, alright. And you are standing somewhere in the northern countries, ok, and the orientation is like as represented over here, ok, could you please draw a drawing for me on how you would actually see the moon. Ok

Learner:

(The learner draws what she would expect to see given the orientation of the models arranged by the Researcher.)

It will look bigger than that. Something like that.

Researcher: Ok, so what will we see?

Learner: You see…

Researcher: Could you shade the part that we will see?

Learner: (The learner does the shading)

Researcher: Ok… (The Researcher shows the camera the picture drawn by the learner).

Ok, so you say the shaded part is what we will be able to see

Learner: Yes

Researcher: Ok… (the Researcher moves closer to the camera to show the picture drawn)

Thank you very much, ok.

Learner Number 2

Researcher: Ok, on the table you've got um three models, Ok, now, the yellow globe that you see towards the right represents the sun, the one that you see in the middle is a hockey ball that will represent the moon, and then the third item that you have which is the model of the earth, that would represent the earth. Right, now the whole idea of it is if you can then given a picture that you find in your textbook, um, I would more, I'd be more interested in you modelling out the relative position of the sun, the earth and the moon based on the picture that is given to you. Ok, now, the first picture that we have is of a full moon.

Right, could you rearrange your models in such a way that it will represent that kind of a moon.

Learner: (The learner arranges the models)

Researcher: Ok, so could you please explain how you came about choosing this relative positions.

Learner: Well, I chose this cause as the moon uh rotates around the earth,

Researcher: Yes

Learner: And it gets to this point, the the sun reflects its light to the moon which reflects it back onto the earth (The learner does the explanation while refereeing to the models)

Researcher: Ok, so this position will enable us to see the full moon

Learner: yes

Researcher: Ok

(The Researcher takes the picture of the full moon, and gives the learner another picture of a moon)

Researcher: Is it possible for us to have a crescent represented like this?

Learner: Uh, I don't think so

Researcher: Ok, so we won't be able to see this type of a moon?

Learner: No

Researcher: Alright, thank you.

(The Researcher takes the Picture away from the learner, and gives the learner another picture to look at).

Researcher: Alright, is it possible for us to see this type of a moon?

Learner: Um, no.

Researcher: Ok, why would you say so?

Learner: (Silence): Ok, I think we would

Researcher: Ok, uhh, then why did you suddenly change your mind?

Learner: Beacause I just then thought of it, pictured it

Researcher: Ok, so could you re-arrange your models in such a way that you would be able to see this kind of a moon.

Learner: (the learner re-arranges the models to represent the picture showed).

Like somewhere around there

Researcher: Ok, so explain please your choice.

Learner: Um, cause the sun is not facing this directly (The learner points to the model to show what she means).

Researcher: Ok

Learner: So it is just facing that part. (The learner again shows what she means)

Researcher: Alright, and that will give us that kind of a moon?

Learner: I think so ya

Researcher: Ok

Researcher: I just want to make sure, (the Researcher gives the learner the previous drawing back the learner)

So you said we won't be able to get that kind of a moon?

Learner: Um, we could.

Researcher: So, this is picture 2, which you just said no to

Learner: Yes

Researcher: So can you explain the sudden change.

Learner: Cause, um, if the other one could, if I could do the other one, the previous one, then I guess this could also work.

Researcher: Ok, the how would the representation be if you had to see this kind of a moon?

Learner: Well, the moon would be slightly be towards me, so, and the sun would face that way), so it would be just that little part. Like that

Researcher: Ok, so you saying it is going to move slightly… Ok

(The Researcher takes the picture away from the learner).

Researcher: Alright, then, here we have got the different shapes of the moon as the moon is going through its cycle. Alright, could you model out what would the moon be doing for us to be seeing the different shapes that we would see. So I am not interested maybe in just one position, I just want to see how would the moon move for us to have the different shapes.

Learner: How would the moon move?

Researcher:uhuh

Researcher: Or how would movements, or how would the movement be in terms of the sun, the earth and the moon.

Learner: (Silence for a few seconds)

Um, it, um, I don't understand

Researcher: Ok, so, as I am saying, these are your different phases of the moon (the Researcher refers to the textbook the learner has been using to learn about the phases of the moon) ok, because the earth, uh, the moon goes through different phases, and hence, as it is moving and we are having our different phases, so are we having our different shapes. So previously, you were modelling a situation where you had a typical type of a moon, alright, so what I am interested in is can you model out how the moon would be relative to the earth and the sun for it to undergo the different shapes.

Learner: Well, I think it's going to rotate around the, well this rotates (The learner refers to the model of the earth to show that it is spinning on its own axis)

Researcher: Yes

Learner: So as it rotates, this, the different countries are going to be having their different moon, their night, they will be able to see the moon

Researcher: Ok, so, is the moon, I see you holding the moon there, will the moon remain there?

Learner: Um, I think it will, it will go higher and lower.

Researcher: Ok, what do you mean by higher and lower?

Learner: Um, because, um, as it, as the earth rotates around the orbit, its, its, going higher and lower in a way.

Researcher: Ok, so how will this enable us to see the different shapes that we see?

Learner: I think it's, um, because of the position it is going to be in

Researcher: Ok, so explain more, what do you mean by position?

Learner: I think if its, if its right behind the earth, then you won't really, you won't see the reflection of the light, but if its in on a different angle, then you would be able to see the different shapes because of the reflection.

