Multimedia Sotho-English E-dictionary for Undergraduate Students in Design and Studio Art

By

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Declaration by Candidate

I, the undersigned, hereby declare that the work contained in this dissertation is my own independent work and that all sources consulted or cited have been indicated in full. This dissertation, or parts thereof, has not previously been submitted by me or anyone else to any other institution in order to obtain a degree.

Refemetswe Vincent Setenane

***Date*: November 2017**

I hereby certify that the above statement is correct.

Ms Leanri van Heerden

Date: November 2017

Dedication

This study is dedicated to my friends and family. I would also like to extend a special thank you to my mother who catapulted my academic career when she dragged me to crèche with blood, sweat, and tears.

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I would like to thank everyone who contributed towards the success of this study. Without their efforts my research would not have been possible.

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Abstract

Introduction: When students study at tertiary institutions they are often confronted with disciplines that are unfamiliar to them. Many of these disciplines are rich in terminology and concepts that students have never been confronted with in their past. In most South African tertiary institutions the language of instruction is English, making it difficult for second language speaking students to grasp the meaning of these terms and concepts. Research has shown that e-dictionaries with multimedia enhancements have greatly facilitated the comprehension of difficult terms and concepts. The inclusion of pictures, videos, animations, cartoons and audio clips into e-dictionaries have been proven to aid students in learning and comprehending new terms and concepts.

Aim: Undergraduate students at the Department of Design and Studio Art, CUT-FS could greatly benefit from the development of a multimedia enhanced Sotho-English e-dictionary. Therefore, the aim of this study was to develop a multimedia enhanced Sotho-English e-dictionary that can be used by undergraduate students from the Department of Design and Studio Art, Central University of Technology, Free State.

Methods: The study was divided into five phases in order to meet the aims and objectives. Firstly, English art and design terms and concepts were sourced from the relevant literature. The English art and design terms and concepts were for first year students at the Department of Design and Studio Art at the Central University of Technology, Free State (CUT-FS). Secondly, Sotho equivalents of the sourced English art and design terms and concepts were devised. Thirdly, the instructional multimedia

aids for the multimedia e-dictionary were designed. Fourthly, the user interface of the e-dictionary was developed. Lastly, the multimedia e-dictionary was tested by undergraduate students at the Department of Design and Studio Art at the CUT-FS. The students were randomly divided into two groups. The control group, Group A, did not have access to a multimedia enhanced e-dictionary while studying art and design terms and concepts. The multimedia group, Group B, had access to a multimedia e-dictionary while studying art and design terms and concepts. Furthermore, purposeful semi-structured interviews were conducted with five Sotho speaking participants of the multimedia group to gather qualitative data about their experience with the multimedia e-dictionary application.

Results: The results of the online comprehension test revealed that the multimedia e-dictionary application successfully facilitated learning amongst the multimedia group students. The group of students that had access to the multimedia e-dictionary application significantly outperformed the group of students that did not have access to the multimedia e-dictionary application (p = 0.0007). The semi-structured interviews that were conducted with a few Sotho speaking students that had access to the application also supported the success of the *SEADD* application.

Chapter 1 – Introduction

1.1 Introduction

When students study at tertiary institutions they are often confronted with disciplines that are unfamiliar to them. Many of these disciplines are rich in terminology and concepts that students have never been confronted with in their past. In most South African tertiary institutions the language of instruction is English, making it difficult for second language speaking students to grasp the meaning of these terms and concepts. At the Central University of Technology, Free State (CUT-FS), the National Diploma offered by the Department of Design and Studio Art, comprises of a number of subjects that are rich in unfamiliar terms and concepts for newly enrolled students, making it difficult for these students to perform satisfactorily (Seepe, 1998: 244). This problem is further exacerbated because the first language of most students is Sotho and not English.

Research has shown that e-dictionaries with multimedia enhancements have greatly facilitated the comprehension of difficult terms and concepts (Yeh & Wang, 2003). The inclusion of pictures, videos, animations, cartoons and audio clips into e-dictionaries have been proven to aid students in learning and comprehending new terms and concepts (Chun & Plass, 1996a; 1996b; Yeh & Wang, 2003; Chun & Payne, 2004; Lew,

2010). Pictorial illustrations, especially, are effective at conveying concepts, because they act as additional meaning indicators in dictionaries (Lew, 2010: 298).

Various authors have indicated that instructional multimedia designs are valuable in explaining complex concepts (Mayer & Gallini, 1990; Mayer & Sims, 1994; Faber *et al.*, 2007). Höffler and Leutner (2007: 723) stated that, "There is strong empirical evidence that learning outcomes are improved by presenting the learner with verbal and pictorial information…" Faber *et al.* (2007: 49) further reminded us that, "The inclusion of different types of visual representation is extremely helpful in specialised knowledge fields since images enhance textual comprehension and complement the linguistic information provided in other data fields."

Sotho speaking students at the CUT-FS that are enrolled in the Design and Studio Art programme, do not have access to a multimedia enhanced Sotho-English e-dictionary providing explanations of terms and concepts in art and design subjects. Because multimedia annotations have been used to enhance vocabulary learning by concurrently using text and image (Chun & Plass, 1996a; 1996b; Yeh and Wang, 2003), the inclusion of multimedia such as videos, pictures, and illustrations could facilitate learning and understanding of problematic terms and concepts.

1.2 Aims and objectives

Undergraduate students at the Department of Design and Studio Art, CUT-FS could greatly benefit from the development of a multimedia enhanced Sotho-English e-dictionary. The multimedia enhanced Sotho-English e-dictionary can alleviate the

language gap, which exists between the students' level of comprehension and the institution's language of instruction, which is English. Thus, the alternative hypothesis that was tested in this study was:

H_A: A multimedia enhanced Sotho-English e-dictionary can facilitate learning and comprehension of undergraduate students at the Department of Design and Studio Art.

Therefore, the aim of this study was to develop a multimedia enhanced Sotho-English e-dictionary that can be used by undergraduate students at the Department of Design and Studio Art, CUT-FS.

To achieve this aim, the following objectives were devised:

- to source words that are problematic for undergraduate students at the Department of Design and Studio Art;
- to design instructional multimedia content that will be used to depict the sourced art and design terms and concepts;
- to develop an interface for a Sotho-English art and design e-dictionary for undergraduate students at the Department of Design and Studio Art; and
- to test the instructional multimedia components of the Sotho-English e-dictionary for its effectiveness to enhance learning and comprehension.

1.3 Delimitations

Only a subset of art and design terms and concepts were selected for the study as opposed to a full set.

1.4 Significance of the study

In the Department of Design and Studio Art, students do not have access to a multimedia enhanced e-dictionary to facilitate their learning and comprehension of difficult terms and concepts. Therefore, a multimedia enhanced e-dictionary should contribute to learning and comprehension of undergraduate students in this department. The e-dictionary would go a long way to introduce Sotho speaking students to art and design terms and concepts in their mother tongue. This is beneficial in mainly two ways: firstly, it will aid in the comprehension of art and design terms and concepts, and secondly it will promote the inclusiveness of an African language in the students' field of study. Furthermore, such an e-dictionary will be the first of its kind in South Africa.

1.5 Layout of chapters:

This dissertation has been arranged into six chapters. Briefly these chapters address the following:

Chapter 1: This chapter introduces the field of study, highlights the problem and provides the aims and objectives of the study.

Chapter 2: A review of the literature that informed the study is discussed in this chapter. Theories from research in multimedia learning, e-dictionary development, and human-computer interaction are reviewed.

Chapter 3: The methodology chapter offers an explanation of the study's research design.

Chapter 4: This chapter provides information regarding how the content for the multimedia e-dictionary was developed. The content was divided into sections that are, text and instructional multimedia.

Chapter 5: The user interface design of the e-dictionary is described in this chapter. The various functionalities, visual design, and the navigation design of the e-dictionary are explained.

Chapter 6: The testing of the e-dictionary is discussed and the results of the test are provided.

Chapter 7: In the concluding chapter the key findings from this study are discussed. Suggestions for future research are also provided.

Chapter 2 – Literature Review

2.1 Multimedia learning

The idea to use images as a memory aid can be traced back to ancient times (Paivio, 2014: 142). Francis Yates' (1966) book, *The Art of Memory*, is frequently cited as a source on the mnemonic use of images by the ancient Greeks. Cave paintings that have been discovered across the globe also serve as examples of how images were used to convey ideas (Carney & Levin, 2002; Tversky *et al.*, 2002; Meggs & Purvis, 2012). Meggs and Purvis (2012: 6) remarked that:

> "The development of writing and visible language had its earliest origins in simple images, for a close connection exists between the drawing of images and the marking of writing. Both are natural ways of communicating ideas, and early people used images as an elementary way to record and transmit information."

The use of static and dynamic visuals as instructional aides in learning has generated much attention in the study of educational technologies (Jenkinson, 2009: 263). Static visuals refer to photos or illustrations, while dynamic visuals refer to animations or videos. The term educational technology refers to the study and process by which learning can be advanced through the use of technology. Research has shown that people learn more effectively from instructional material that utilises images and text as opposed to text-only representations (Narayanan & Hegarty, 2002; Mayer, 2003; Hegarty, 2004; Mayer *et al.*, 2005).

Multimedia presentations are usually divided into two major formats. These formats comprise of words, which include printed or spoken text and images that include static and dynamic media. The term multimedia can be extended to include other modalities such as, haptic (feel), smell, music, or non-speech sound, for example the sound of a bell (Mayer, 2002; Paivio, 2006). Multimedia learning is thus concerned with the use of both text and images to promote learning.

Multimedia learning is distinguished by two major approaches to research. These approaches are referred to as a technology-centred approach and a learner-centred approach (Mayer, 2003; Schnotz & Lowe, 2003; Mayer, 2009). The technology-centred approach focuses on the integration of multimedia into electronic devices and emerging communication technologies such as the internet or mobile devices (Mayer, 2009:10-11). This approach is mostly concerned with comparing the usefulness of various technologies in conveying information. For example, a comparative study on learning from mobile devices as opposed to personal computers falls into this category (Sung & Mayer, 2013). A technology-centred approach is criticised for placing emphasis on the technologies being used, instead of whether the intended learning objectives are being met (Schnotz & Lowe, 2003: 117). However, a technology-centred approach can be useful in testing the usability of devices, especially user interfaces (Jenkinson, 2009: 274).

The learner-centred approach is concerned with how the human mind works and processes information. In the learner-centred approach, the focus is on the use of multimedia technology as an aid to human cognition (Mayer, 2009: 13). A higher degree of learning is achieved when multimedia designs are in line with how the human mind

works (Schnotz & Lowe, 2003; Mayer *et al.*, 2005; Mayer, 2009). In essence, multimedia designs that account for people's cognitive limitations are better at conveying concepts than those that do not (Sweller, 2006; Paivio, 2014).

2.2 Multimedia learning and cognition

The amount of information that the human mind can process is limited (Sweller, 2006; Mayer, 2009). This limitation can be accounted for by employing a learner-centred approach when developing instructional multimedia (Mayer, 2003; Schnotz & Bannert, 2003; Schnotz & Lowe, 2003; Sung & Mayer, 2013). There are three multimedia learning theories on human cognition that stand out in the literature. These theories are: *dual-coding theory* (Paivio, 1986; Clark & Paivio, 1987; Paivio, 2014), *cognitive load theory* (Sweller, 2006; Sweller *et al*., 2011; Wong *et al.*, 2012), and *cognitive theory of multimedia learning* (Mayer, 2003; Mayer, 2009).

2.2.1 Dual coding theory

The use of verbal only modes of instruction has a long history in education (Sadoski *et al*., 1991; Anglin *et al.*, 2004; Paivio, 2014). Various researchers have argued against the dominant use of verbal only modes of instruction and have proposed a dual coding theory of learning (Paivio, 1986; Clark & Paivio, 1987; Clark & Paivio, 1991; Sadoski *et al.*, 1991). Dual coding theory is concerned with how humans process information. The theory posits that, the mind processes information using two distinct subsystems; a verbal subsystem and a non-verbal (imagery) subsystem (Paivio, 1986; Paivio, 2006). The verbal subsystem is used to process language and it is activated by verbal stimuli

referred to as *logogens* (Paivio, 2014: 146). The non-verbal (imagery) subsystem processes non-linguistic objects and events and it is triggered by non-verbal stimuli called *imagens* (Paivio, 2014: 146). Cognition as proposed by dual-coding theory is the interplay of these subsystems and the extent to which both have developed (Clark & Paivio, 1987; Sadoski *et al.*, 1991; Paivio, 2014).

2.2.2 Cognitive load theory

Cognitive load theory proposes that the amount of information an individual can process is determined by the limitations of working memory. This theory was developed to describe the limited capacity of working memory and provides instructional design principles to accommodate the acquisition of knowledge in long-term memory (Sweller, 2006; Kühl *et al.*, 2011; Sweller *et al.*, 2011). Working memory can only manage a limited amount of new information, but it can process unlimited amounts of information from long term memory (Sweller, 2006: 166). This means that prior-knowledge, which is stored in long-term memory, can alter the limited capacity of working memory (Sweller, 2006; Höffler & Leutner, 2007). Thus, when multimedia instructional material is developed, the alteration of long-term memory should be considered in order to accommodate the limitations of working memory (Sweller *et al.*, 2011; Wong *et al.*, 2012).

There are two distinct types of cognitive load: *intrinsic cognitive load* and *extraneous cognitive load* (Sweller *et al.*, 2011: 57). Intrinsic cognitive load is inherent within the basic structure of the information to be learnt (Sweller *et al.*, 2011; Wong *et al.*, 2012). This type of cognitive load refers to the intellectual complexity of learning material and

cannot be modified (Wong *et al.*, 2012: 450). The term *germane cognitive load* is used to describe, working memory resources required to deal with intrinsic cognitive load resulting in learning (Wong. *et al.*, 2012: 450). Extraneous cognitive load is imposed mainly by instructional design practise (Sweller, 2006; Mayer, 2009; Höffler & Leutner, 2011). Extraneous cognitive load can be caused by the transitivity of animations, decorative or seductive elements, and interactivity (interfaces) when learning with multimedia aids (Carney & Levin, 2002; Höffler & Leutner, 2007; Höffler & Leutner, 2011; Brucker *et al.*, 2014). Often instructional design practise causes an unnecessary increase in the number of elements that must be processed simultaneously in working memory (Wong *et al.*, 2012: 450). For this reason various researchers have focused their studies on how extraneous cognitive load can be reduced (Lowe, 2003; Lewalter, 2003; Mayer *et al.*, 2005; Sweller, 2006; Kühl *et al.*, 2011; Brucker *et al.*, 2014).

2.2.3 Cognitive theory of multimedia learning

The cognitive theory of multimedia learning focuses on how learners build connections between words and images. This theory is based upon three assumptions. These assumptions cover the *dual channel assumption*, the *limited capacity assumption*, and the *active learning assumption* (Mayer, 2003; Schnotz & Lowe, 2003; Höffler & Leutner, 2007). The dual channel assumption, which is based on Paivio's (1986) dual-coding theory, proposes the existence of two separate information processing subsystems; a verbal and a non-verbal (imagery) subsystem. The limited capacity assumption is based on cognitive load theory as described by Sweller (2006) and Sweller *et al.* (2011), and refers to the limited capacity of the working memory in processing new information

(Mayer, 2003, Schnotz & Lowe, 2003). The active learning assumption posits that meaningful learning takes place when the learner actively processes information (Mayer, 2003; Schnotz & Lowe, 2003; Mayer, 2009). Active processing requires the learner to select, organise, and integrate information (Mayer, 2003; Höffler & Leutner, 2007; Jenkinson, 2009; Mayer 2009; Fiorella & Mayer, 2015).

When designing instructional multimedia, five cognitive theory of multimedia learning principles apply. The principles were developed to reduce extraneous processing and enhance learning (Mayer, 2009: 86). These principles take into account *coherence*, *signalling*, *redundancy*, *spatial contiguity*, and *temporal contiguity*.

The coherence principle refers to the exclusion of extraneous material such as words, sounds, or graphics that are irrelevant to the multimedia instruction. Irrelevant details can distract learners from the intended instructional message and consequently limit their learning (Lewalter, 2003; Lowe, 2003).

The signalling principle addresses the use of cues that highlight essential words and visual materials. This principle states that people will learn more efficiently when their attention is drawn towards important information, which in turn will guide the learner in creating connections between key elements in the learning material (Mayer *et al.*, 2005).

The redundancy principle addresses learning involving dynamic audio-visual learning materials. This principle states that people learn better from graphics and narration; rather than from graphics, narration, and printed text. Presenting redundant on-screen

text with audio splits the learner's attention which creates extraneous processing (Mayer, 2009: 118).

The spatial contiguity principle specifies that people learn more deeply when essential words are placed near or next to their corresponding graphics on the screen or page. The rationale is that spatial proximity makes it easier for learners to develop connections between corresponding words and graphics (Mayer & Sims, 1994; Mayer *et al.*, 2005).

The fifth principle, temporal contiguity, states that multimedia material is more effective to achieve learning when corresponding words (including narrations) and images are presented simultaneously rather than successively. This principle also helps learners develop connections between corresponding words and images (Mayer & Sims, 1994; Mayer, 2003).

2.3 Learning from static media

Static media such as images, illustrations, and photographs have been used as learning aids in various areas of learning (Mayer & Gallini, 1990; Chun & Plass, 1996a; 1996b; Brucker *et al.*, 2014). This type of media can either be printed or digitally stored on an electronic device (Mayer *et al.*, 2003: 131-132). It has been claimed that people learn better from material that includes text and images as opposed to material that consists of text only (Lowe, 2003; Höffler & Leutner, 2007; Jenkinson, 2009, Mayer, 2014a). Thus, enhanced learning takes place, because images are representational in nature so they can be used as additional meaning indicators (Carney & Levin, 2002; Lew, 2010).

It is important for instructional designers, especially those in the field of graphic design, to understand when and under which conditions images promote learning from text (De Lange *et al.*, 2009). Images can serve various functions in text processing. These functions are categorised as; *decorative, representational, organisational, interpretational, and transformational* (Carney & Levin, 2002: 7).

Decorative illustrations bear little or no relation to the text and as such tend to be text-irrelevant. Text irrelevant elements in images and animations have been found to be detrimental in promoting learning, because they distract people from the thematically relevant information (Mayer & Gallini, 1990; Mayer, 2003; Schnotz & Lowe, 2003; Hegarty, 2004). Decorative elements are also referred to as *seductive details*, which are interesting but irrelevant information or images (Mayer & Estrella, 2014; Heidig, Muller, & Reichelt, 2015). According to the *coherence principle,* irrelevant elements increase extraneous cognitive load and therefore should be avoided (Mayer, 2003, Mayer *et al.*, 2003; Mayer, 2009). Recent studies have analysed the use of decorative details as motivational factors in improving learning from multimedia (Mayer, 2014b; Mayer & Estrella, 2014; Plass *et al*., 2013). Decorative details include elements such as colour and shape. These studies focused on *emotional design*, which investigate how decorative details foster learning by affecting learners' emotions (Plass. *et al.*, 2013: 2). It could be concluded from these studies that decorative elements should be used to highlight important information and not salient information (Magner *et al*., 2014; Mayer, 2014b; Mayer & Estrella, 2014; Schneider *et al*., 2016).