Researcher: You said if it's behind the earth, you won't be able to see the reflection, Ok, and then I gave you um, the moon representation of the full moon (Researcher gives back the picture of the moon full moon), and you had it more or less in the position, in that position, so now, could you please explain then if you said that the sun is shining on the moon and it is reflecting and now are you saying that it won't be able to be seen, alright, could you please explain that logic?

Learner: Ok, um, basically like if its, if its… the further it is, if its away like hidden, this pos, in this area, then you won't really see it but, if its, the, if its higher or if its here, then you will be more or less be able to see it.

Researcher: (The Researcher takes away the picture)

Ok, alright. So in terms of the different moon phases, how would you explain it using the different models?

Learner: Um, as the earth rotates

Researcher: Yes

Learner: um, the sun reflects its light on the this which will reflect back onto the earth, so if the sun if the moon is here (learner illustrates by means of using the model), then its more or less in line with the sun, and if it is around here, its, it is not really directly, so the sun, the, the light is only on the one side.

Researcher: Ok

Learner: So that the shape from there which was a full moon to now that is half

Researcher: Ok, alright, so then just this small shift would enable us to see all these different shapes?

Learner: Not all of them

Researcher: Ok, so could you explain how it would be if we had to witness all the different shapes.

Learner: Ok, it is from full moon there (The learner is using the models to explain the cause of the moon phases.

Researcher: Yes

Learner: and it moves just a little bit, then its, that part is just slightly covered, so that's, um , that's now it's a half shape, and as it moves, this side here is now facing that way, and the sun is just facing this side, and it is just a little bit of reflection, and then as it moves closer and closer, and when it gets to this point, the sun is only hitting this side and not that side,

Researcher:urhure

Learner: so its just only a half.

And then when you get here there is no, there is no moon, the reflection is hitting this part and not the other. And then as it moves this side, it is only getting the sun , and that side isn't, and then it keeps moving, and then this side, half, half-moon reflects. And then does that

Researcher: ok, could you please just return to this position. (The Researcher point to the learner the position in which he would like the learner to move). You said here there would be no moon, could you please explain that. What do you mean by no moon?

Learner: well, you won't, the people here (The learner points to the model of the earth), won't be able to see the moon because the moon is a 3d shape, so the sun is reflecting at the back and not the front

Researcher: Ok

Could you please stand here at the side

Is it possible for us to have this kind of an orientation?

Silence…

The sun relative to the earth relative to the moon…is it possible for it be positioned it the way I am positioning it right now?

Learner: Um, yes

Researcher: Ok, right, imagine this stick figure to be you, you are in the northern hemisphere, ok, you have the sun in this position, and you have got the moon in this position, right, and you are looking at the moon, ok, could you please draw for me what you would be able to see when you see the moon based on this type of position, ok,

Learner draws what they think they will see

Ok, so which picture is it?

Learner: this one

Researcher: right, the second one, ok

And um, which part would we be able to see? Is it the unshaded part?

Learner: Yes, this is what you will be able to see.

Researcher: Ok, alright, and this is a crescent?

Learner: Yes

Researcher: ok

Alright, thank you very much and thank you for your time.

Learner number 3

Researcher: Alright, on the table over there you've got three different models, ok, so I will explain to you what the models actually represent. So the yellow globe represents the sun, the one in the middle represents the earth as it is in the shape of the earth, and the hockey ball represents the moon. Ok, so the whole idea is for you then to be able to see a picture from a textbook, alright, and then move the models in such a way that we are then able to see the picture that I will be actually showing you. Ok. Is that understood?.

Learner: Yes

Researcher: Fine, alright, so the very first picture

(The Researcher gives the learner the picture).

Alright, uh, could you rearrange the models so that we are able to see the full moon as represented in the picture

(The learner takes the models and illustrates how one is able to see a full moon.)

Could you please then explain how you modelled that out and how you will be able to see that full moon?

Learner: Ok, so the sun is bigger than the earth so that when is shines it gets around and it reflects of the moon so we can see the whole surface

Researcher: Alright.

(The Researcher hands the learner the second drawing)

Are we able then to see a moon like that in the sky?

Learner: Silence (the learner takes the models to try and see what it would look like)

Researcher: Are we able to see it

Learner: Ya

Researcher: Ok, how would that orientation be?

Learner: It's like here, so then , and then it hits like here and shines a bit of it so that you can see that part over there.

Researcher: Right, and then are we able to see a moon like thatin the sky?

Learner: Ya (the learner nods)

Researcher: Ok, so please rearrange it so that you see what is represented in the picture

Learner: It would be like over here

Researcher: Alright, please explain.

Learner: so then, the sun shines on most of the moon except for the part over here (The learner shows which part will not shine)

Researcher: Oh ok, alright.

Learner: The Researcher brings the textbook with the sequence of the moon phases:

Researcher: Alright, this is a typical sequence on the cycle of the moon on how we would be able to see it uh, on different nights as it is going through its cycle. Ok, could you represent with the model how the moon would actually move while it is going through its cycles?

Learner: It would go like around this until it is a full moon

Researcher: Sorry, I cannot here you

Learner: Until it is a full moon

Researcher: Ok

Alright, so imagine this toothpick is you, alright, and you are in the northern hemisphere, ok, and you said that we are able to see an orientation like this, ok. So if you were this person, how would you see the actual moon in this type of position? Could you draw it for me please?

Learner: The learner draws the diagram.

Researcher: So the shaded part is what I will be able to see?

Learner: No, it's this part (the learner shows the Researcher which part will be seen)

Researcher: The un-shaded part would be?

Learner: Yes

Researcher: Ok

Learner number 4

Researcher: Um, on the table you have three models. Ok, the yellow globe represents the sun, the one you have in the middle which is a hockey ball represents the moon, and then the model of the earth then just represents the earth. Alright, the whole idea is for me to give you a picture that you find in your textbook, and try and re-arrange um the models to see the relative positions on how they would be when you actually see a diff a part of a moon, based on the picture that I give you. Alright, the first one is a full moon. So could you please re-arrange the models in such a way that you could see that full moon?

Learner: Ok

Learner: I think it will be like that (the learner shows the Researcher by means of models what the pic would look like.

Researcher: ok, can you explain um that orientation?

Learner: The sun will shine the light on the moon, and we will see that part of the moon: you will see that part of the outline

Researcher: Ok

The Researcher gives the learner another drawing

Is it possible for us to see a moon like that?

Learner: Yes

Researcher: Ok, could you please then re-arrange your models

Learner: (The learner re-arranges the models)

Like that

Researcher: Ok, can you explain that choice?

Learner: Ok, it's because of the light again, that it would be covering this most of the side of the moon, so we will only see a small piece of it here

Researcher: Oh Ok

Is it possible for us to see a moon like that?

Learner: Yes

Researcher: Ok, so can you please re-arrange your models again

Learner: (The learner arranges the models)

Researcher: Ok, can you explain that?

Learner: I am not too sure on where to put it… I think maybe there.

Researcher: Ok, is it fine where I have positioned the sun?

Learner: Um

Researcher: or should I hold the moon for you?

Learner: Yes

Learner: I think, I think like that (The learner refereeing to the orientation of the models)

Researcher: So explain

Learner: Uh, once again, the light from the sun makes us see parts of the moon and from the position from which the sun is, we only see a certain part of the moon. `

Researcher: Ok, so this position will enable us to see that kind of a moon?

Learner: Uh, yes

Researcher: ok, ok thank you

Alright, so this diagram from your textbook uh has the different phases of the moon, ok, as it is going through its cycle. Could you show us using the model um how the movement will be for us to be able to see the different phases of the moon?

Learner: Ok, so do I tell you when it is that

Researcher: Yeah, you can if you want to

Learner: Ok, so you know that the moon moves around the sun, and the earth and the moon move around, I mean, the moon moves around the earth, and the earth and the moon move around the sun, so when the sun is in a certain position, and it reflects light on the moon, and therefore we only see a certain part of the moon, the part that is light lit up is that part that we see, so, as it moves around you see bigger pieces, and it moves around every 28 days.

Researcher: Ok, so show me that movement please.

Learner: uh ok, of everything moving?

Researcher: The Researcher nods.

Well, the just leave the earth.

Learner: so it can stand still

Researcher: Ya

Learner: ok, so this would be moving like that, while that will be moving around this here, so it will all move at the same time.

Researcher: Ok, so what do you mean by all move at the same time?

Ok, just concentrate on the sun, how would the sun be moving

Learner: Ok, the sun stands still,

Researcher: Ok, because I saw you moving the sun …alright, so the sun stands still, so where will the sun be when it is standing still?

Learner: the sun? the sun will be like (The learner indicates where the sun would be) on this side of the earth.

Researcher: ok, so, what will the moon be doing then?

Learner: It would be rotating around

Researcher: Show me, show me

Learner: It would be moving, uh, like this (the learner indicates this movement) like that

Researcher: alright, and that movement will enable us to see the different phases?

Learner: Yes

Researcher: ok

Alright, this is the sun, ok, let me hold it for you…alright, and this is the moon, is it possible for us to have this type of an orientation?

Learner: Um, no

Researcher: Ok, why do you say no

Learner: because the moon would be too far away from the earth

Researcher: Ok

(The Researcher brings the moon closer without changing the orientation)

So if it is here?

Learner: I don't know, I think so, Yes

Researcher: So if it like this it is not possible (the Researchers puts the moon where it originally was in the beginning.

Learner: It is a bit far away from the earth

Researcher: so is it possible or not possible?

Learner: It is, possible

Researcher: Ok, if it is here, is it possible for us to see it (The Researcher pulls the moon further away)

Learner: No

Researcher: Why do you say so?

Learner: No, we can see it because of the earth's light

Researcher: Ok, alright. So, imagine this is you standing on the northern hemisphere, somewhere in Russia. Ok, and you have got the sun over here, and you got the moon over here, alright, could you draw for me what you would be able to see if you are looking at the moon? Ok

Learner: Alright

Half a moon

Researcher: Sorry, what would it be?

Learner: Half a moon

Researcher: Ok, so you are saying that it is half a moon? Altight, um, I see you shading, um, which part will we be able to see?

Learner: the part that is shaded

Researcher:ok, and you say it is half a moon?

Learner Number 5

Researcher: Alright, um, the whole point of this is to then to look at if I give you a picture, how can you represent the models that are given to you on the table. Right, now on the table, the yellow ball alright, would then represent the sun, the hockey ball which is right in the middle would represent the moon. And then the ball that you have which is the model of the earth then would represent earth. And I will give you a picture which you have actually seen from a textbook, and then I want you then to re-arrange the models in terms of what you see in the picture, ok, is that understood?