Representational images are the most commonly used type of images, because they are text-relevant (Anglin *et al.*, 2004: 875). These types of representations mirror some

or all of the text content such as actors, objects, and activities happening in the text. Representational images can be either realistic or schematic. Realistic images refer to photographs taken of real world objects, such as a photograph of a frog being used to depict the definition of a frog. In contrast, schematic images consist of simple line drawings and only enough details to make the depicted content recognisable (Brucker *et al.*, 2014: 332). Highly detailed photographs are not always better for learning than line drawings of the same topic (Lew, 2010; Brucker *et al.*, 2014). The details depicted in realistic images could become distracting by drawing the viewers' attention to irrelevant elements (Lew, 2010: 300), while schematic images can be designed without irrelevant elements. The absence of irrelevant elements in schematic images increases the perceptibility of the relevant elements, thereby improving learning (Brucker *et al.*, 2014: 332). In essence, learners might require less cognitive resources to understand schematic images in comparison to realistic images.

Organisational images organise information into a coherent structure. A map is a typical example of an organisational image (Carney & Levin, 2002: 12). Organisational images are generally used to help learners develop qualitative relationships amongst different components in their learning content (Jabbour, 2012: 13). These kinds of images are effective when they adhere to the *contiguity principle*, because people learn best when corresponding words and images are closely aligned (Mayer, 2009: 135). When organisational images are used concurrently in multimedia, as opposed to successively, students' performance is improved in a problem solving (Mayer & Sims, 1994). Concurrently presented text and images allows learners to build referential connections between content components (Mayer *et al.*, 2005). In contrast, when text and images

are presented successively, learners are required to create connections between transient components of the content, because the images and text are isolated from each other. This in turn increases the cognitive resources required to learn when using successively presented text and images in multimedia, thereby hampering effective learning (Mayer & Sims, 1994; Mayer, 2009).

Interpretational images assist in clarifying difficult text such as abstract concepts and or ideas that are hard to understand (Anglin *et al.*, 2004). Studies that analyse interpretational images tend to test their effectiveness in clarifying scientific or technical concepts (Carney & Levin, 2002: 13). For example, Mayer and Gallini (1990) conducted three experiments to test the effect of scientific illustrations on problem-solving and verbatim retention of how the mechanical system of a bicycle pump and a brake worked. The results of these experiments showed that for scientific illustrations to be effective in problem-solving and verbatim retention, four conditions should be met. Firstly, the text must present a cause-and-effect system that allows for qualitative reasoning. Secondly, the performance measures must evaluate the learners' understanding and qualitative reasoning about the system. Thirdly, the illustrations must help the learner build a workable mental model of the system. Lastly, learners must spontaneously engage in active learning processes such as the construction of a runnable mental model of the system.

Transformational or mnemonic images are created to have a direct impact on a person's memory (Laufenberg & Scruggs, 1986; Carney & Levin, 2002; Anglin *et al.*, 2004). Transformational images are used to aid a learner's memory by using images of concrete objects to represent concepts. For example, in computer software a refuse bin

represents the delete function. According to dual coding theory, associating concepts to images can enhance the recall of an idea, because of the dual representation of the idea (Paivio, 1986, Clark & Paivio, 1987).

In conclusion, static media such as photographs and illustrations have been used to enhance textual information as a means to aid learning. It is important for instructional designers to understand the conditions under which such media promotes comprehension (De Lange *et al.*, 2009). Carney and Levin's (2002) five functions of images in text processing can act as a guideline in developing effective multimedia instructional messages. These functions can be used alongside Mayer's (2003) cognitive theory of multimedia learning when developing multimedia instructional messages.

2.4 Learning from dynamic media

Dynamic media refers to animations and videos. The major difference between dynamic media and static media is that dynamic media allows for the continuous depiction of change over time (Tversky *et al.*, 2002; Hegarty, 2004). In contrast, static media can only provide snapshots in time. Dynamic media can be described as a series of rapidly changing frames, which suggest movement to the viewer (Höffler & Leutner, 2007: 723). The perceived benefit of dynamic displays is that they provide an accurate presentation of a process or procedure to facilitate the generation of a mental model (Lewalter, 2003; Lowe, 2003). These mental models play a major role in facilitating learning. Static media, on the other hand, requires learners to develop their own mental models (Kühl *et al.*, 2011: 178). When using static media to infer temporal changes, only key changes

can be depicted in a sequence of static illustrations. The representation of temporal change using static illustrations can be problematic for students with low spatial ability (Höffler & Leutner, 2011: 209).

Dynamic media are often regarded as very realistic, because they are able to portray processes or procedures in real time. A machine in motion is a classic example of how dynamic media has been used to promote the understanding of a system of motion (Hegarty, 2004: 345). Dynamic media can also be used to depict abstract concepts of processes or procedures that are not visible, but are spatially distributed, such as statistical concepts of animal population growth (Ainsworth & Van Labeke, 2004), computer algorithms (Narayanan & Hegarty, 2002), and changes in pressure or temperature on a weather map (Lowe, 2003).

There are three types of change events that are used in dynamic media animations (Lowe, 2003; Ainsworth & Van Labeke, 2004). These changes are *transformations*, *translations*, and *transitions*. Firstly, transformations, involve changes in form, through the alteration of object properties, such as size, shape, colour, and texture. Secondly, translations relate to changes in position and entail the movement of objects from one place to another. Lastly, transitions relate to inclusion changes, which occur when objects appear or disappear on a particular display. The different change events in dynamic displays are a consequence of temporal changes that occur when a process or procedure is taking place. These changes are considered to be transient (Lewalter, 2003; Ainsworth & Van Labeke, 2004). Transitivity in dynamic media occurs when viewers have to integrate incoming information frame-by-frame. The transitivity of animations can lead to increased extraneous cognitive load and therefore reduce the

viewer's comprehension of the presented material (Höffler & Leutner, 2011: 209-210). This occurs because old information has to be stored in working-memory, while new information is being processed (Sweller, 2006; Sweller *et al.*, 2011). The transitivity problem can be alleviated through the introduction of interactivity. Allowing viewers to control the pace of an animation to match their comprehension speed can reduce extraneous cognitive load and improve learning (Hegarty, 2004: 347).

There are two principles that should be considered when developing dynamic media displays for multimedia learning. These principles are the *congruence principle* and the *apprehension principle* (Tversky *et al.*, 2002: 257-258). The congruence principle states that external representations in the form of dynamic media should correspond with internal representations of a learner's mental models (Schnotz & Bannert, 2003: 154). The apprehension principle states that dynamic media should be readily and accurately perceived and comprehended. Reducing extraneous material such as salient or irrelevant elements can help draw the learner's attention towards the thematically relevant components in the learning material (Mayer, 2009; Wong *et al.*, 2012).

Learner differences contribute to the effectiveness of learning when using dynamic media instructional designs. Some of these learner differences include spatial ability, prior knowledge, and cognitive ability (Höffler & Leutner, 2007: 724). Low prior knowledge learners benefit more from dynamic media instructional messages than high prior knowledge learners (Mayer & Gallini, 1990; Mayer & Anderson, 1991; Lewalter, 2003; Schnotz & Bannert, 2003; Mayer, 2009). High prior knowledge learners invest less mental effort in understanding a given topic, which means that they have enough cognitive capacity to engage with dynamic media on a detailed level (Höffler & Leutner,

2007: 724). Spatial ability also plays a role in how well learners are able to develop their own mental models from dynamic media (Mayer & Sims, 1994; Hegarty, 2004; Höffler & Leutner, 2011; Brucker *et al.*, 2014). Learners with low spatial ability benefit more from animations when compared to static images, because animations depict temporal changes (Höffler & Leutner, 2011; Kühl, 2011).

2.5 Learning vocabulary with multimedia

One of the major aspects of language learning involves vocabulary learning. Vocabulary learning affects an individual's level of reading comprehension and the extent to which they can express themselves verbally (August *et al*., 2005: 50). Additionally, syntactic knowledge of a language has also been found to contribute towards reading comprehension (Chun & Plass, 1996a: 507). This is especially true for people that are learning a foreign language (August *et al.*, 2005; Yanguas, 2009). Hatch and Brown (1995: 373) proposed five steps to vocabulary acquisition:

> "(1) having sources for encountering new words; (2) getting a clear image, either visual or auditory or both, of the forms of the new words; (3) learning the meaning of the words; (4) making a strong memory connection between the forms and the meanings of the words; and (5) using the words."

Glossary annotations have been shown to aid vocabulary acquisition. In particular, multimedia glossary annotations have facilitated vocabulary acquisition when learning a foreign language (Plass *et al*., 2003; Yeh & Wang, 2003; Chun & Payne, 2004; Yanguas, 2009). A gloss is a brief definition, which explains the meaning of a word (Vela, 2015: 305). Glossaries are used by learners to comprehend and learn new words

(Vela, 2015: 306). The traditional way of glossing or annotating words is with textual information (Chun & Plass, 1996b: 183). However, with modern computer technology it is possible to use a variety of multimedia such as; text, images, animations or videos, and audio (Plass *et al.*, 2003: 222). The effectiveness of instructional multimedia as an aid to language learning can be explained with dual coding theory (Paivio, 1986; Kim & Gilman, 2008). Therefore, when providing learners with two retrieval cues namely, verbal and visual, it can enhance their learning (Carney & Levin, 2002; Mayer, 2003; Yanguas, 2009).

Teaching a second language requires an understanding of how people process information. Jim Cummins (1979), a linguistics researcher, is credited with identifying the distinction between developing basic interpersonal communication skills (BICS) and cognitive academic language proficiency (CALP) in second language acquisition. BICS refer to, surface conversational fluency in a second language (Cummins, 2008: 71). CALP refers to, "[S]tudents' ability to understand and express, in both oral and written modes, concepts and ideas that are relevant to success in school" (Cummins, 2008: 71). The cognitive demands of developing CALP are much higher than those required in developing BICS (Lilywhite, 2011: 5-6). Students learning academic content in their second language utilise more cognitive resources on trying to infer word meaning from context (Mayer *et al*., 2014: 653).

Instructional multimedia can be used to reduce the cognitive demands that arise when learning new information (Sweller, 2006; Sweller *et al.*, 2011). The teaching of academic content in a second language, while providing instructional aids on the mechanics of language processing is called, *sheltered instruction* (Hinkel, 2013: 311). Several studies

have shown that multimedia assists learners in comprehending unknown words (Yeh & Wang, 2003; Chun & Payne, 2004; Kim & Gilman, 2008; Mayer *et al.*, 2014). Thus, based on the literature, multimedia glosses and dictionaries can be used to enhance the reading comprehension and vocabulary learning of a foreign language (Chun & Plass, 1996a; Lew, 2010; Loucky, 2010).

2.6 Defining an e-dictionary

Electronic dictionaries offer a multitude of features which are over and above those offered by their print counterparts (Nesi, 2000; Lew, 2010; Loucky, 2010). Nesi (2000: 839) explained that, “The term electronic dictionary [e-dictionary] can be used to refer to any reference material stored in electronic form that gives information about spelling, meaning, or use of words.” Traditional printed dictionaries are called linguistic (language) dictionaries, because they commonly use words to convey meaning (Lew, 2010: 292). Dictionaries that focus on the world are called encyclopaedic dictionaries (Gangla-Birir, 2005: 40). The distinction between encyclopaedic and linguistic dictionaries collapsed in the nineties as lexicographers realised that, linguistic dictionaries could benefit from encyclopaedic content, such as illustrations (Gangla-Birir, 2005).

E-dictionaries are a combination of both linguistic and encyclopaedic dictionaries. Features such as; audio, video, animations, illustrations, and hyperlinking enhance the primary need of dictionary users, which is the acquisition of meaning (Lew, 2010; Prinsloo *et al.*, 2012). Users are also able to quickly access information through the use of hyperlinking, which is a word, phrase, or image that a person can click on to jump to

a new document or to a new section within the same document (Christensson, 2006: Online). Hyperlinking can also be used to link an e-dictionary to other online sources in order to cross reference terms (Prinsloo *et al.*, 2012; Du Plessis, 2014). Linking an e-dictionary to other online sources could help broaden the scope of a term and provide users with more in-depth information on its meaning and applications.

There are only a few e-dictionaries that are directed towards the South African market. E-dictionaries have revolutionised the way in which people look up vocabulary information, however, in South Africa the uptake of this technology has been slow (Du Plessis, 2014). This is especially true for indigenous languages such as Sotho, Xhosa and Zulu (Prinsloo, 2012; Du Plessis, 2014). Currently, adequate e-dictionaries are only available in English and Afrikaans. It is possibly not profitable or marketable to design e-dictionaries for the other South African languages (Du Plessis 2014: 77). The available South African e-dictionaries are mostly monolingual and bilingual general language dictionaries. They rarely contain words for specialised knowledge fields (Du Plessis, 2014: 77). However, there are various other multilingual dictionaries in multiple fields of knowledge that have been published by the Department of Sports, Art and Recreation (Department of Sport, Arts, Culture and Recreation, 2013b: online). These dictionaries are available online in a downloadable form of a Portable Document Format (PDF). In essence these dictionaries function as printed dictionaries. Furthermore, they do not include any illustrations or animations, which could aid in conveying the meaning of some of the terms present in the document.

Most e-dictionaries require internet access either to download the software or to access its content. Although e-dictionaries offer an innovative way to learn new words, the

issue of access is problematic. The use of mobile devices such as smartphones and tablets could contribute to alleviating this problem. In the past few years, access to mobile technology has risen dramatically in Africa (Kreutzer, 2009; Aker & Mbiti, 2010). During 2014 the market volume of mobile phones in South Africa grew to 25.8 million handsets, of which 51% of these mobile phones were smart phones (Marketline, 2015: online). Mobile technology has gradually become the number one platform that multimedia designers are developing content for (Kreutzer, 2009: 59). Thus, mobile phones have become a viable platform to develop e-dictionaries for.

2.7 User interface designs

The term *user interface* refers to the means by which users interact with a computer to accomplish some goal (Silver, 2005: 7). The definition can be expanded to include how humans interact with content (Blair-Early & Zender, 2008: 89). For example, interactive dynamic media that allows users to control its pace requires an interface to be designed. User interface design research falls under the broad category of human-computer interaction (HCI). The two basic considerations of an interface are users and content (Blair-Early & Zender, 2008; Scheiderman & Plaisant, 2010).

A user-centred design process should be followed when designing an interface. This process will ensure that software meets the needs of its users (De Schryver & Prinsloo, 2000; Silver, 2005; Hornbæk, 2006; Lazar *et al.*, 2010; Heid & Zimmermann, 2012).The interface designer has to prioritise the user's experience when developing an interface (Silver, 2005: 9). The user in this regard refers to any individual who wishes to accomplish a goal using software or a website (Sauro & Lewis, 2012: 9). The usability of

a system is determined by the following: effectiveness, efficiency, and satisfaction (Silver, 2005; Scheinderman & Plaisant, 2010). Silver (2005: 9) explained that:

> "Effectiveness is the accuracy and completeness with which specified users can achieve specified goals in particular environments. Efficiency is the resources expended in relation to the accuracy and completeness of goals achieved. Satisfaction is the comfort and acceptability of the work system to its users and other people affected by its use."

Design aesthetics play an important role in user interface design. In user interface design, designers follow either a classical aesthetic approach or an expressive aesthetic approach (Lavie & Tractinsky, 2004; Heidig *et al.*, 2015). The classical aesthetic approach refers to orderly and clear design that can be likened to the design rules as suggested by usability experts (Lavie & Tractinsky, 2004). Expressive aesthetics are determined by a designer's creativity and ability to break design conventions (Lavie & Tractinsky, 2004). Aesthetically appealing visuals can make content more appealing for the user and thus motivate the user to engage further with the presented material (Lavie & Tractinsky, 2004; Van Schaik & Ling, 2009). However, the classic aesthetic approach is still being employed, because it is generally regarded as being less distracting to the user (Heidig *et al.*, 2015: 81).

Aesthetically appealing content and interface designs affect users' willingness to continually use software. Studies by Sung and Mayer (2012), Pereira *et al.* (2015), and Hong *et al.* (2017) on government online e-learning platforms, showed that satisfaction with content and interface design greatly influenced the students' intention to continually use the e-learning platforms. Aesthetic appeal in user interface design has been found

to positively affect students' emotional states, but not their learning outcomes (Leutner, 2014; Plass *et al.*, 2013). The congruence principle, which states that extraneous elements should be avoided in instructional design, could explain the lack of improved learning outcomes when learning using expressive aesthetics (Hong *et al.*, 2017).

2.8 Conclusion

Using instructional multimedia as an aid to learning can be beneficial in various ways. Providing learners with a dual representation of an idea, visual and textual, can greatly enhance their comprehension (Mayer, 2009; Höffler & Leutner, 2011; Paivio, 2014). However, the integration of technology into the field of education poses various challenges. So instructional designers should develop an understanding of how people learn and engage with electronic devices. Both the learner-centred and technology-centred approach can be useful in reducing the cognitive load associated with multimedia learning.

Chapter 3 – Methodology

3.1 Study design

The research design of the study followed a mixed methods approach. Creswell (2014: 4) explained that; “Mixed methods research is an approach to inquiry involving collecting both quantitative and qualitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks.” Some components of the project utilised qualitative data and qualitative analytic procedures, while others involved collecting quantitative data and employing quantitative analytic procedures.

The study was divided into five phases in order to meet the aims and objectives. Firstly, English art and design terms and concepts were sourced from the relevant literature. The English art and design terms and concepts were for first year students at the Department of Design and Studio Art at the Central University of Technology, Free State (CUT-FS). Secondly, Sotho equivalents of the sourced English art and design terms and concepts were devised. Thirdly, the instructional multimedia aids for the multimedia e-dictionary were designed. Fourthly, the user interface of the e-dictionary was developed. Lastly, the multimedia e-dictionary was tested by undergraduate students at the Department of Design and Studio Art at the CUT-FS.