Learner: Yes

Researcher: right, so the first picture, um, is the full moon. Alright, so, could you pleases re-arrange your models in such a way that we will be able to see that kind of a moon?

Learner: I think that is how you put it

Researcher: Ok, could you please explain then why you would have this kind of an orientation for you to see the full moon?

Learner: Um, sir, cause I think the sun would be um, the sun is like reflecting on that area, and the moon is reflecting more on the earth. I think

Researcher: So this orientation will enable for us to then see the full moon?

Learner: Yes Sir

Researcher: Sorry?

Learner: I think so sir

Researcher: Alright.

` (Next picture)

Right. Is it possible for you to see this kind of a moon?

Learner: Yes

Researcher: Alright, could you re-arrange the models so that we are able to see this crescent.

Learner: I think it will be something like that sir

Researcher: Ok, please explain

Learner: Um sir, because like the sun is reflecting more onto earth, rather than the moon, I think

Researcher: Alright, so this position would eneble us to see the crescent

Learner: Yes

Researcher: Thank you

Then, is it possible for us to be able to see that moon?

Learner: I think so

Researcher: Ok, so can you re-arrange the models in such a way that you are able to see this type of a moon

Ok, please explain

Learner: Um sir, because like , like half of the like, half of the moon is reflecting to the earth, the earth and not a lot of the sun is, ya, reflecting sir.

Researcher: So, this orientation will enable us to see the gibbous one?

Learner: Ya

Researcher: Ok, alright, so this is um the cycle in which the moon then goes through its different shapes as it goes through a cycle. So could you please show moon using the models how the moon would be moving in order for us to get the different shapes that we get

Ok, so for it to go through the different phases, whats happening. Please explain what you have just shown me here

Learner: Um, sir the moon is like going around and like when, like the day goes from morning to night, that's when they like move, its like globe, ya

Researcher: Alright, so I saw you moving the sun and the moon, ok , is that correct?

Learner: Yes

Researcher: Ok, so the explanation of moving the sun and the moon?

Learner: Like um, like uh, how do I, like what do you mean sir?

Researcher: ok, so you were doing this orientation, so you were moving like this (the Researcher showed the learner on how they were moving the sun and the earth). Ok, so could you explain to me why are you doing that type of movement?

Learner: um, cause sir like when it is day time, then the sun comes out on this area of the earth, and then when it is night time, then the moon comes to that area.

Researcher: So this movement enables us to see the different shapes

Learner: yes

Researcher: Ok

Alright, so this is the sun, and this is the moon, is it possible for us to have this type of an orientation?

Learner: I don't think so

Researcher: ok, so why don't you think so?

Learner: Um, sir,cause like wouldn't it be like, wouldn't it be like both reflecting to the same think like

Researcher: Ok, so explain a bit more what you mean by both?

Learner: Like, during like day time, wouldn't the moon be like the same time as the sun

Researcher: Ok, um, is that your explanation?

Learner: Yes sir

Researcher: Alright, so its not possible for us to have this type of orientation?

Learner: No sir

Researcher: sorry

Learner: I don't think so

Researcher: ok

Learner Number 6

Researcher: Alright, on the table, you have got three models. Ok, the yellow globe represents the sun, the white hockey ball represents the moon, and the earth model represents the earth. Alright, the whole idea um is to look at a picture that you will find in a textbook, alright, and uh re-arrange the models in such a way that we are able to see what is represented by the picture. Ok, simple enough? Alright. So, the first one is a picture of the full moon. Right, could you re-arrange the models in such a way that we are able to see a full moon?

Learner: Ok, Doesn't this need to be up, like,

Researcher: Ok, and

Learner: And its too, and it needs to be here I think

Researcher: Ok, and the sun is remaining in its position?

Learner: No

Researcher: Ok,

Learner: The sun also needs to come that side

Researcher: So, can you please explain why you arranged it this way?

Learner: Oh, because like the sun is going to reflect on the side, which it's gonna make like the moon shine there

Researcher: So this representation enables us to be able to see that

Learner: Yes I think

Researcher: Alright, is it possible for us to see a moon like that?

Learner: Yes

Researcher: Could you please re-arrange your models in such a way that its represents this moon

Learner: Ok, Like that

Researcher: ok, so could you please explain your arrangements.

Learner: Ok, like, you, the sun is going to reflect here and it is like only going to show like half of the moon.

Researcher: Ok, thank you

And then is it possible to see a moon like this?

Learner: Yes, I think so

Researcher: Ok, so re-arrange your models in such a way that we are able to see a moon like this

Learner: Like this

Researcher: Ok, Explain please

Learner: Ok, like because then you can only see a part of the moon because the sun is shining here so you can only see a part of the moon.

Researcher: alright, so this arrangement will enable us to see that moon?

Learner: I think so, yes

Researcher: Ok

Then this is just a representation of the different phases of the moon. Ok, so could you model out how movements would be in such a way that we are able to see the different phases.

Learner: Oh, I must like move the…

Researcher: mmm

Learner: Must I start from there

Researcher: it does not matter; I'm just interested in how the movement is for us to see the different phases of the moon.

Learner: Ok, like the moon and the moon goes around the, no nono, the earth goes around the sun, and the moon kind of like follows the like kind of follows the earth

Researcher: Ok, so demonstrate to me what do you mean?