3.1.1 Phase 1: Identification and sourcing of English art and design terms and concepts

Prior to the development of the multimedia e-dictionary, a number of English art and design terms and concepts had to be identified and sourced. These terms and concepts were then used as the source material for the multimedia e-dictionary. A few criteria were devised for the identification and sourcing of appropriate terms and concepts. These criteria were:

- Terms and concepts that students traditionally found difficult to grasp should be included in the study.
- Terms and concepts should be sourced from design glossaries and curriculum study guides of the modules offered for the various qualifications at the Department of Design and Studio Art at the CUT-FS.
- Terms and concepts should include elements of art (colour, line, shape, space, texture, and value), graphic art, painting, photography, printing, and sculpting.

A focus group was established to select the terms and concepts suitable for the development of multimedia content and which complied with the selection criteria. The participants in the focus group were lecturers from the Department of Design and Studio Art at the CUT-FS, an art lecturer from Motheo TVET College in Bloemfontein, a terminologist from The Free State Department of Sport, Arts, Culture and Recreation, and the study's supervisors. The objective of the focus group was to establish which of the terms and concepts the focus group members regarded as difficult for the students

to comprehend. The focus group members were also asked to deliberate on the number of art and design terms and concepts that should be included in this study.

3.1.2 Phase 2: Devising Sotho equivalents for the selected English art and design terms and concepts

The Sotho equivalents of the selected English art and design terms and concepts were devised though a terminology development workshop. This workshop was held at the CUT-FS in conjunction with the Free State Department of Sport, Arts, Culture and Recreation. The workshop participants consisted of terminologists, lexicographers, lecturers from the Department of Design and Studio Art, Sotho authors, and students from the Department of Communication Sciences at the CUT-FS. The workshop was conducted in both English and Sotho. “Terminology development efforts typically take a top-down and selective participation approach, relying on workshops in a multidisciplinary setting, which is also advocated by TermNet” (Keet & Barbour, 2014: 1-2).

3.1.3 Phase 3: Development and design of e-dictionary multimedia content

A literature search was conducted to source design principles for the development of instructional multimedia content. Mayer (2009: 86) proposed five principles that can be applied to the design of instructional multimedia. These principles can be used to improve the effectiveness of instructional multimedia as learning aids. The five principles are:

- Coherence principle: Exclude extraneous material such as words, sounds, or graphics that are irrelevant to the multimedia instruction (Mayer & Gallini, 1990; Lewalter, 2003; Lowe, 2003; Mayer, 2003).

- Signalling principle: Utilise cues that highlight essential words and graphics (Mayer, 2003; Mayer *et al.*, 2005).

- Redundancy principle: People learn better from graphics and narration than from graphics, narration, and printed text (Mayer, 2009: 118). The use of narration was outside the scope of the present study. Static text was used for both dynamic and static multimedia. None of the text was narrated.

- Spatial contiguity principle: People learn more deeply when essential words are placed near or next to their corresponding graphics on the screen or page (Mayer & Sims, 1994; Mayer *et al.*, 2005).

- Temporal contiguity principle: Multimedia material is more effective when corresponding words (including narrations) and images are presented simultaneously rather than successively (Mayer & Sims, 1994; Mayer, 2003).

The five principles proposed by Mayer (2009) were applied to the design of the instructional multimedia content. Some preliminary designs were created to be able to understand how these principles can be applied. After understanding how the principles could be applied to a design, the designs for all the multimedia content were created.

3.1.4 Phase 4: Development of the Sotho-English art and design e-dictionary user interface

A conceptual framework was developed for the design of an e-dictionary user interface. The conceptual framework focused on improving the user experience of e-dictionary users. Devising a suitable conceptual framework required the following areas to be addressed; user interface design guidelines, navigation design guidelines, and the evaluation of existing e-dictionaries. The proposed conceptual framework was then applied to the development of a user interface for the multimedia e-dictionary.

Through careful consideration of existing literature on human-computer interaction research, user interface design guidelines were identified. These guidelines underpinned the visual design of the multimedia e-dictionary user interface. The guidelines were recommended by user interface designers as best practises. These guidelines were; simplicity, consistency, purposeful layout, colour and texture, typography, feedback and affordances (U.S. Dept. of Health and Human Services 2006: Online).

The navigation design of the multimedia e-dictionary was informed by existing navigation design guidelines. Various navigation design guidelines were found in a literature search. The navigation design that best suited the needs of e-dictionary users was applied to the user interface.

An online search was used to locate existing e-dictionaries. The purpose of the search was to develop an understanding of the various functions that e-dictionaries offer.

Furthermore, the user interfaces of existing e-dictionaries were also evaluated. The criterion for the online search was for art and design multimedia e-dictionaries directed at both a South African and an international market. The inclusion of multimedia in the e-dictionaries was an important factor. The following search queries were used to locate existing e-dictionaries: *dictionary, art and design dictionary, multimedia art and design dictionary, multimedia dictionary, English-Sotho dictionary, multimedia English-Sotho dictionary, and South African multimedia dictionary*. International was well as locally developed e-dictionaries were evaluated and compared based on existing user interface design guidelines.

A conceptual framework was developed by taking design and navigation guidelines sourced from the literature into account. The evaluation of existing e-dictionaries was used to provide inputs on functionality aspects of e-dictionaries.

3.1.5 Phase 5: Test and refinement of e-dictionary application

The multimedia e-dictionary was tested to ascertain whether it met the aims and objectives of the study. It was tested among first year students at the Department of Design and Studio Art at the CUT-FS. An online comprehension test was created to test the effectiveness of the multimedia e-dictionary as a learning aid. The test was created according to the assessment guidelines of the CUT-FS. The assessment guidelines are based on Bloom's revised taxonomy of educational objectives. The Bloom's taxonomies are divided into six levels which are: knowledge, comprehension, application, analysis, synthesis and evaluation. The university assessment guidelines provide prescriptions on which levels of Bloom's taxonomies should be focused on in assessments for each

year of study. For example, first year students are required to answer questions from the first, second, and third level taxonomies. Because the comprehension test was answered by first year students, the questions of the online comprehension test utilised taxonomies from the first three levels of Bloom's taxonomy, namely, remembering, understanding, and application.

After developing a draft comprehension test, the content was refined by a focus group. This focus group consisted of the study leaders in art and design subjects. The first draft of the test was then piloted by 18 Extended Curriculum Program (ECP) students from the Department of Design and Studio Art at the CUT-FS. The students were asked if the questions were clear and unambiguous. The results of the pilot test were used to refine and finalise the comprehension test.

The participants in the final comprehension test were undergraduate students enrolled at the Department of Design and Studio Art at the CUT-FS. Only students in their first year of study were included as participants. There were a total of 34 participants. The participants were randomly divided into two groups. The one group was referred to as the control group (Group A), while the other was referred to as the multimedia group (Group B). The participants of the control group were provided with art and design terms and concepts in English, excluding multimedia enhancements. This group did not have access to the multimedia e-dictionary beta version. The participants of the multimedia group studied a list of art and design terms and concepts using the multimedia e-dictionary application beta version. An Android Operating System emulator, called *Bluestacks* (www.bluestacks.com) was used to run the mobile application on personal computers in the Department of Design and Studio Art's computer laboratories. After

studying all the art and design terms and concepts, students from both groups were tested on a random sample of those words.

Summary statistics were calculated for the two groups. The control group data and the multimedia group data were also compared with one another by performing a t-test.

A small group of students were purposefully selected from the multimedia group (Group B) for semi-structured interviews. Only Sotho speaking participants were selected for interviews from the multimedia group. The interviews were conducted in order to collect qualitative data about the students' experience while using the multimedia e-dictionary beta application. The qualitative data was used to develop an understanding of the Sotho speaking students' experience while using the application.

Chapter 4 – Developing Content for the Sotho-English Art and Design E-Dictionary

4.1 Introduction

There were two types of content that had to be developed for the multimedia e-dictionary application, text and imagery. Firstly, art and design terms and concepts had to be sourced and selected. Secondly, instructional multimedia had to be designed. The English terms and concepts were sourced from various art and design glossaries as well as curriculum study guides. The sourced terms and concepts were regarded as the population of the study. A focus group was then established for the selection of terms and concepts from the sourced population. The Sotho equivalents for the selected English terms and concepts were created through a terminology development workshop. The instructional multimedia for each respective term and concept were designed according to the principles proposed by the cognitive theory of multimedia learning (Mayer, 2009). The various principles were not used in isolation, but rather in conjunction with one another. All the multimedia content can be viewed online at the following link on Dropbox: https://www.dropbox.com/sh/di85ki18g0zs4eu/AACxBBmO82F1uVvMwigwiVHQa?dl=0

4.2 English terms and concepts and their Sotho equivalents

The initial list of art and design terms and concepts that were identified and selected consisted of 56 words. These art and design terms and concepts were then scrutinized for their relevance and difficulty to understand for first year students. A total of 17 art and design terms and concepts were excluded based on the two scrutinizing criteria. Thus, a total of 39 art and design terms and concepts were included in the final list of terms and concepts that were used for the development of instructional multimedia content. The final list of words consisted of 36 nouns, two adjectives, and one verb. Table 4.1 provides a list of all the art and design terms and concepts that were initially selected. The table also indicates which terms and concepts were excluded and the reasons for their exclusion.

Table 4.1: Original list of art and design terms and concepts including terms and concepts that were excluded together with the reasons for exclusion where S= word selected as part of the final list; E1= word considered easy enough for first years; E2= concept considered a basic term that informs drawing; E3= term considered to be in common usage in the art and design field; and E4= concept considered a basic term that informs all disciplines in art and design.

English Term	Definition	Assess-ment
Additive primaries *noun*	In colour reproduction, red, green, and blue. When lights of these colours are added together, they produce the sensation of white light (Jackson, 1986: 2).	S
Airbrush *noun*	A mechanical painting tool which emits a fine spray of liquid paint or ink. It is fed with a supply of the medium from an attached reservoir and, separately, with compressed air from an external source. The paint combines with the air jet at the tip of the tool to form the spray, in sophisticated models with an adjustable nozzle, the paint can be directed as a broad spray or a line as sharp as a pencil mark, but the airbrush itself does not make contact with the support as does a paintbrush or drawing tool (Martin, 1986: 7).	S
Airbrush *verb*	1. To spray with an airbrush. 2. To alter (an image, especially a photograph) by means of an airbrush or other technique in order to increase its attractiveness or conceal an unwanted part. 3. To alter or obscure (an unwanted part) in an image, especially by using an airbrush (American heritage, 2011: Online).	S
Anamorphosis *noun*	A two-dimensional image designed and executed in such a way that from a frontal viewpoint it appears completely distorted, to the point of being unrecognizable, and can only be seen in correct shape and proportion when viewed from a particular angle, through a special lens, or reflected in a curved mirror (American heritage, 2011: Online).	S
Aperture *noun*	The lens opening on the camera that regulates the amount of light passing through the lens (Jackson, 1986: 5). The diameter of the aperture is measured in f-stops.	S
Ascender *noun*	The upper part of lower-case letters such as b, d, h, etc., that extend above the x-height (Jackson, 1986: 7).	S

English Term	Definition	Assess-ment
Baseline *noun*	In composition, the line on which the bottoms of letters rest, exclusive of descender that fall below the baseline. An imaginary line on which a line of type rests (Jackson, 1986: 12).	S
Bezier curve *noun*	1. A smooth, mathematically defined curve or line consisting of two endpoints (anchors) and two control points (Adams & Dolin, 2002: 494). 2. (Computer science) a curve in a drawing program that is defined mathematically, and whose shape can be altered by dragging either of its two interior determining points with a mouse (McGraw- Hill, 2003: Online).	S
Bleed *noun*	1. An illustration or type is said to bleed when it prints off the edge of a trimmed page. Bleed illustrations are usually imposed so as to print beyond the trimmed page size. An illustration may bleed at the head, front, foot, or gutter (back) of a page (Jackson, 1986:12). 2. Bleeding *noun* a. A spread of oil from an oil-based paint or printing ink as it seeps into the ground or support. This may be seen as a discoloured area surrounding a brush mark or printed line: if the oil is a vehicle for a strong pigment, the bleeding may be tinged with colour. b. The merging of one colour with another on the support when paint is applied in a dilute or liquid form (Martin, 1986: 21-22).	S
Calligraphy *noun*	1. The art of fine writing, or handwriting as an art. The term refers to lettering written directly with a pen or brush and which depends upon the shape of the tool for its characteristic form. It differs from ordinary handwriting in that the aesthetic qualities have equal importance with the meaning of the text and there are established conventions of style and technique. It is also distinguished from the broader field of graphic lettering in that it has a fluidity derived from the letters being written, not drawn or mechanically constructed. Broadly speaking, penmanship is a tradition of western calligraphy while the brush is the tool of oriental and Islamic traditions (Martin, 1986: 32). 2. Elegant, decorative writing. Lines used in artworks that possess the qualities found in this kind of writing may be called “calligraphic” and are generally flowing and rhythmical (Ocvirk *et al.*, 2002: 76).	S

English Term	Definition	Assess-ment
Camera obscura *noun*	(Latin: Dark chamber) 1. A device arranged either in a box or in a small room, for projecting the image of an object or scene outside the chamber onto a sheet of paper or glass screen inside, from which it can be traced in outline. The chamber is dark, and light enters through a small hole cut in one wall, projecting an inverted image of its outside source on the opposite wall, or on a surface placed to intercept it. A lens and mirror may be used to focus the image and turn it right way up (Martin, 1986:33). 2. A system of lenses and mirrors that condenses and reflects an image on to a white surface. Used as an aid to drawing by tracing from the 16th century. The apparatus had to be used in a darkened box (Hill, 1974: 144).	S
Caricature *noun*	A portrait, whether a drawing, painting, print or sculpture, in which the subject's physical characteristics are exaggerated and distorted for comic effect, frequently as a means of passing satirical comment (Martin, 1986: 35).	S
Collage *noun*	1. The technique of creating an image or design by sticking paper, card, fabric, printed matter, string and other materials to a flat support. It is often combined with painting and drawing techniques. 2. An object or image created in this way. Its surface may be flat or in shallow relief, depending on the materials used (Martin, 1986: 46).	S
Colour bar *noun*	On four-color process proofs, samples of the colours used to print the image, showing the amount of ink used, the trapping, and the relative densities across the press sheet (Jackson, 1986: 43).	S
Curvilinear *adjective*	Stressing the use of curved lines, as opposed to rectilinear, which stresses straight lines (Ocvirk *et al.*, 2002: 96).	S
Descender *noun*	That part of a lower-case letter extending below the baseline, as in g or p (Jackson, 1986: 63).	S
Double-page spread *noun*	Any two facing pages on which the layout requires that copy on both pages matches up the binding edge; copy that extends across the gutter margins (Jackson, 1986: 68).	S
Duotone *noun*	A common printing technique by which a halftone is printed in two ink colours—most often black and another colour (Jackson, 1986: 72).	S

English Term	Definition	Assess-ment
Exposure *noun*	In photography, the length of time the shutter or diaphragm of the camera remains open to admit light for reflecting the image upon the film (Jackson, 1986: 79).	S
Foreshortening *noun*	Fine Arts, to reduce or distort (parts of a represented object that are not parallel to the picture plane) in order to convey the illusion of three-dimensional space as perceived by the human eye: often done according to the rules of perspective (Random House, n.d.: Online).	S
Four-colour process *noun*	The four basic colours of ink (yellow, magenta, cyan, and black), which reproduce full-colour photographs or art (Jackson, 1986: 90).	S
Gestalt *noun*	Gestalt refers to the concept that the whole "togetherness" of something is greater than the sum of its individual parts. It is the total concept of the item being created – rather than just thinking of the separate pieces that make up the item (Creative Glossary, n.d.: Online).	S
Grayscale *noun*	A strip of standard gray tones, ranging from white to black, measuring tonal range and contrast (gamma) obtained (Jackson, 1986:96).	S
Guide mark *noun*	A method of using cross line marks on the offset press plate to indicate trim, centering of the sheet, centering of the plate, etc.; these are sometimes called register marks (Jackson, 1986: 92).	S
Gutter *noun*	In binding, the blank space where two pages meet. Also, the blank space between columns of type (Jackson, 1986: 98).	S
Halftone *noun*	Picture with gradations of tone, formed by dots of varying sizes (Jackson, 1986: 99).	S
Hue *noun*	The basic quality of a true colour, e.g. red, orange, orange-red, not referring to the possible range of tones of an individual colour, e.g. light red, dark red (Martin, 1986: 102).	S
Initial letter *noun*	A large capital or decorated letter used to begin a chapter section or sometimes a paragraph (Jackson, 1986: 108).	S
Intaglio *noun*	Intaglio printing is the reverse of relief printing. An intaglio image is transferred from a sunken surface. Copperplate etching and engraving are two intaglio processes. Industrial intaglio printing is called gravure. Gravure is used for extremely long press runs (Adams & Dolin, 2002: 5).	S

English Term	Definition	Assess-ment
Ligature *noun*	Two or more letters merged into one character. In the days of hot metal typesetting, there were five standard ligatures: fi, fl, ff, ffi, and ffl: the ligatures were necessary because otherwise the f would curl into the next letter. There is no technical necessity for ligatures now, though it is thought that they give type a classy look (Jackson, 1986: 118).	S
Lithography *noun*	Lithography as it is known today is a relatively new process, dating from around 1798. A lithographic image is transferred from a flat surface. Certain areas on the surface are chemically treated to accept ink while other areas are left untreated so that they will repel ink. When the surface is inked, the ink remains in the ink-receptive areas, but not in the untreated areas. When a material such as paper contacts the surface, ink is transferred to the paper. This process is sometimes called planography, offset lithography, offset, or photo-offset lithography (Adams & Dolin, 2002: 7).	S
Monochromatic *adjective*	Having only one hue; the complete range of value of one colour from white to black (Ocvirk *et al.*, 2002: 148).	S
Relief printing *noun*	The relief printing process includes letterpress printing, flexographic printing, and all other methods of transferring an image from a raised surface. Although it was a major process in the printing industry, letterpress printing has been replaced largely by other printing processes. Most relief printing done today is done with flexography (Adams & Dolin, 2002: 5).	S
Sans serif *noun*	San serif means “without serifs”. San serif characters are typically formed with uniform strokes and with perfectly vertical letter stress. These type designs generally communicate a modern, clean visual appearance (Adams & Dolin, 2002: 37).	S
Screen printing *noun*	Screen printing is one of the five basic printing processes. The concept is to transfer an image by allowing ink to pass through openings in a stencil that has been applied to a screen mesh. A flexible squeegee is used to force ink through the stencil opening. Although such terms as silk screen, mitography, seriography, and selectine might be classified within this framework, screen printing is the label the industry recognizes and uses (Adams & Dolin, 2002: 294).	S
Serif *noun*	Small strokes that project out from the top or bottom of main letter strokes. Serifs can be vertical or horizontal strokes. Horizontal serifs are parallel to the base line. Vertical letter strokes or serifs are at right angles to the base line, or slightly off 90 degrees (Adams & Dolin, 2002: 36).	S

English Term	Definition	Assess-ment
Square serif *noun*	Square serif typefaces are sometimes referred to as Egyptian typefaces. The serifs on square serif typefaces are not rounded but rather appear as blocks or slabs connected to the main character strokes. Square serif faces are often used in larger point sizes, they tend to make the printed page appear dense and black. Square serif faces generally communicate a feeling of strength or power (Adams & Dolin, 2002: 37).	S
Subtractive primaries *noun*	Colours formed when any two additional primary colours of light are mixed; subtractive colours are yellow, magenta, and cyan; yellow is the additive mixture of red and green light; cyan is the additive mixture of blue and green light (Adams & Dolin, 2002: 510).	S
Type family *noun*	All sizes and weights of basic type design; members may vary in weight, width, or other treatment. For example, a family may include roman, italic, and boldface treatments of a certain typeface (Jackson, 1986: 81).	S
Asymmetrical *adjective*	The description of a form or composition which, assuming a central axis through the form, displays a varied arrangement of components around or on either side of the axis. The arrangement is not necessarily out of balance, but the balance does not depend upon similarity between the component parts and their relative positions within the overall structure (Martin, 1986: 13).	E1
Cast shadow *noun*	The dark area that occurs on a surface as a result of something being placed between that surface and a light source (Ocvirk *et al.*, 2002: 118).	E1
Chisel *noun*	A steel bar formed into a cutting tool by sharpening one end to a point or wedge. The tool can have a great variety of points or cutting-edges and is used principally by sculptors for carving or working stone, wood or metal (Hill, 1974: 172).	E1
Easel *noun*	An adjustable stand upon which a canvas or panel is held while it is being painted (Hill, 1974: 224).	E1
Highlight *noun*	The lightest tone in a drawn or painted image, particularly a small dash or patch of white representing the point of maximum light reflection on a surface (Martin, 1986, 100).	E1
Justified *verb*	Describes text copy that is typeset flush to both the left and the right margin (Jackson, 1986: 112).	E1

English Term	Definition	Assess-ment
Lay figure *noun*	A jointed, wooden doll-like figure constructed in correct human proportions. It can be arranged in a variety of poses, clothed or draped, as an aid to drawing or painting a figure study or composition. Originally, lay figures were life-size models: modern versions are generally small and proportionately scale down, consisting of simple cylindrical and ovoid forms with moveable joints (Martin, 1986: 115).	E1
Symmetrical *adjective*	The description of a form or composition which, assuming a vertical axis through the form, displays a balanced arrangement of similar components around or on either side of the axis (Martin, 1986: 202).	E1
Atmospheric perspective *noun*	The method of creating an illusion of distance in a painting by representing distant objects and landscape with less emphasis in outline, detail, tonal contrast and colour intensity than applied to objects in the foreground. This corresponds to the natural loss of clarity in a view over a considerable distance, due to atmospheric effects. In addition, colours may seem to acquire a bluish tinge as they recede and this effect is also imitated. Also called aerial perspective and, less accurately, colour perspective (Martin, 1986:13).	E2
Bust *noun*	A form of figure sculpture representing the head and shoulders only (Martin, 1986: 31).	E3
Calliper *noun*	A sculptor's instrument for measuring three-dimensional forms. It consists of two metal arms hinged together at one end: at the other end, each arm is pointed and curved inwards, so the points come together when the instrument is closed. To take a measurement, the arms are opened out and fitted on either side of a form or projection, the points touching the surface of the sculpture (Martin, 1986: 32).	E3
Diptych *noun*	A picture or other work of art consisting of two parts facing one another like the pages of a book and usually hinged together (Chilvers, 1990: 129).	E3
Gatefold *noun*	A four-page insert, having foldouts on either side of the centre spread (Jackson, 1986: 92).	E3
Implied shape *noun*	A shape suggested or created by the psychological connection of dots, lines, areas, or their edges, creating the visual appearance of a shape that does not physically exist (Ocvirk *et al.*, 2002: 96).	E3

English Term	Definition	Assess-ment
Kiln *noun*	An oven which can be heated to high temperatures under controlled conditions for the firing of ceramic ware, glazes and slips or enamelling materials. Kilns arc available in different sizes and types for domestic, studio and industrial use, and may be fired by electricity, gas, oil or solid fuel. Electricity is now commonly used in studio work as it is convenient, clean and reliable (Martin, 1986: 111).	E3
Non-representational art *noun*	Defines work encompassing non-recognisable imagery. This ranges from pure abstraction (non-recognisable but derived from a recognisable object) to non-objective art (not a product of the abstraction process, but derived from the artist's mind) (Ocvirk *et al.*, 2002: 96).	E3
Complimentary colour *noun*	Two colours directly opposite each other on the colour wheel. A primary colour is complementary to a secondary colour, which is a mixture of the two remaining primaries (Ocvirk *et al.*, 2002: 148).	E4

Sotho equivalents were devised for each of the art and design terms and concepts in the final list. The members of the terminology workshop that facilitated this process applied mainly two different processes to develop these equivalent terms and concepts. These processes included coining and borrowing. The coining of a new term or concept referred to a process whereby the members devised a completely new term. Borrowing referred to when the members of the terminology workshop loaned a term or concept from existing terms and concepts (Department of Sports, Arts, Culture and Recreation, 2013a: 8). Table 4.2 provides the newly devised Sotho equivalent terms and concepts.

Table 4.2: List of English terms and concepts and their Sotho equivalent term or concept.

English term	Sotho term	Word type	Borrowed or coined
Additive primaries	Motswakotwalo	noun	Coined
Airbrush	Sefafatsi	noun	Coined
Airbrush	-fafatsa	verb	Coined
Anamorphosis	Sethetsa/ thetsane/ moqasea	noun	Coined
Aperture	Aphetjha	noun	Borrowed
Ascender	Tlhakuntjhotjho (hodimo)	noun	Coined
Baseline	Mosehlelo	noun	Coined
Bezier curve	Khefe ya *Bezier*	noun	Borrowed
1. Bleed 2. Bleeding	Phetiso Modutlo/ moqhitso	noun	Coined
Calligraphy	Mokgabongolo/ khalikrafi	noun	Coined/ Borrowed
Camera obscura	Setwalatsi	noun	Coined
Caricature	Kharikhetjha	noun	Borrowed
Collage	Kholaje	noun	Borrowed
Colour bar	Mebalaletoto/ letotommala	noun	Coined

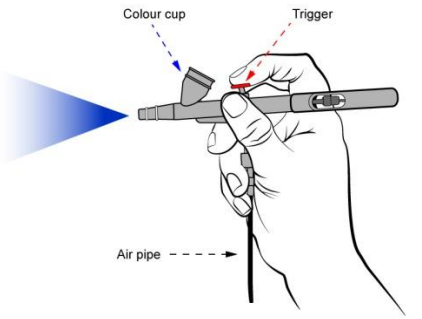
English term	Sotho term	Word type	Borrowed or coined
Curvilinear	Khefe	adjective	Borrowed
Descender	Ditlhakuntjhotjho (tlase)	noun	Coined
Double-page spread	Motakoqephepedi	noun	Coined
Duotone	Mebalapedi	noun	Coined
Exposure	Kolokganya	noun	Coined
Foreshortening	Phokotso/ notlo	noun	Coined
Four-colour process	Tlhahisomebalamene	noun	Coined
Gestalt	Gestalte	noun	Borrowed
Grayscale	Sekalathothofa	noun	Coined
Guide mark	Ditataisi	noun	Coined
Gutter	Ngolokarohanong	noun	Coined
Halftone	Setshwantshotheba	noun	Coined
Hue	Bolengmmala	noun	Coined
Initial letter	Tlhakuqaloleikgethi	noun	Coined
Intaglio	Kgatisotebo	noun	Coined
Ligature	Tlhakumomano/ Liketjha	noun	Coined/ Borrowed
Lithography	Lithokrafi	noun	Borrowed
Monochromatic	Ntshetsopelemmala	adjective	Coined
Relief printing	Kgatisophahamo	noun	Coined
Sans serif	Tlhakupoosho	noun	Coined
Screen printing	Setensele	noun	Borrowed
Serif	Tlhakukgabo	noun	Coined
Square serif	Tlhakukgabosekwere	noun	Coined
Subtractive primaries	Motswakofifi/ motswakotsho	noun	Coined
Type family	Mongolotshwano	noun	Coined

4.2 Selection of multimedia type

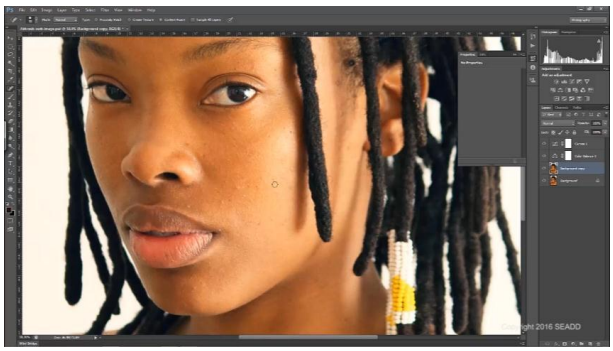
Different multimedia types were developed for each respective term and concept. Static media were used to depict terms and concepts that fall under factual knowledge. Factual knowledge is sometimes used interchangeably with verbal knowledge, "[K]nowledge that can easily or even exclusively be expressed using words such as terminology and definitions" (Brucker *et al.*, 2014: 332). Static and dynamic media are equally suited to express factual knowledge (Lewalter, 2003: 179). Dynamic media were used to depict terms and concepts that described processes. The use of dynamic media to depict processes is especially useful for low-spatial ability as well low prior knowledge students (Höffler & Leutner, 2007; Höffler & Leutner, 2011).

The context of use of a term affected the selection of media types. The terms which had one context of use were depicted with either images or animations respectively. The terms with one context of use are the ones that do not have alternative meanings in the art and design field. For example, "caricature", can only refer to a satirical portrait of an individual. No other meaning can be attached to the term. Some terms' meanings were affected by their contexts of use. The term *airbrush* had to be depicted with both static and dynamic media, because it has two meanings, which differ based on context. The first meaning, which is a noun, refers to a physical airbrush (Figure 4.1a). This meaning of the word can be depicted with an image. The second meaning, which is a verb, refers to the act of *airbrushing* (Figure 4.2b). According to the online American heritage dictionary (2011: Online) *airbrushing* means, "To alter (an image, especially a photograph) by means of an airbrush or other technique in order to increase its

attractiveness or conceal an unwanted part." This meaning of the word was depicted with an animation. That was done to show the process of altering an image.



a. Multimedia design of the airbrush (noun) illustration.

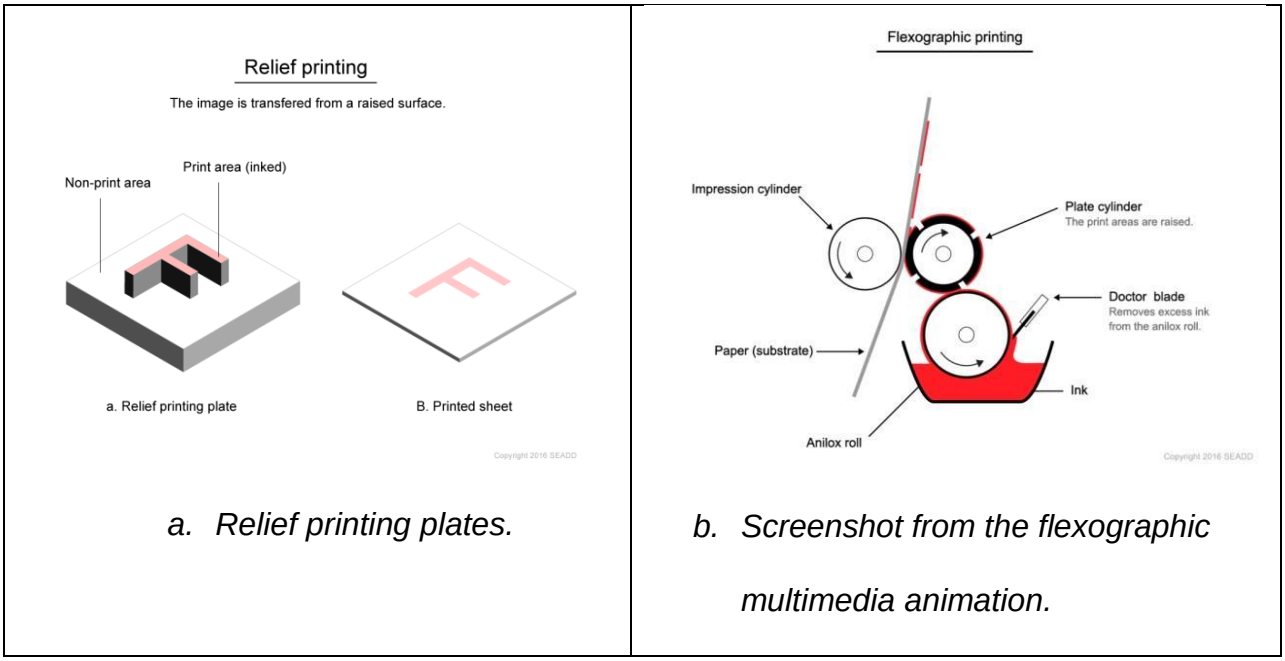


b. Screenshot from the airbrush (verb) multimedia animation.

Figure 4.1: Multimedia designs that were used to depict the meaning of airbrush.

The printing terms, *intaglio*, *lithography*, and *relief printing* had to be depicted with both static and dynamic media. This was done to explain the appearance and function of each printing process' plates. Images were used to depict the plates of the different printing processes (Figure 4.2a). Animations were used to indicate how the entire process of printing takes place (Figure 4.2b). It is important to depict the process to students so that they can understand how each printing process' plates are used. For example, *screen printing* was depicted only with images, because the process is relatively simple. A stencil is always used to print even with more advanced forms that utilise photographic techniques (Adams & Dolin, 202: 295). So the process can easily

be depicted with images. Conversely, *intaglio*, *lithography*, and *relief printing* utilise more complex machinery that have to be depicted with diagrams. Using animations for complex diagrams can help students to create relational connections between the various components (Mayer & Gallini, 1990; Hegarty, 2004). *Relief printing* is interesting in that its printing plates are easy to understand, because they can be related to rubber stamps (Figure 4.2a). However, the modern application of relief printing plates is not so easy to visualise. Traditional *relief printing* has been replaced by *flexographic printing* (Figure 4.2b), which requires the use of more complex machinery (Adams & Dolin, 2002: 354). Therefore, it was necessary to create an animation depicting the modern application of *relief printing* which is called, *flexography*.



a. Relief printing plates.

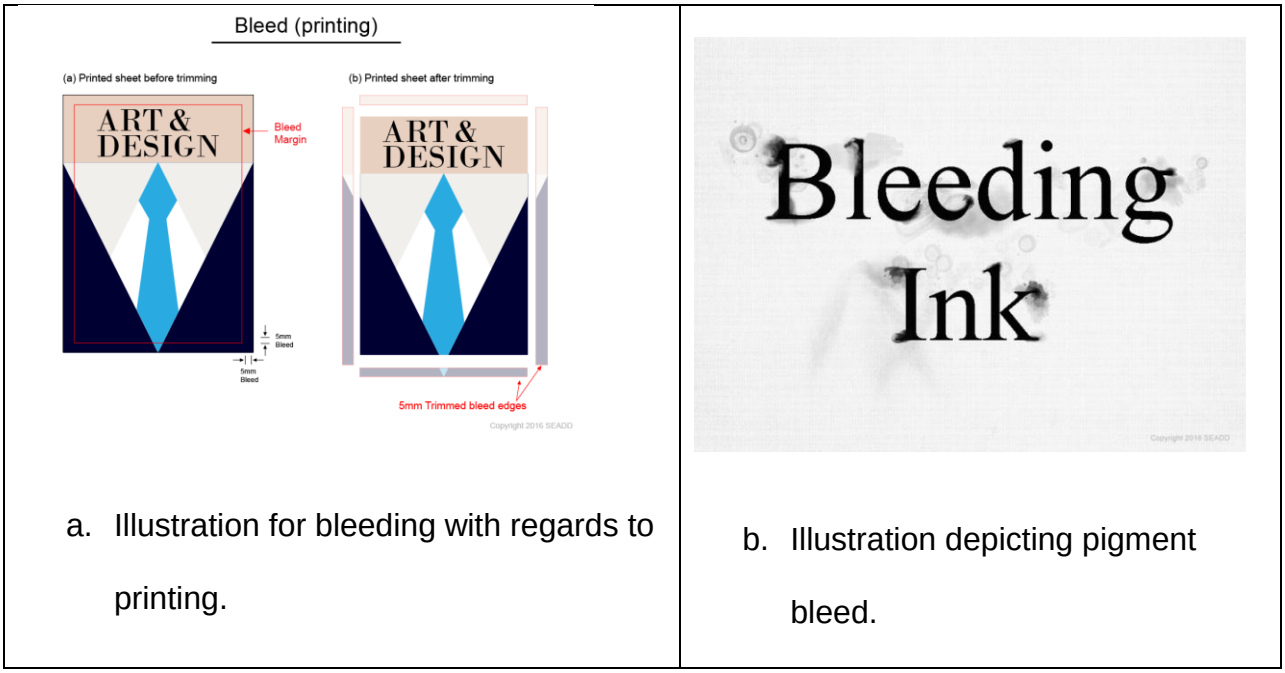
b. Screenshot from the flexographic multimedia animation.

Figure 4.2: Multimedia designs that were used to depict relief printing.

The term *bleed* has two meanings which made it necessary to depict it with two different designs. The two meanings of *bleed* could be depicted using images. Both meanings are not active processes so images could be used to depict them. Figure 4.3a depicts the first meaning of *bleed* which is defined as:

> "An illustration or type is said to bleed when it prints off the edge of a trimmed page. Bleed illustrations are usually imposed so as to print beyond the trimmed page size. An illustration may bleed at the head, front, foot, or gutter (back) of a page" (Jackson, 1986:12).

The first meaning of bleed is used as a technical term in printing. Figure 4.3b depicts the second meaning, *bleeding*, which is defined as, "The merging of one colour with another on the support when paint is applied in a dilute or liquid form" (Martin, 1986: 21-22). In this regard bleeding refers to the (undesired) mixture of paints or inks when applied to a substrate such as paper, cloth, canvas, etc.



a. Illustration for bleeding with regards to printing.

b. Illustration depicting pigment bleed.

Figure 4.3: Different illustrations to depict the meaning of bleed.