Learner: Like for like that this type of moon then you have like the moon would be like here, and then as it goes around the the moon goes like this and it keeps moving and gets bigger and bigger.

Researcher:ok, and that movement will enable us to see the different shapes of the moon?

Learner: Yes

Researcher: Ok, Is it possible for us to have an orientation like this?

Learner: No

Researcher: Ok, why not?

Learner: Uh, because, oh wait, it is

Researcher: Ok, so imagine this is you, in the northern hemisphere, alright, the toothpick represents you, you have the sun over here, and you have the moon over here. So could you please draw for us what would you be able to see if you are looking at the moon?

Learner: Like what do you mean?

Researcher: Ok, so, this is the moon, and this is the sun, as I showed you this orientation. So you are looking at the moon. So could you draw for me what would you be able to see when you are looking at the moon?

Learner: Oh, sir, I think you will be able to see a full moon.

Learner number 7

Researcher: Alright, um, on the table you have three models, Uh, the yellow globe represents the sun, the white hockey ball represents the moon, and the model of the earth as you see it over there would then represent the earth. And the whole idea is for you to look at the picture from a textbook, and then re-arrange the models in such a way that you are representing what you see in the picture. Is that understood

Learner: Yes

Researcher: Alright, the first picture

This is the full moon, alright, so could you please re-arrange your models in such a way that we are able to see a full moon

Ok

Oh, you have changed it?

Learner: Yes

Researcher: Ok, so please explain then your orientation?

Learner: Ok, um, I put the sun here

Researcher: Just like that

Learner: Ok, I put the sun here so that, um this moon in the middle, so that the light of the moon could show properly.

Researcher: Ok, so explain how this orientation will help us to see a full moon?

Learner: By moving the big one to the side, and then the small one in the middle,

Researcher: Explain a bit more, you said that moving the big one to the side, which big one are you talking about?

Learner: The sun

Researcher: Ok, you moving the sun and the small one to the side?

Learner: to the middle

Researcher, to the middle, ok, so why you are moving this one here and this one in the middle?

So what I am asking is you saying that this will enable for us to see a full moon?

Learner: (The learnere nods)

Researcher: So what im asking is why do you say so?

Learner: Um, the reason why I say so is because um the sun could be big, and maybe if it is in the middle, it will like close the moon, but then if I move the small one, maybe the full moon will show.

Researcher: Ok, so if you say maybe if you move the small one so that the full moon would show, how would you move the small one?

Learner: Um, I don't know,

Researcher: Ok, its not a problem

Researcher: Alright, this is a second picture of a crescent, alright, so please re-arrange your model, or is it possible for us to see a moon like this in the first place?

Learner: Not really

Researcher: Ok, so you would not be able to see a moon like this?

Learner: I think, ok, you could and ya, you can see a moon like that

Researcher: Ok, so if you can see a moon like this, then please re-arrange the models to show me how they would be forming to be able to see this type of a moon?

Ok, so please explain this

Learner: Ok, um, the reason why I move it like this the sun to the side is because if like the sun is in the middle and then it would be on the way for the moon and you would not be able to see the moon fully like that.

Researcher: like, like the picture that we are seeing?

Learner: Yes

Researcher: Ok

Is it possible to see a moon like this?

Learner: Um, no

Researcher: ok, why?

Learner: The reason why I say so maybe it's because, if you um, you can't like really see the moon fully like that

Researcher: Alright, thank you

Researcher: Ok, so this is what you get shown in the textbook in terms of how the moon would go through its different phases, ok, so could you show me using the models how the moon would move for us to see these different shapes that we see?

Learner: Like this, do I have to do like every single one?

Researcher: um, no, I'm more interested in how it would move for us to see the different shapes that ispotrayed by the textbook.

Researcher: So I'm not saying that individually stop, I'm just saying how would the moon be `moving for us to see the different shapes?

Learner: I don't know

Researcher: Sorry

Learner: I don't know.

Researcher: Ok

Is it possible for us to see an orientation like this?

Learner: Yes

Researcher: ok, fine,

So imagine that you are standing here, in the northern hemisphere, somewhere in a country in Asia, and you have the sun here, and you have got the moon over here, could you please draw for me what I would be able to see if I am standing like this? Ok

So what idbe able to see?

Learner: You will be able to see the sun

Researcher: Ok, draw for me what we will be able to see

Ok, so that is what we will be able to see?

Learner: Yes

Researcher: ok, so what is this picture that you have drawn

Learner: It's the sun

Researcher: It's the sun? So we will be able to see the sun but now the moon?

Learner: (the learner nods)

Researcher: Ok

Learner number 8

Researcher: alright, on the table you have three different models, the yellow globe represents the sun, the hockey ball represents the moon, and then the earth model represents the earth. Right, the idea is for me then to give you a picture which you find in your textbook, and then try and re-arrange your models is such a way that we are able to see what is represented in the picture.

Learner: Ok

Researcher: ok, so the first one. It's a full moon, so could you please re-arrange your models in such a way that we are able to see that kind of a moon?

Learner: like this

Researcher: ok, could you please then explain why you arrange them this way?

Learner: Um, ok like the sun is directly behind the moon, so then, so um, so like we on earth can see um can see the moon, the whole moon fully because the reflection of the sun is coming from behind the moon

Researcher: Ok, thank you

Is it possible for us to see a moon like this?

Learner: um, like, yes I think it is

Researcher: Alright, so could you please re-arrange your models in such a way that we are able to see that kind of a moon.

Learner: I think that's that's it

Researcher: Ok, so please explain

Learner: um, I am thinking ok because like the shape of the moon is kind of showing by the corner, so the reflection of the sun would reflect the moon from the side, from a vertical side, so the um the shade would be near the sun, and the moon would shine on the vertical side i think

Researcher: Ok, so what do you mean the moon will shine on the vertical side?

Learner: For us, um, it will show in the vertical, on the opposite side, because the other opposite side is shaded.

Researcher: Oh ok, so the shade side is what we will be able to see?

Learner: No, the side that is not shaded, its like, ok

Researcher: ok, so this orientation will enable for us to see that?

Learner: Yes

Researcher: alright, then is it possible for us to be able to see a moon like this?

Learner: Yes I think, ya it is

Researcher: Alright, so please re-arrange your models

Um, please explain your choice

Learner: um, ì think it is just like the other one but in the opposite way. Because, if um the sun is a bit closer to the earth, then um the piece that is at the bottom like that one will be shaded, and the top side would be like not shaded.

Researcher: Ok, thank you

Alright, so the diagrams here represent the different phases of the moon. Ok, so could you show me using your model the movement of the moon relevant to the sun and the earth how it would move to enable us to see the different shapes of the moon.

Learner: ok, um, I think um the sun, it will start her, the sun, and then we will have full moon, and it would rotate on the other side by the time it is

Researcher: Ok, show me with your models.

Learner: It would rotate like this, and it will change the different shapes, then by the time the sun is behind, then I think that then we will not be having a moon. It would be, um, then it will rotate and go on the other side, so it will be the opposite side of how it began, like the shape until it is there again for another full moon

Researcher: So, its just the sun that is moving

Learner:ya

Researcher: As you showed me, alright, and then the moon is then staying in one position? While changing its shape?

Learner: Or maybe um the moon would actually rotate around the sun and the earth.

Researcher: Ok, like how

Learner: Like rotate and will go the other way around

Researcher: Alright, but earlier on you just showed me the sun moving, and you are now showing me the moon moving. So maybe, could you show me when both the sun and the earth are moving?

Learner: When both of them are moving

Researcher: mmm

Learner: Ok, um, I think when maybe the sun is moving, on the same place, and the earth is moving around the sun and the moon.

Researcher: Could you repeat that

Learner: Like the sun would be moving, but , will be just turning around in one position

Researcher: ok, so show me what you mean by the sun would be moving?

Learner: The sun would be moving like this, then the earth will be moving around the sun,

Researcher: Ok

Learner: ok and the moon would also at some stage be moving.

Researcher: How will the moon be moving?

Learner: Im not sure, but

Researcher: Ok, so are you saying that all of them will be moving

Learner: Ya

Researcher: Ok, alright, so let's try and isolate it. So show me how the moon will be moving?

Learner: Ok, like, like that (the learner illustrates to the Researcher the movement)

Researcher: Ok, so show me how the sun would be moving?

Learner: the sun will be just moving like … (Learner showing the sun spinning on its own axis.

Researcher: Ok, like spinning on its own axis?

Learner: Ya

Researcher: And then the earth?

Learner: The earth would be moving around the sun and the moon.

Researcher: Ok, could you show me a combination between the moon and the earth?

Learner: I don't understand

Researcher: Ok, you said this is just spinning like this, so this is moving, and that is moving. So I am just asking you to show me when both of them are moving

Learner: Ok, it will be kinda like following each other

Researcher: Oh, ok,

Learner: in different times

Researcher: In different times?

Learner: Ya

Researcher: Ok, thank you

Is it possible for us to have an orientation like this?

Learner: Yes it is

Researcher: Ok, so imagine this is you, the toothpick, in the northern hemisphere, this is the sun, and this is the moon as I showed you, right, could you draw for me what you would see when you are looking at the moon. Ok

Alright, thank you very much

Appendix E: Wits Ethics Clearance

Wits School of Education:STUDENT NUMBER: 0414063K

2011ECE130**C**

24 August 2011

Mr. Albert Lubabalo Bhulana

21 Valiant Street

Eden Park

1458

Dear Mr. Bhulana

Application for Ethics Clearance: Master of Science

Thank you very much for your ethics application. The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate has considered your application for ethics clearance for your proposal entitled:

Grade 6-8 textbook analysis and Grade 8 learners three dimensional model representation of Moon Phases.

The committee recently met and I am pleased to inform you that clearance was granted. The committee was delighted about the ways in which you have taken care of and given consideration to the ethical dimensions of your research project. Congratulations to you and your supervisor!

Please use the above protocol number in all correspondence to the relevant research parties (schools, parents, learners etc.) and include it in your research report or project on the title page.

The Protocol Number above should be submitted to the Graduate Studies in Education

Committee upon submission of your final research report.

All the best with your research project.