4.3 Multimedia content

The instructional multimedia designs were developed according to the principles proposed by the cognitive theory of multimedia learning. Mayer (2009) recommended five principles to reduce extraneous cognitive load and increase learning. The principles he proposed were, the *coherence principle*, *signalling principle*, *redundancy principle*, *spatial contiguity principle*, and *temporal contiguity principle*. Although it is not always possible to isolate and use a single design principle in the development of an instructional multimedia design, some of the instructional multimedia designs in this study do demonstrate the design principles of Mayer (2009) relatively well. All the demonstrations show multimedia designs in which two design principles were applied, of which one explains one of the given principles. For the remainder of the instructional

multimedia designs that were created in this study, more than one of the design principles proposed by Mayer (2009) was applied.

4.3.1 Application of coherence principle in multimedia design

The application of the coherence principle refers to the avoidance of extraneous content. Unnecessary details may distract learners from the intended instructional message and consequently limit their learning (Lewalter, 2003; Lowe, 2003). Thus, in the design of the instructional multimedia, irrelevant words, sounds, or graphics should be omitted from their designs. Figure 4.4 depicts an illustration for an aperture. In the design of the multimedia diagram of an aperture, the major design principle that was applied was the coherence principle. An aperture can be described as “the lens opening on the camera that regulates the amount of light passing through the lens” (Jackson, 1986: 5). To understand the working of an aperture, the interaction between the diameter of the aperture and the amount of light passing through is the most important information. Therefore, in the design of the multimedia content, the coherence principle was applied by illustrating only the lens opening as opposed to an entire camera or lens barrel. Furthermore, only the diameter of the lens opening (aperture) was depicted instead of any other elements such as, a lens barrel or camera, which could become distracting.

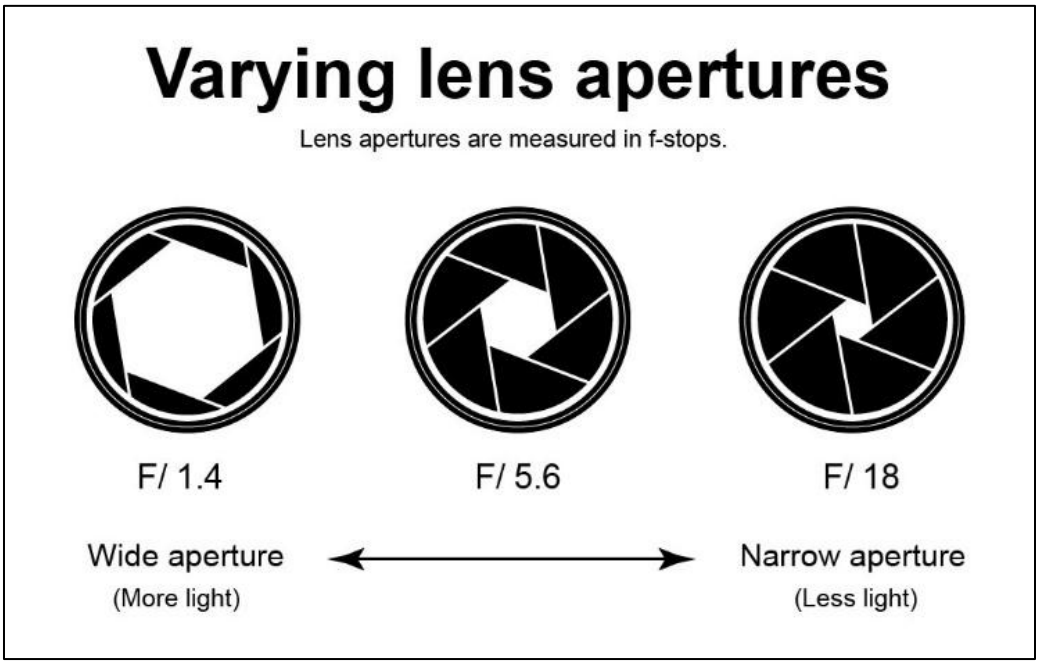


Figure 4.4: Multimedia design of an aperture.

4.3.2 Application of signalling principle in multimedia design

In the application of the signalling principle, cues are used to highlight essential words and graphics. Thus, by applying this principle in the design of multimedia content, a learner's attention is drawn towards important information. The signalling principle can be applied by, for example, highlighting verbal material using outlines, headings, underlining, and pointer words such as first, second, third. Furthermore, visual material can be highlighted using arrows, flashing, and spotlighting (Mayer, 2014a). Figure 4.5 depicts the illustration for an ascender, which has been used to accentuate the letter "d" in the word "design". The ascender is the upper part of a lower case letter "d" that is highlighted in blue. In this example, the ascender acts as a signal to draw the reader to the word.

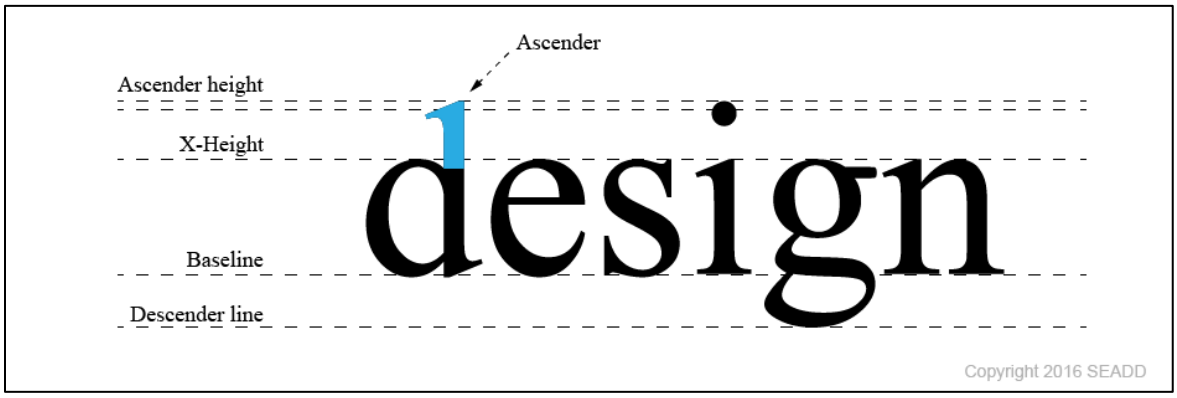


Figure 4.5: Multimedia design of an ascender.

4.3.3 Application of redundancy principle in multimedia design

In the application of the redundancy principle the number of design elements is kept to a minimum. For example, people learn better from graphics and narration than from graphics, narration, and printed text. Static text as opposed to narration was used to provide information for both dynamic and static multimedia. However, all the textual information was presented to the viewer concurrently with the images and animations. Figure 4.6 depicts a screenshot taken from the multimedia animation design of a camera obscura. The animation shows a projection of a flowering pot plant. The redundancy principle was applied by providing textual information that describes the process of light projection that takes place when using a camera obscura to capture an image.

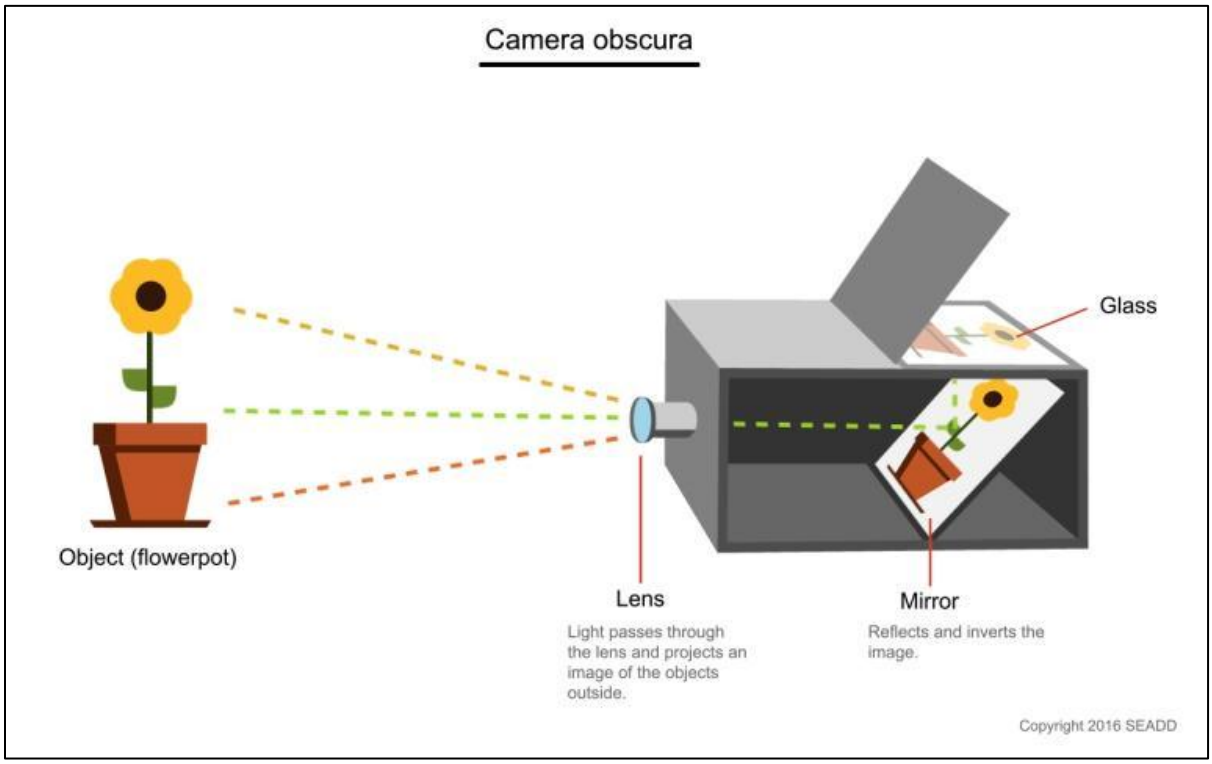


Figure 4.6: Multimedia animation design of a camera obscura.

4.3.4 Application of spatial contiguity principle in multimedia design

When applying the spatial contiguity principle, essential words were placed near or next to their corresponding graphics on the screen or page. The rationale of this principle refers to spatial proximity of corresponding words and graphics that makes it easier for learners to develop connections between the words and graphics (Mayer & Sims, 1994; Mayer *et al.*, 2005). Figure 4.7 depicts a screenshot taken from the multimedia animation illustrating a lithography press. The spatial contiguity principle was applied by placing all the text alongside the corresponding parts of the diagram of the lithographic printing press. Placing the words and the specific elements of the diagram in close proximity should to aid the learner in developing relational connections between the

various components of the lithography press. Also, explanations of each individual part further help learners understand how each part contributes to the entire lithographic printing process (Mayer & Gallini, 1990: 715-716).

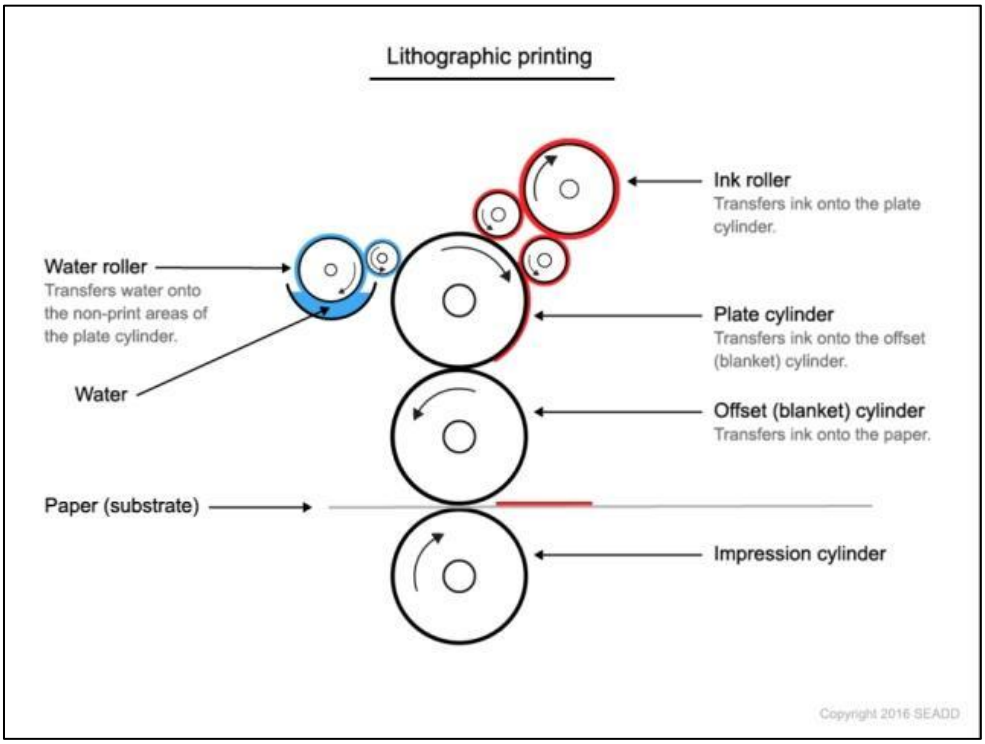


Figure 4.7: Multimedia animation design of the lithography process.

4.3.5 Application of temporal contiguity principle in multimedia design

The temporal contiguity principle is applied by presenting words (including narrations) and pictures simultaneously rather than successively. This principle helps learners develop connections between corresponding words and pictures (Mayer & Sims, 1994; Mayer, 2003). Furthermore, the principle refers to describing temporal changes that take place during an animation. Information describing temporal changes should be

provided as the change happens rather than before or after the change has happened. Figure 4.8 depicts a screenshot taken from the multimedia animation illustrating flexographic printing. The temporal contiguity principle was applied by demonstrating the flexographic printing process as a single animated diagrammatic representation. Words that describe the various graphic components and their functions are presented as the flexographic printing process take place. The descriptive text is presented concurrently with the flexographic printing process multimedia animation as opposed to successively. This helps to enable the viewer in developing relational connections between the temporal changes that take place during the process.

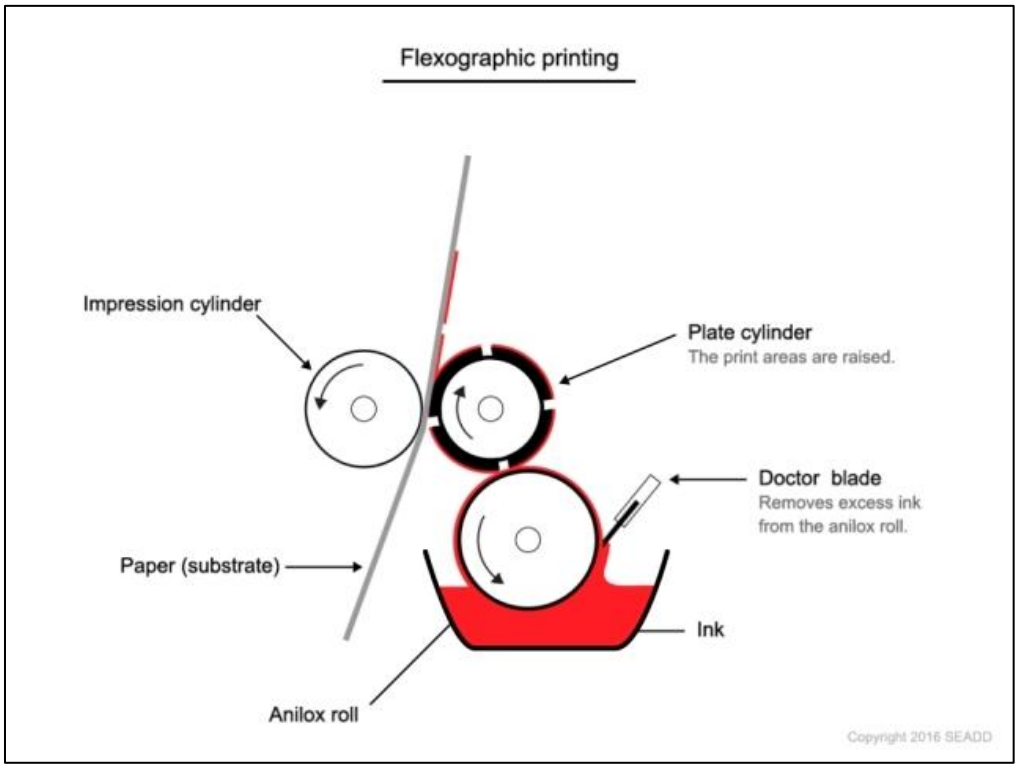


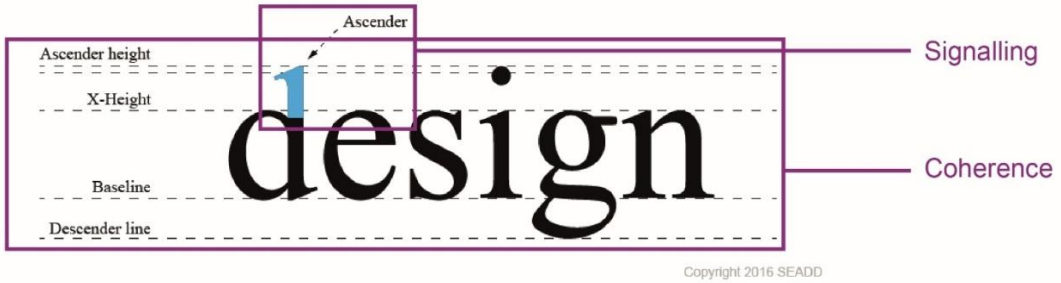
Figure 4.8: Multimedia animation of the flexographic printing process.

4.4 Application of multiple design principles used in the development of multimedia content

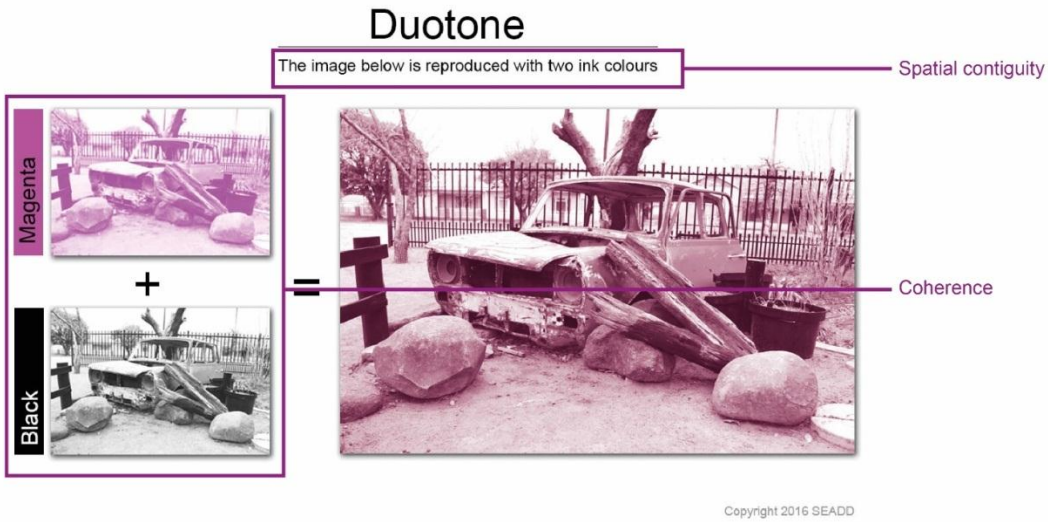
The multimedia design principles were not applied in isolation. In all instances more than one principle was applied to a design. The design principle that was most frequently used was the coherence principle. This principle informed all the designs, because it is concerned with the removal of irrelevant elements in instructional multimedia. Another useful principle was the signalling principle. It aided in guiding the viewer's attention towards important changes or elements on the designs. The spatial contiguity principle was also applied frequently. Important words were placed near or

next to their corresponding graphics on the screen or page. The redundancy and temporal contiguity principles were only applied to animations, because they apply to multimedia designs that change over time.