Yours sincerely

M Mabeta

Matsie Mabeta
Wits School of Education

Cc Supervisor: Dr. A. Lelliott (via email)

27 St Andrews Road, Parktown, Johannesburg, 2193 • Private Bag 3, Wits 2050, South Africa

Tel: +27 11 717-3007 • Fax: +27 11 717-3009 • E-mail: enquiries@educ.wits.ac.za • Website: www.wits.ac.za

Appendix F: Ethics Clearance from Gauteng Department of Education

education
Department: Education
GAUTENG PROVINCE

For administrative use:
Reference no. D2012/114

GDE RESEARCH APPROVAL LETTER

Date:	**12 July 2011**
Name of Researcher:	**Bhulana L.A.**
Address of Researcher:	**21 Valiant Street**
	Eden Park
	1458
Telephone Number:	**011 385 0522 / 071 355 3024**
Fax Number:	**011 616 6000**
Email address:	**bhulanal@yahoo.com**
Research Topic:	**Grade 6 - 8 textbook analysis and grade 8 learners' three dimensional model representation of Moon Phases**
Number and type of schools:	**ONE Secondary School**
District/s/HO	**Johannesburg East**

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

1. *The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*

1

Making education a societal priority

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: David.Makhado@gauteng.gov.za
Website: www.education.gpg.gov.za

4. *A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
5. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
6. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
7. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year.*
8. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
9. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
10. *The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
11. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
12. *On completion of the study the researcher must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
13. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.*
14. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

13 July 2011

Shadrack Phele MIRMSA
[Member of the Institute of Risk Management South Africa]
CHIEF EDUCATION SPECIALIST: RESEARCH COORDINATION

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: David.Makhado@gauteng.gov.za
Website: www.education.gpg.gov.za

Appendix G: Consent forms



21 Valiant Street

Eden Park

1458

July 07, 2011

Educator (Researcher)

Jeppe High School for Girls

Kensington

Dear Madam

Research title: **Grade 6 – 8 textbook analysis and grade 8 learners three dimensional model representation of Moon Phases**

I, Lubabalo Albert Bhulana request your permission to involve your teacher MsPhabiaSpiterri and her grade 8 learners in my study involving learners three dimensional model representation of Moon Phases. I am enrolled for a Masters degree (Science education) at the University of Witwatersrand under the supervision of Dr. Anthony Lelliott.

The purpose of the study is to investigate whether science textbook diagrams used for teaching, have an effect on learners in learning about the moon phases. I plan to work with this teacher and her learners who are willing to participate in the study. The study is valuable because it may inform instruction on what pedagogical strategies can be undertaken to improve instruction of Moon Phases.

During the data collection process I will administer a pre-test to control for instruction. I will also interview learners, and in the interview, will observe how learners represent moon phases using models. The observation will be videotaped.

All the information collected in this study will be kept confidential and used only for the purpose of this study. No names or personal details of participants or the name of the school will be revealed in

reporting the outcomes of the study. Participants are free to withdraw at any time during the study and if participation is withdrawn any information collected on the participant will not be used in the study. If you require more information you can contact me or my supervisor by email or phone.

Yours Faithfully

Researcher — Cell: 0713553024

Lubabalo Albert Bhulana — Email: bhulanal@yahoo.com

Supervisor — Telephone: (011) 717 3413

Dr. Anthony Lelliott — Email: Tony.Lelliott@wits.ac.za

Consent form for the principal

I _____ do/do not (circle one) give informed consent for Lubabalo Albert Bhulana to conduct his research with a grade 8 class.

_____ _____ _____

(Print) Name Signature Date



21 Valiant Street

Eden Park

1458

July 07, 2011

Educator (Researcher)

Jeppe High School for Girls

Kensington

Dear Parent

Research title: **Grade 6 – 8 textbook analysis and grade 8 learners three dimensional model representation of Moon Phases**

I, Lubabalo Albert Bhulana request your permission to involve your daughter in my study involving learners three dimensional model representation of Moon Phases. I am enrolled for a Masters degree (Science education) at the University of Witwatersrand under the supervision of Dr. Anthony Lelliott.

The purpose of the study is to investigate whether science textbook diagrams used for teaching, have an effect on learners in learning about the moon phases. I plan to work with the teacher and her learners in this study. The study is valuable because it may inform instruction on what pedagogical strategies can be undertaken to improve instruction of Moon Phases.

During the data collection process I will administer a pre-test to control for instruction. I will also interview learners, and in the interview, I will observe how learners represent moon phases using models. The observation will be videotaped.

All the information collected in this study will be kept confidential and used only for the purpose of this study. No names or personal details of participants or the name of the school will be revealed in reporting the outcomes of the study. Participants are free to withdraw at any time during the study and if participation is withdrawn any information collected on the participant will not be used in the study. If you require more information you can contact me or my supervisor by email or phone.

Yours Faithfully

Researcher

Lubabalo Albert Bhulana

Cell: 0713553024

Email: bhulanal@yahoo.com

Supervisor

Dr. Anthony Lelliott

Telephone: (011) 717 3413

Email: Tony.Lelliott@wits.ac.za

Consent form for the principal

I _____ do/do not (circle one) give informed consent for Lubabalo Albert Bhulana to conduct his research with my daughter's participation.

_____ _____ _____

(Print) Name Signature Date

21 Valiant Street

Eden Park

1458

July 07, 2011

Educator (Researcher)

Jeppe High School for Girls

Kensington

Dear Teacher

Research title: **Grade 6 – 8 textbook analysis and grade 8 learners three dimensional model representation of Moon Phases**

I, Lubabalo Albert Bhulana request your (MsPhabiaSpiterri) consent to participate in my study. Furthermore I also request consent for your grade 8 learners to participate in my study. The study involves learners three dimensional model representation of Moon Phases. I am enrolled for a Masters degree (Science education) at the University of Witwatersrand under the supervision of Dr. Anthony Lelliott.