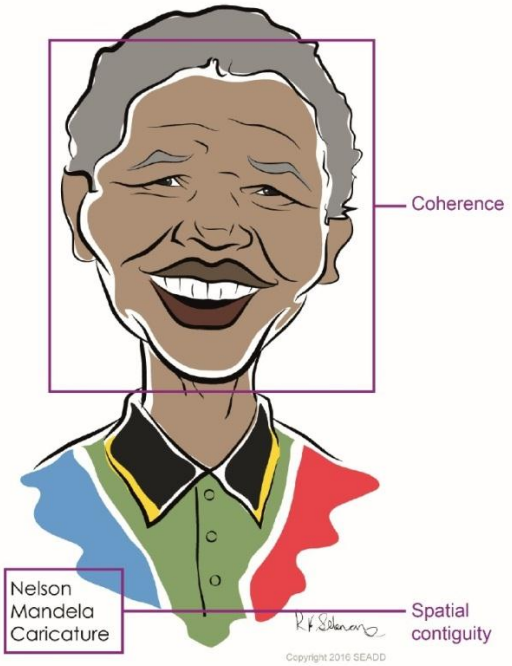
The designs for the easier terms and concepts only had two instructional multimedia principles applied to them. Figure 4.9 depicts some of the designs that were informed by two principles.



a. Ascender illustration.



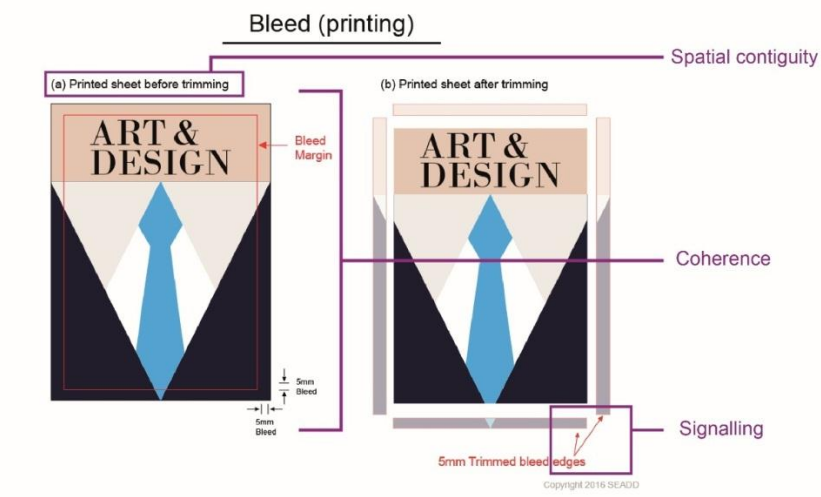
b. Duotone illustration.



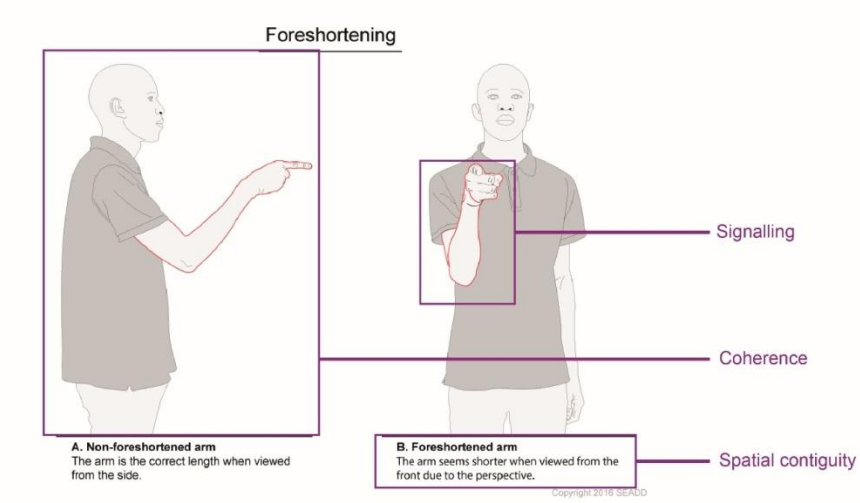
c. Caricature illustration.

Figure 4.9: Multimedia designs with two principles.

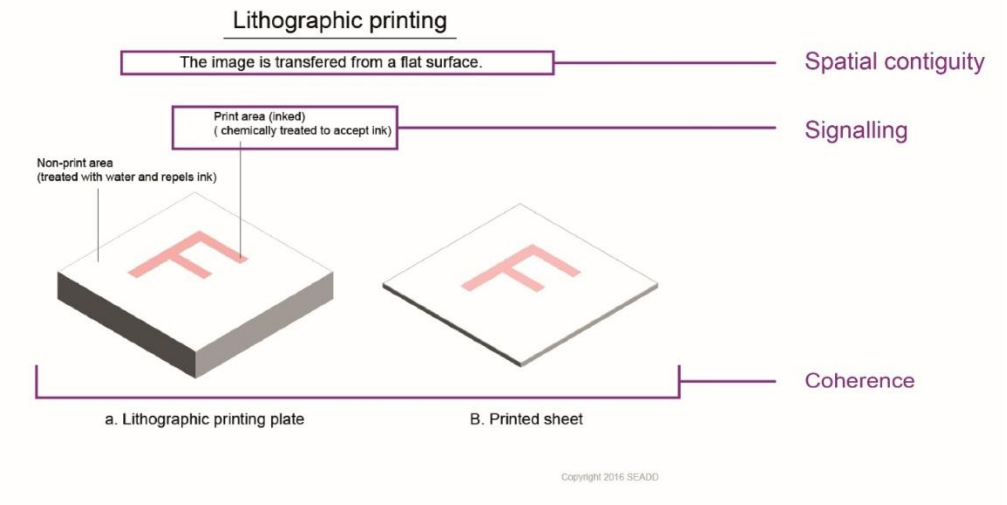
The more complex terms and concepts required the use of more instructional multimedia design principles. Figure 4.10 shows designs in which three principles were applied. More principles were applied to the designs in order to increase their effectiveness in improving learning.



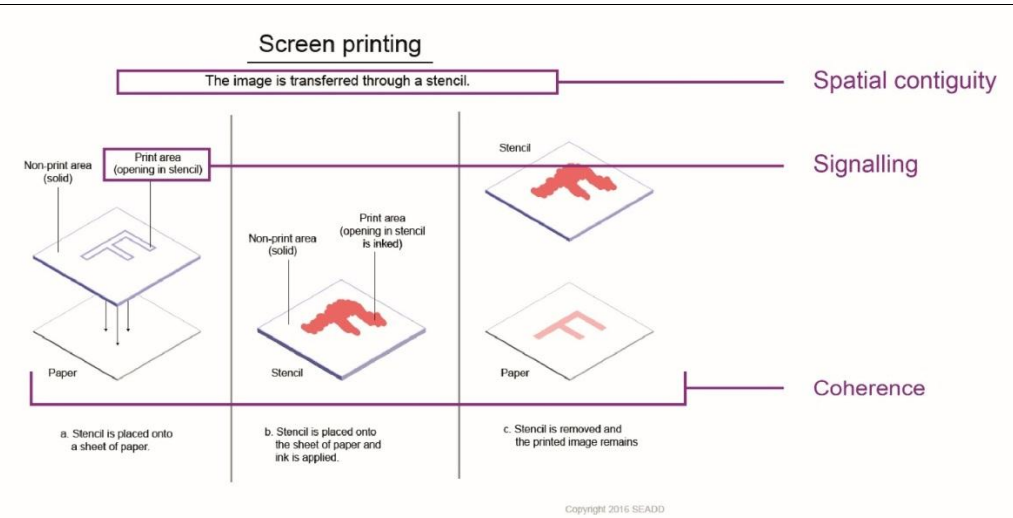
a. Bleed illustration.



b. Foreshortening illustration.



c. Lithographic printing illustration.

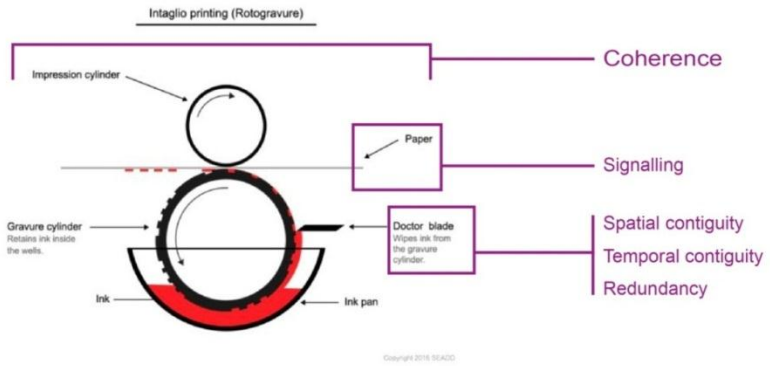


d. Screen printing illustration.

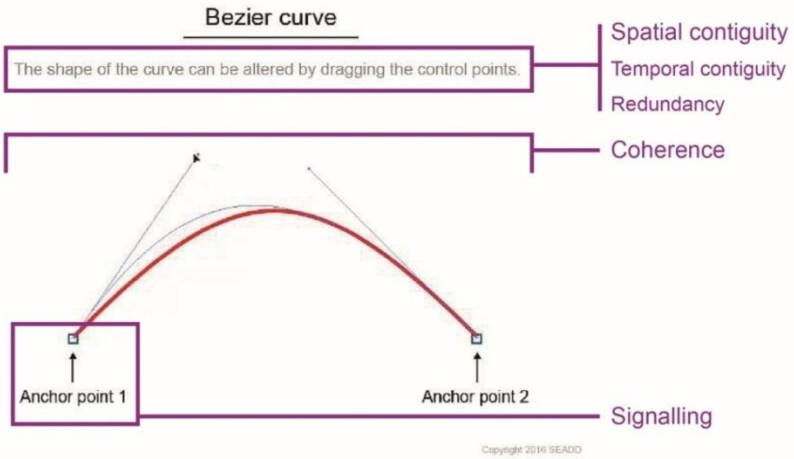
Figure 4.10: Multimedia designs with three principles.

The animated instructional multimedia required the use of all the design principles. Figure 4.11 shows screenshots animated designs in which five principles were applied.

All five principles were applied to the animated designs in order to increase their effectiveness in improving learning.



a. Screenshot of the intaglio printing animation.



b. Screenshot of the Bezier curve animation.

Figure 4.11: Multimedia designs with five principles.

4.5 Discussion

Multimedia designs were developed for 39 art and design terms and concepts. These art and design terms and concepts were deemed difficult for first year students at the

Department of Design and Studio Art, CUT-FS. Sotho equivalents were also devised for all the art and design terms and concepts. The Sotho equivalents were developed either through coining and or borrowing, in the hope that these equivalents would also contribute to the learning process. The instructional multimedia was designed according to the principles proposed by the cognitive theory of multimedia learning. The principles were not used in isolation, but rather in conjunction to ensure that the instructional multimedia designs would facilitate learning.

Chapter 5 – User Interface Design for the Sotho-English Art and Design E-dictionary

5.1 Introduction

The success of any e-dictionary lies in the strength of its content. E-dictionaries are used as electronic reference materials. They provide users with information on the meaning, spelling, or use of words. Therefore, e-dictionary users have to able to efficiently find the information that they are looking for. Access to e-dictionary content is thus important, because it affects how well e-dictionaries cater to the user's needs.

The ease at which users navigate through interfaces can greatly influence their satisfaction with software (Courage & Baxter, 2005; Silver, 2005). Navigation determines the user's access to content when using computer software. E-dictionaries require users to navigate through an interface in order to access the information that they require. Navigating through an e-dictionary interface can lead to increased cognitive load if the user focuses more on navigation than on the content that is stored in the e-dictionary.

When designing an e-dictionary, it is important to take note of aspects that address content, as well as the interface. Therefore, content and navigation are the two most important aspects to consider when designing an e-dictionary. The two major components that influence a user's satisfaction with an e-dictionary are interface and content. Some existing design guidelines have been suggested for the development of

navigable interfaces (U.S. Dept. of Health and Human Services 2006: Online). To develop the user interface for the Sotho-English Art and Design E-Dictionary (*SEADD*) beta application a conceptual framework was developed. The development of the conceptual framework entailed the following:

- existing user interface design guidelines were sourced from the literature;
- navigation design guidelines were also sourced from the literature; and
- different e-dictionaries were evaluated and compared.

5.2 Designing a conceptual framework

A conceptual framework was devised to underpin the design of the *SEADD* application's interface. The design of the conceptual framework was divided into three phases. Firstly, existing user interface design guidelines were sourced from the literature. Secondly, navigational design guidelines that affect user interfaces were identified. Lastly, existing e-dictionaries were evaluated and compared based on their interfaces and functions. After the three phases had been completed, a conceptual framework was proposed and applied to the design of the *SEADD* application's interface.

5.2.1 User interface design guidelines

When designing an interface for an e-dictionary it is important to follow suitable guidelines that inform the design process. Several authors have proposed design guidelines as best practices that can be followed when developing a user interface (U.S. Dept. of Health and Human Services 2006: Online). These guidelines focus strongly on

a user-centred approach for the design process. There are seven guidelines that are used by most designers to ensure that user interface navigation is optimal (Table 5.1).

Table 5.1: User interface design guidelines (amended from U.S. Dept. of Health and Human Services, 2006).

Guideline	Description
Simplicity	Simplicity refers to avoiding clutter in the layout and using clear language to guide the user.
Consistency	Consistency refers to the creation of common user interface elements, because patterns contribute to a more efficient layout.
Purposeful layout	A purposeful page layout refers to the utilisation of spatial relationships to establish a sense of hierarchy.
Colour and texture	Colour and texture can be used to draw attention to elements on a page or website.
Typography	Typography is used to create hierarchy and clarity. Typefaces also contribute towards legibility and readability.
Feedback	Feedback refers to a system that communicates what's happening to users by informing them of any changes in state, actions, and errors.
Affordances	Affordances reduce the burden on users by anticipating their goals and developing defaults that allow them to easily navigate through a system.

5.2.2 Navigational guidelines

The menu structure of any software application, including e-dictionaries is determined by a navigation design. The navigation design guides users between various tasks that they can perform while using an interface. These tasks refer to particular functions that

users need to accomplish when using a software application (Silver, 2005: 78). Menu designs influence how users navigate through software applications when completing a task. The main task of an e-dictionary user is to locate a term (or concept) and its meaning (Lew, 2010: 291). Thus, e-dictionaries should be designed with a menu structure that allows the user to locate the meaning of a term or concept in an efficient manner.

A menu structure comprises of a range of options that a user can choose and select. These options within a menu can be visualised as a hierarchical tree structure (Zaphiris, 2001; Yu & Roh, 2002). Each major option represents a level in the hierarchical tree structure. These levels are synonymous with the major functions that the software application performs. A particular hierarchical tree structure of a menu determines the ease at which a user is able to complete tasks. The two major hierarchical tree structures that are often applied when designing navigation menu structures are the broad-shallow and narrow-deep structures. The broad-shallow menu design has a relatively large number of levels with a few sub-options per level and therefore has a wide and short appearance (Lazar *et al.*, 2010: 7). The narrow-deep hierarchical tree structure, on the other hand, has a relatively small number of levels, but contains several sub-levels, each with a number of sub-options. The narrow-deep hierarchical tree structure, therefore, has a narrow and tall appearance. Narrow-deep menu structures are problematic, because an increase in the amount of levels that need to be navigated by the user leads to confusion and frustration (Lazar *et al.*, 2010: 7). Menu structures should thus provide users with well a defined sequence of steps when completing a task without causing confusion and frustration (Zaphiris, 2001: 541).

Therefore, the broad-shallow menu structures are often preferred over narrow-deep menu structures (Norman & Chin, 1988 Lazar *et al.*, 2010).

5.2.3 Evaluation of the various functions of e-dictionaries

a. Online search for existing e-dictionaries

An online search was undertaken to source existing multimedia e-dictionaries. The inclusion of multimedia in these e-dictionaries was the major selection criterion. The search covered international, as well as locally developed monolingual and bilingual e-dictionaries. The inclusion of locally developed e-dictionaries was important, because of the richly diverse language landscape in South Africa.

The initial online search for multimedia e-dictionaries was for art and design e-dictionaries. Art and design e-dictionaries were considered first, because the current study is about the development of a multimedia art and design e-dictionary. The search revealed that the art and design e-dictionaries that were sourced were not of a high standard in respect to interface design. One of the art and design dictionaries that was located was called *Artlex.com* (http://www.artlex.com). The multimedia content contained in *Artlex.com* is very small in scale, making it difficult to view. This webpage was considered to be a poor example of a user interface design. Because this initial search did not reveal suitable multimedia e-dictionaries, the online search was extended to general language e-dictionaries.

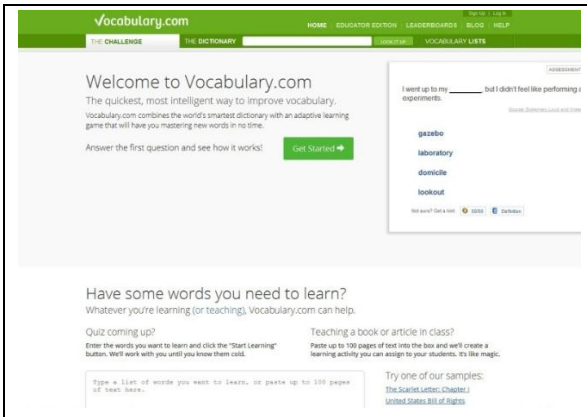
After extending the online search, several international multimedia e-dictionaries were found. From the search results, two international multimedia e-dictionaries were good

examples of interface design. These e-dictionaries were *Vocabulary.com* (http://www.vocabulary.com) and the *Maori-English* online dictionary (http://maoridictionary.co.nz/). These two e-dictionaries were then selected to be studied further. Both the selected multimedia e-dictionaries focused on the primary need of e-dictionary users, which is the location of meaning. Furthermore, their interfaces were simple and easy to navigate. Several international multimedia e-dictionaries were not selected for evaluation. These multimedia e-dictionaries had some noticeable shortcomings in their interface designs. These shortcomings included cluttered layouts with an overwhelming amount of advertisements and confusing navigation with an unnecessary number of functions.

The extended search revealed a lack of local online multimedia e-dictionaries. A South African multimedia e-dictionary that was developed for sign language by the University of Stellenbosch was found; however, this multimedia e-dictionary was not available for evaluation, because it had not been published at the time of this study (Fourie-Basson, Online: 2016). The lack of local multimedia e-dictionaries to include in this study made it necessary to broaden the search criteria for locally developed e-dictionaries to also include e-dictionaries that did not contain multimedia. The search for local multimedia e-dictionaries was focused on bilingual Sotho-English e-dictionaries. From the search results two local e-dictionaries were selected. The selected local e-dictionaries were the most easily available online.

b. Comparison of the sourced international e-dictionaries

Vocabulary.com uses images amongst other media to help its users learn new words in a fun and interactive way. On the homepage (Figure 5.1a) it is stated that, "*Vocabulary.com* combines the world's smartest dictionary with an adaptive learning game that will have you mastering new words in no time" (Thinkmap, 1998: Online). Figure 5.1b depicts an interactive picture challenge. The user is required to select the image which best represents the word "insect". Clicking on an image triggers off a response which will let the user know whether their answer is correct or not. The user gets a point for every correct response. In the end the user is provided with a total score out of 100 points.



a. Screenshot of Vocabulary.com homepage.

a. Screenshot from the *Vocabulary.com* picture challenge.

Figure 5.1: Screenshot of the Vocabulary.com Home page and picture challenge.

Individual data is stored for users that open a profile on the *Vocabulary.com* website. *Vocabulary.com* stores individual user data to assist its users with specific words that

they might be struggling to comprehend. A dashboard interface allows users to view statistical data of their learning progress. This is a more advanced feature that many e-dictionaries do not offer (Prinsloo *et al.*, 2012; Du Plessis, 2014). The website is tailored for both educators as well as learners. Educators are able to track their learners' progress in relation to the learning outcomes that have been set. The learners can also track their own progress by identifying which words they have learnt and how much more they need to learn.

The bilingual *Maori-English* online dictionary is another e-dictionary that employs multimedia aids to assist its users (Figure 5.2) (Moorfield, 2003: Online). The multimedia is used mostly for encyclopaedic entries such as, animals. There are also links to more learning resources including, but not limited to, podcasts, a television series, and study guides. The extra learning resources provide learners with interactivity while learning new words. For example, the podcast function, which provides learners with audio recordings of words, can improve learners' pronunciation of words they are not familiar with. Furthermore, the *Maori-English* e-dictionary also offers interactive games to enhance learning. Users of the *Maori-English* e-dictionary are also provided with an online forum where they can discuss various topics regarding the Maori culture and language.

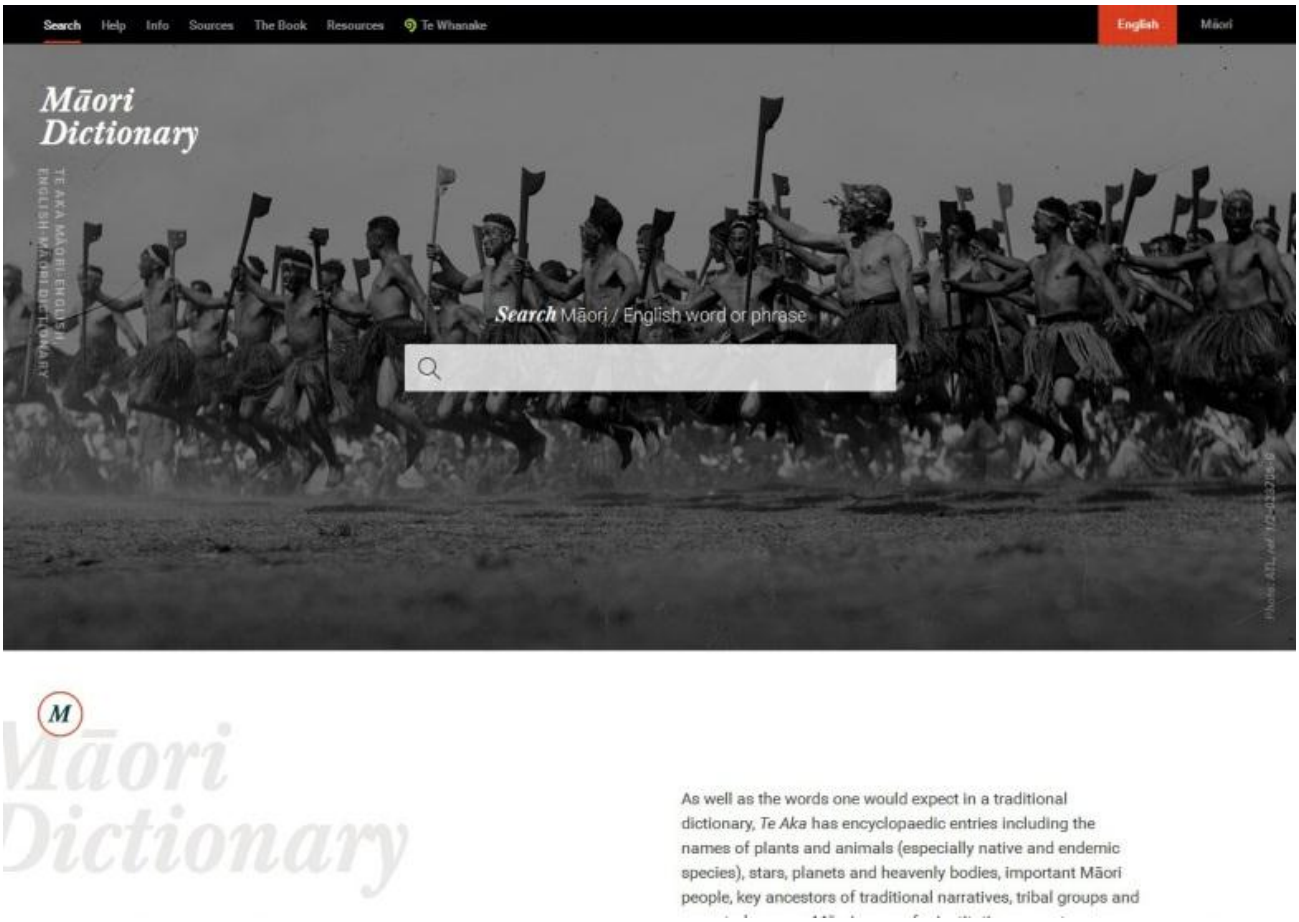


Figure 5.2: English-Maori e-dictionary home page.

User satisfaction with a website or software affects continuance of use (Van Schaik & Ling, 2009; Hong. *et al.*, 2017). The international multimedia online e-dictionaries that were selected had simplistic user interfaces that were easy to navigate. All the necessary links and buttons to important information were easy to find upon viewing the homepages. A good starting point is important when engaging with a new interface, because such encounters involve a learning process (Blair-Early & Zender, 2008). A clear and consistent use of colour, shape, size, typography, and terminology also helps to direct users towards important information. This is referred to as, *visibility* (Nielsen, 1995; Silver, 2005). Shneiderman and Plaisant, (2010: 103) elaborated that,

"Inconsistency in elements such as the positioning of buttons or colours will slow users down by 5-10%, while changes to terminology slow users by 20-25%."

Users should be able to easily exit or stop a session after utilising a function (Nielsen, 1995: Online). The bilingual English-Maori dictionary requires the user to scroll either to the bottom or the top of the page in order to find an exit or alternative menu options. This can be a time consuming process especially for long entries or search results. Conversely, *Vocabulary.com* has a more streamlined interface. The website's primary menu options are constantly visible at the top of the page irrespective of the user's position on the screen. This feature allows the user to always be aware of their exit options.

c. Comparison of the sourced local e-dictionaries

There are existing e-dictionaries that have been developed for a South African market. Through a *Google* search query *Sesotho online* (Olivier, 2014: Online) (http:// www.sesotho.web.za) was identified. Several issues arose upon viewing the home page (Figure 5.3). The layout of the page is cluttered with text. There is a bit of hierarchy created through colour coding. Each main category is distinguished by the colour blue and the sub-categories are labelled green. The clutter could have been simplified through the use of drop-down menus at the top of the page. Drop-down menus consist of menu titles (File, Edit, Insert, etc.) which provide a list of options when activated (Silver, 2005: 116). Therefore, interface designers can use drop-down menus to establish hierarchy in a page layout.

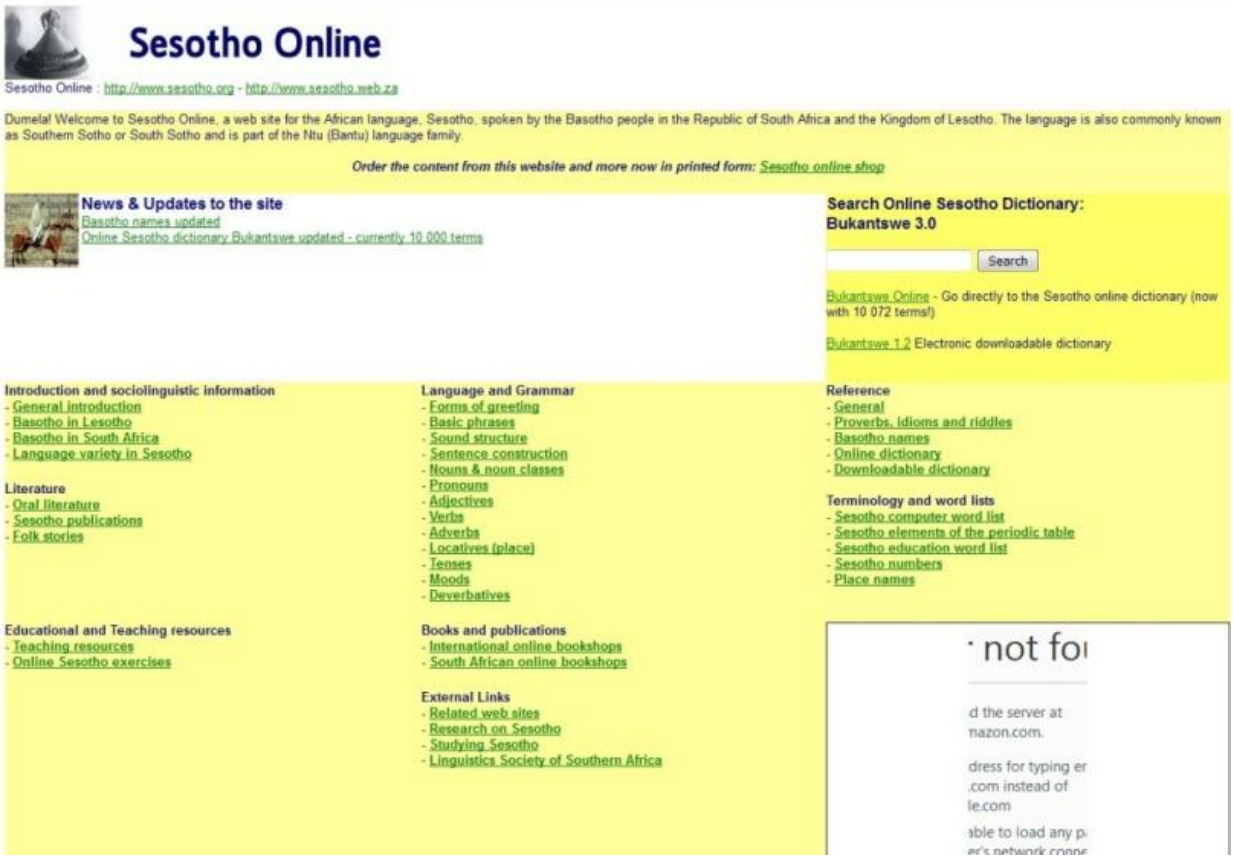


Figure 5.3: Sesotho Online home page.

The search field should preferably be placed at the top of the layout. Creating a familiar user interface layout can improve the navigability of software (Silver, 2005; Shneiderman & Plaisant, 2010). The search function is also not customisable. Effective search queries allow users to customise their results in order to quickly get the information that they need. Studies that analysed customisable web search results suggested that providing results that are specific to users is very important (Teevan *et al*., 2005; Radlinski & Dumais, 2006). Different users require different information even if they have similar search queries (Radlinski & Dumais, 2006). *Sesotho Online* is a basic online dictionary and apart from hyperlinking it does not fully exploit the features offered by a digital platform.

Freelang.net (Beaumont, 1997: Online) (http:// www.freelang.net/dictionary/sesotho) offers a personal computer (PC) Sotho-English e-dictionary which can be installed on a user's PC (Figure 5.4). The software has a better layout than *Sesotho Online* as it contains less clutter and utilises drop-down menus. It, unfortunately, presents a user with a long word list. When searching for a term the user is directed to where the word is located amongst other terms in the word list. This can be fixed by directing the user to the search item or items that are similar to their search query rather than an entire word list.

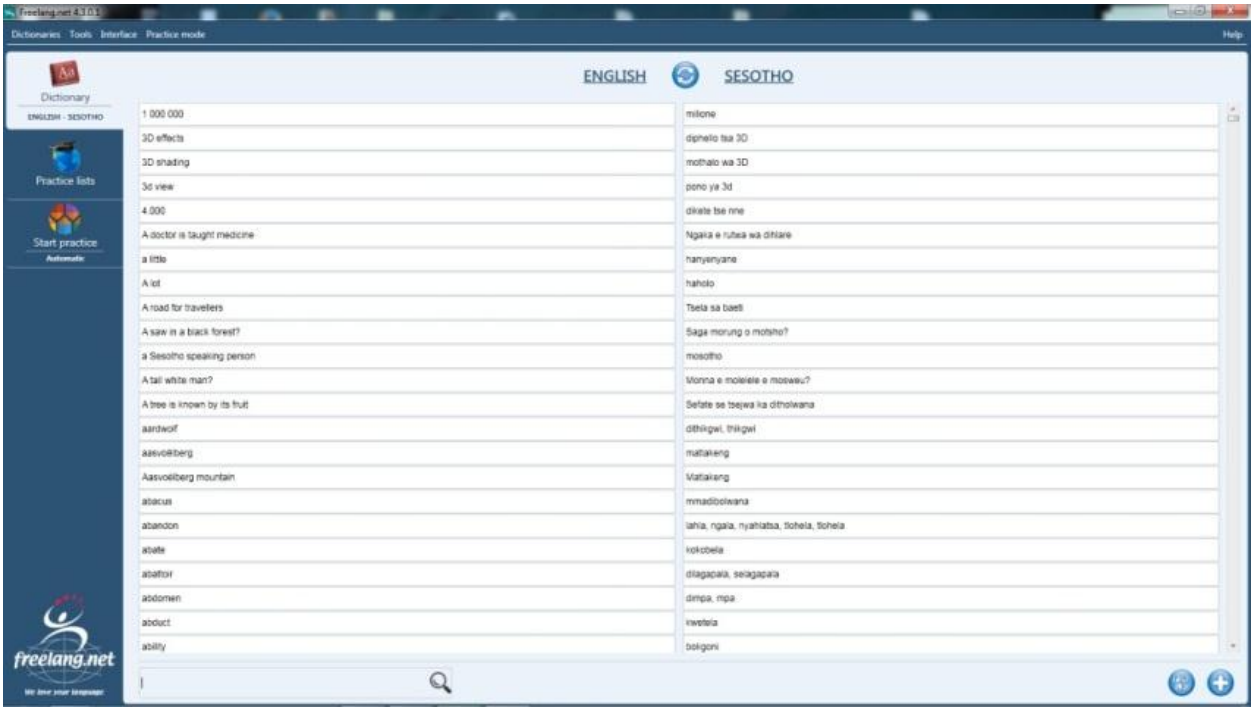


Figure 5.4: Freelang.net home page.

One notable e-dictionary project is the *Sesotho sa Leboa Dictionary Project* (SeDiPro), a bilingual Sesotho sa Leboa (a Bantu language spoken in South Africa) and English dictionary (http://africanlanguages.com/sdp). The dictionary is worth mentioning,

because the webpage's interface can be altered to Sesotho sa Leboa (De Schryver & Joffe, 2004: 188). None of the locally produced e-dictionaries, which were evaluated and compared, had such a function. So this is a step in the right direction, because it contributes towards improving multiculturalism on the internet. Unfortunately, SeDiPro has been offline since 27 July 2015 so it was not possible to evaluate its interface.

d. Discussion of the sourced local and international e-dictionaries

The two international and two local e-dictionaries were evaluated using a list of proposed guidelines for user interface designs (U.S. Dept. of Health and Human Services 2006: Online). A 5-point likert scale was used to evaluate the selected e-dictionaries, with the following options to select; 1-poor, 2-fair, 3-good, 4-very good, and 5-excellent. The design criteria for the evaluation of the e-dictionaries were simplicity, consistency, purposeful layout, colour and texture, typography, feedback, and affordances. The guidelines allow software to be evaluated in terms of its visual design, navigation, and functionality. The visual design allows users to visually engage with an interface. The navigation determines how various functions and information can be accessed in software. The functionality of software is determined by the various tasks that users can accomplish while using software. Table 5.2 indicates the user interface evaluation of the selected e-dictionaries. The evaluation of the e-dictionaries revealed that the two international e-dictionaries provided the best examples of all seven design criteria.

Table 5.2: User interface evaluation of the selected e-dictionaries.

Criterion	International e-dictionary		Local e-dictionary	
	Vocabulary.com	*Maori-English*	*Freelang.Net*	*Sesotho Online*
Simplicity	4	5	3	2
Consistency	4	5	3	2
Purposeful Layout	4	4	2	2
Colour and texture	4	4	3	3
Typography	5	4	3	3
Feedback	5	4	2	2
Affordances	5	4	3	2
Total	31	30	18	15

The values in the 5-point likert scale were rated as follows: 1-poor, 2-fair, 3-good, 4-very good, 5-excellent.

The evaluation of existing e-dictionaries provided visual examples of different interface design practices. A comparison of local and international e-dictionaries showed that the interface designs of international e-dictionaries were superior to that of local e-dictionaries. The international e-dictionaries were evaluated as superior, because of the increased prevalence of design guidelines in their user interface designs. The user interface design guidelines, which were most prominently applied in the international e-dictionaries, were simplicity and purposeful layout. These guidelines allow users to quickly access information, because they use spatial relationships to guide users. Typography and colour relationships were implemented in all the e-dictionaries as a means to establish visual hierarchy. It was clear from the evaluation that the seven

proposed user interface design guidelines lead to an improved user experience when navigating software.