The purpose of the study is to investigate whether science textbook diagrams used for teaching, have an effect on learners in learning about the moon phases. I plan to work with you the teacher and your learners who are willing to participate in the study. The study is valuable because it may inform instruction on what pedagogical strategies can be undertaken to improve instruction of Moon Phases.

During the data collection process I will administer a pre-test to control for instruction. I will also interview the learners, and in the interview, will observe how learners represent moon phases using models. The observation will be videotaped.

All the information collected in this study will be kept confidential and used only for the purpose of this study. No names or personal details of participants or the name of the school will be revealed in reporting the outcomes of the study.Participants are free to withdraw at any time during the study

and if participation is withdrawn any information collected on the participant will not be used in the study. If you require more information you can contact me or my supervisor by email or phone.

Yours Faithfully

Researcher	Cell: 0713553024
Lubabalo Albert Bhulana	Email: bhulanal@yahoo.com
Supervisor	Telephone: (011) 717 3413
Dr. Anthony Lelliott	Email: Tony.Lelliott@wits.ac.za

Consent form for the teacher

I _____ do/do not (circle one) give informed consent to Lubabalo Albert Bhulana to participate in his study and to conduct his research using my grade 8 class.

_____ _____ _____

(Print) Name Signature Date



21 Valiant Street

Eden Park

1458

July 07, 2011

Educator (Researcher)

Jeppe High School for Girls

Kensington

Dear Learner

Research title: **Grade 6 – 8 textbook analysis and grade 8 learners three dimensional model representation of Moon Phases**

I, Lubabalo Albert Bhulana request your consent to involve you in my study involving learners three dimensional model representation of Moon Phases. I am enrolled for a Masters degree (Science education) at the University of Witwatersrand under the supervision of Dr. Anthony Lelliott.

The purpose of the study is to investigate whether science textbook diagrams used for teaching, have an effect on learners in learning about the moon phases. The study is valuable because it may inform instruction on what pedagogical strategies can be undertaken to improve instruction of Moon Phases.

During the data collection process I will administer a pre-test to control for instruction. I will also administer an interview with learners, and in the interview, I will observe how learners represent moon phases using models. The observation will be videotaped.

All the information collected in this study will be kept confidential and used only for the purpose of this study. No names or personal details of participants or the name of the school will be revealed in reporting the outcomes of the study.Participants are free to withdraw at any time during the study

and if participation is withdrawn any information collected on the participant will not be used in the study. If you require more information you can contact me or my supervisor by email or phone.

Yours Faithfully

Researcher Contact number: (011) 616-5090

Lubabalo Albert Bhulana

Supervisor Telephone: (011) 717 3413

Dr. Anthony Lelliott Email: Tony.Lelliott@wits.ac.za

Consent form for the Learner

I _____ do/do not (circle one) give informed consent for Lubabalo Albert Bhulana to conduct his research with my participation.

_____ _____ _____

(Print) Name Signature Date



21 Valiant Street

Eden Park

1458

July 07, 2011

Educator (Researcher)

Jeppe High School for Girls

Kensington

Informed Consent Form

Dear Parent

Your child's participation in this project is voluntary. In addition to your informed consent, your child will also be asked if she would like to participate in this project. Only those children who have signed parental consent and who want to participate will be permitted to participate. Any child may withdraw participation at any time during this study. You are free to withdraw your consent for your child's participation at any time and for any reason without penalty or consequence. These decisions will not affect your child's status or grades in any way.

The information that is obtained during this study, will be kept strictly confidential and will not become a part of your child's school record. Any academic use of the information obtained in this study or publication of the research results will make use of pseudonyms, ensuring that your child remains anonymous.

Please complete the informed consent form below indicating clearly whether your child has been given consent to participate and return this note to school with your child.

You may keep the attached copy of this letter for your own records.

Sincerely,

Researcher: Mr L.A. Bhulana

Phone Number: 071-355-3024

Supervisor: Dr Tony Lelliott

Phone number: (011) 717-3260

****

I do / do not (circle one) give informed consent for my child_____ (name of child) to participate in the study described above and to be videotaped.

_____ _____ _____

(Print) Parent's name Parent's signature Date



21 Valiant Street

Eden Park

1458

July 07, 2011

Educator (Researcher)

Jeppe High School for Girls

Kensington

Dear Learner

Informed Consent Form

Your participation in this project is voluntary. Only those learners who have signed parental consent forms and who want to participate will be permitted to participate. You may withdraw participation from the study at any time for any reason without penalty or consequence. These decisions will not affect your status or grades in any way.

The information that is obtained during this study, will be kept strictly confidential and will not become a part of your school record. Any academic use of the information obtained in this study or publication of the research results will make use of pseudonyms, ensuring your anonymity.

Please complete the informed consent form below indicating clearly whether you are willing to participate in this study and give your consent.

I look forward to working with you. I think that my research will be enjoyable and may help you to use group work as an effective way of learning.

Sincerely,

Researcher: Mr L.A. Bhulana

Phone Number: 071-355-3024

Supervisor: Dr Tony Lelliott

Phone number: (011) 717-3260

****

I _____do/do not (circle one) give informed consent to participate in the study described and to be videotaped during the interview.

_____ _____ _____

(Print) Learner name Learner's signature Date