5.2.4 Conceptual framework

The user experience is the most important factor in interface design. The user's experience when using software is determined by the visual design, the navigation, and the functionality of an interface. A conceptual framework was devised to underpin the design of the *SEADD* application's interface. Firstly, the visual design of the interface was based on seven proposed user interface design guidelines. Secondly, the menu structure of the *SEADD* application was designed according to navigation design guidelines. Lastly, existing e-dictionaries were evaluated and compared based on their interface designs. These evaluations were used to identify functionality guidelines. Figure 5.5 shows a flow diagram of the conceptual framework that underpinned the design of the *SEADD* application's user interface.

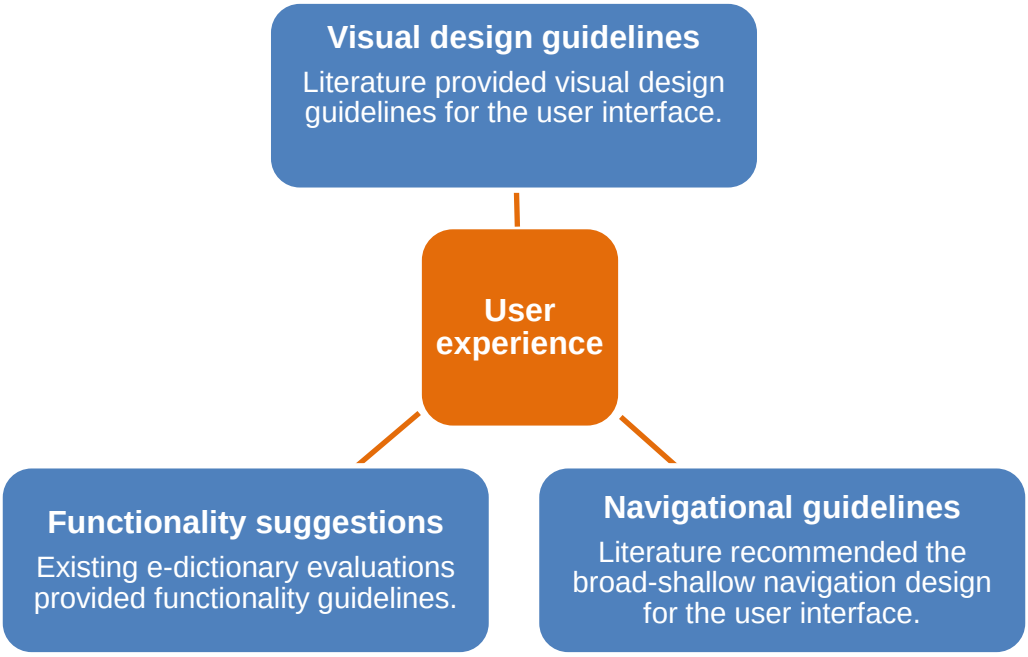


Figure 5.5: Conceptual framework that underpinned the design of the SEADD application's user interface.

The visual design of an interface is the first point of contact that users have with software. Seven design principles were identified that are often applied to the design of user interfaces. These principles are simplicity, consistency, purposeful layout, colour and texture, typography, feedback, and affordances. By combining these proposed design principles in the visual design of a user interface, the user's experience of the e-dictionary should be greatly improved.

The menu structure of an interface determines its navigability. An ideal menu structure is one that allows users to quickly find information. The number of levels that users have to access before completing a task has to be reduced to a bare minimum. Adding an unnecessary number of levels between tasks will confuse users and thus prevent them from completing their intended task. A broad-shallow menu structure adds simplicity to

the menu structure making it possible for users to quickly find information. Thus, it was concluded that the broad-shallow menu structure should be used for the development of the *SEADD* application.

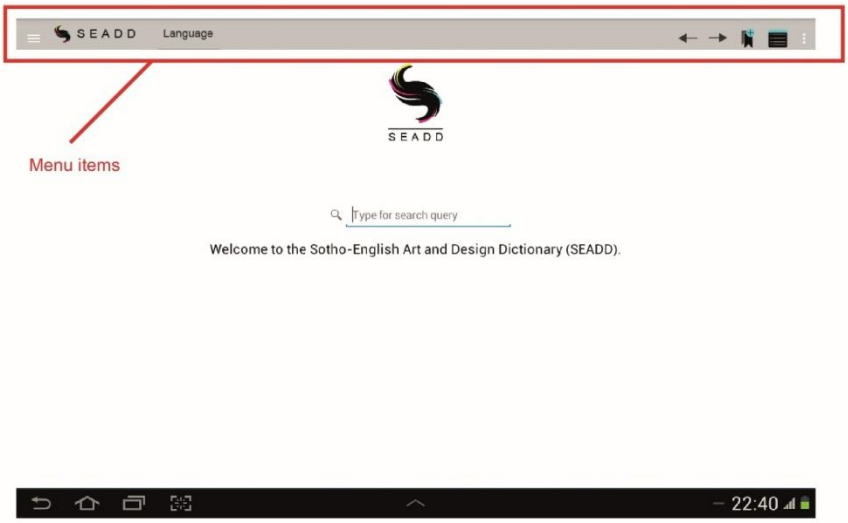
Several functionality ideas were gleaned from the existing e-dictionaries that were evaluated. The e-dictionaries that had implemented user interface design guidelines to their interfaces were superior to those that had not. The evaluation of the existing e-dictionaries revealed that simple and purposeful layout design can act as visual guides for the user. Also, typography and colour can be used to establish hierarchy of information in a layout. This will allow users to quickly access information. Because the main function of any e-dictionary should be to provide users with meaning, it is important to design the e-dictionary to achieve this goal. Therefore, the addition of multimedia to an e-dictionary should provide users a means to achieve this goal. Applying design aesthetics to an e-dictionary interface should enhance the user's experience rather than distract the user from the intended task.

5.3 Designing of the *SEADD* application

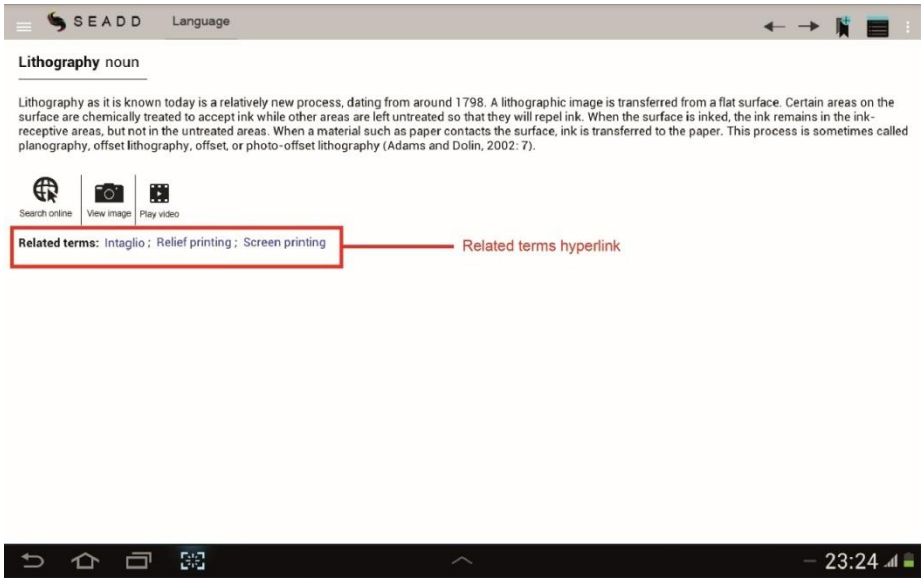
The development of the conceptual framework informed the design of a beta version of the *SEADD* application by providing guidelines in three main areas. These areas included user interface design, navigation and several functionality ideas concluded from the evaluation of existing e-dictionaries. Therefore, when the *SEADD* application was designed, these ideas were taken into consideration.

5.3.1 Application of user interface design guidelines

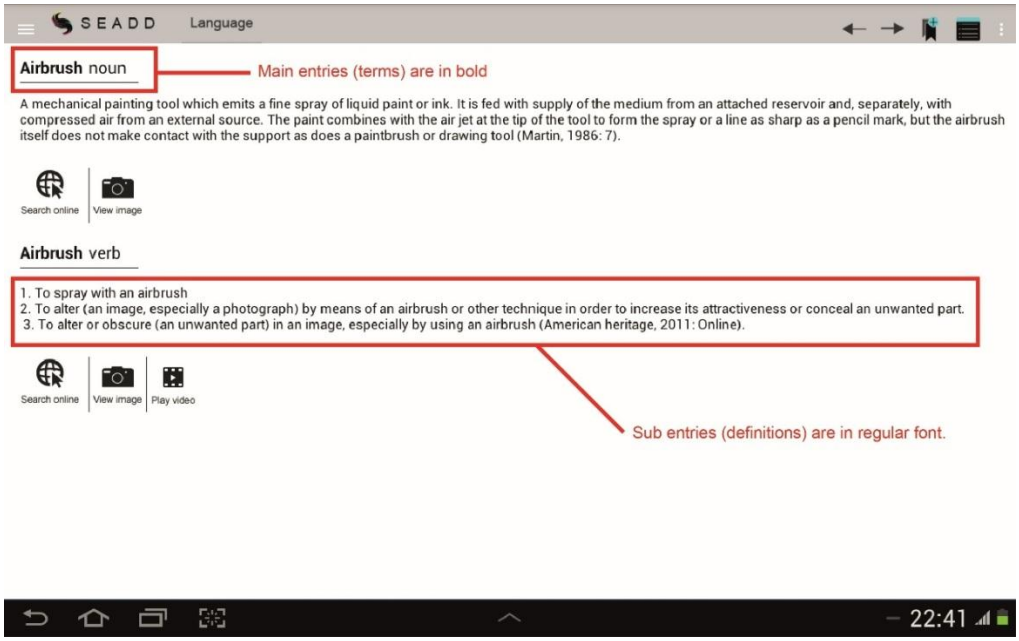
The *SEADD* application's interface's was designed by applying the proposed design guidelines. The interface's visual design was kept simple by avoiding clutter in the layout and using clear language. The user is provided with only the necessary options upon viewing the homepage (Figure 5.6a). The user is also provided with various options to find a term and obtain its meaning. Consistency was enhanced by the use of common user interface elements. Because users often have some prior knowledge of the use of e-dictionaries, it was decided to match the language in the various menu items with those of thee-dictionaries that were evaluated in this study. The navigation hierarchy was established by placing the main menu items at the top of the page (Figure 5.6a). Placing important menu items at the top of an interface increases their visibility to the users. To further draw the user's attention to important elements on the pages, colour was strategically applied. The links to *related terms* were colour coded blue for consistency with other existing e-dictionary applications (Figure 5.6b). Typography was used to establish navigation hierarchy, thereby enhancing legibility and readability. For example, a bold Arial typeface was used for main entries (terms), while regular Arial typeface was used for definitions (Figure 5.6c).



a. Screenshot of the *SEADD* home page showing the menu items at the top of the page.



b. Screenshot of the *SEADD* application's term page showing related terms by depicting them in blue.



c. Screenshot of the *SEADD* application showing how typography was used to indicate hierarchy.

Figure 5.6: Screenshots of various interface design guidelines that were applied to the SEADD application.

The interface of the *SEADD* application reacts to user inputs. For example, when selecting the vocabulary button on the top-down menu at the top of the page, the vocabulary list appears on the left of the page (Figure 5.7).

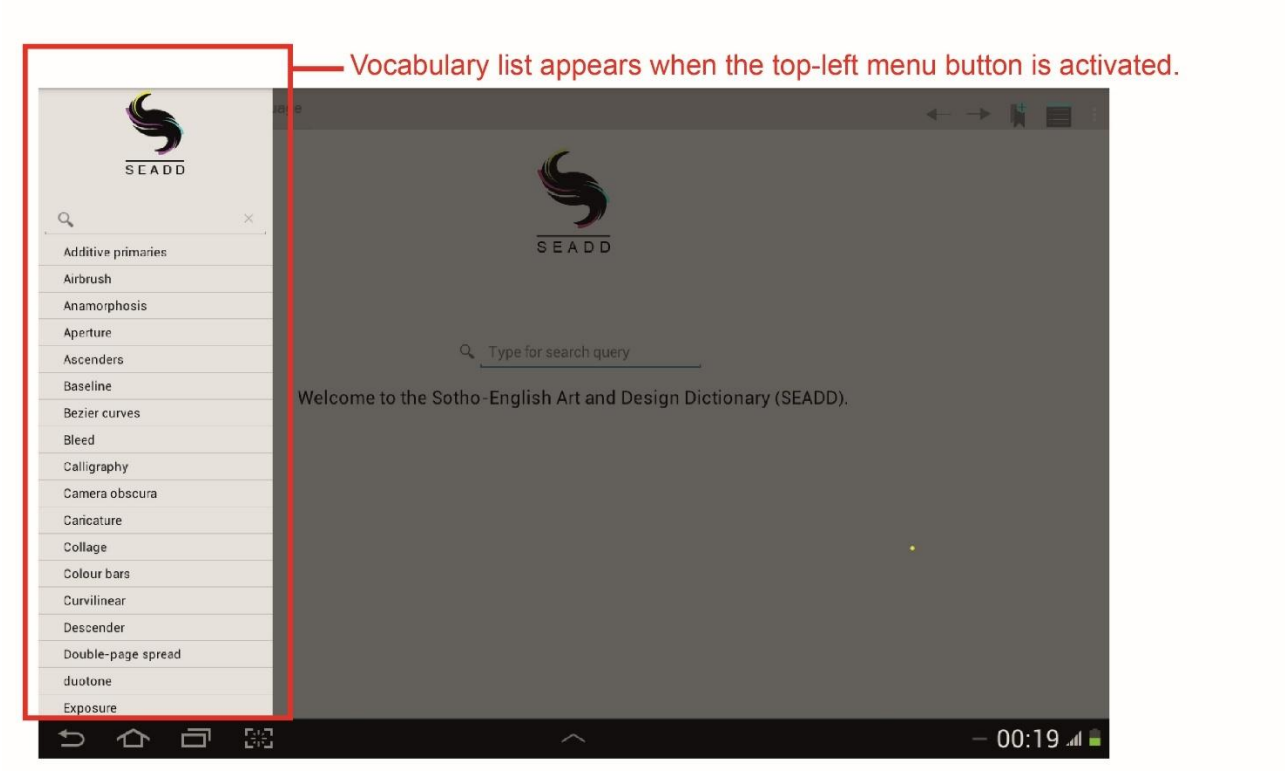


Figure 5.7: Screenshot of the SEADD application's vocabulary list which appears when selecting the appropriate button on the top-down menu at the top of the page.

The interface was designed to allow users to easily return to the main menu. By clicking on the *SEADD* logo, a user is able to return to the main menu (Figure 5.8). Alternatively the back button can also be used to return to previous selections. These functions provide the user with a default option in case the user needs to return to a familiar page.

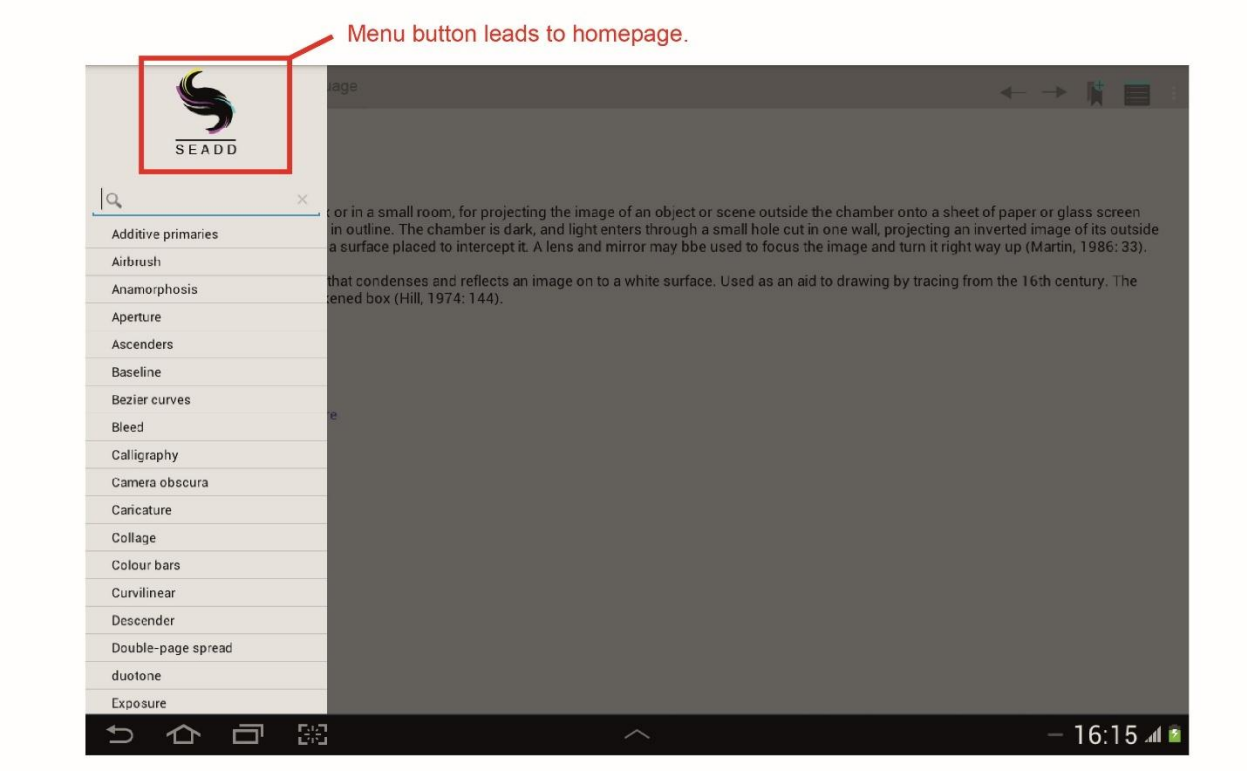


Figure 5.8: Screenshot of the SEADD application's home button option that can be activated to return to the home page.

5.3.2 Application of navigation guidelines

In the design of the *SEADD* application's menu structure, a broad-shallow design was implemented as informed by the conceptual framework. Figure 5.9 provides a flowchart depicting how a user can navigate through the *SEADD* application's menu structure in order to complete various tasks. The *SEADD* application's menu structure was designed to allow users access to terms from anywhere in the application. The major functions are colour coded in orange, while the sublevels are in blue.

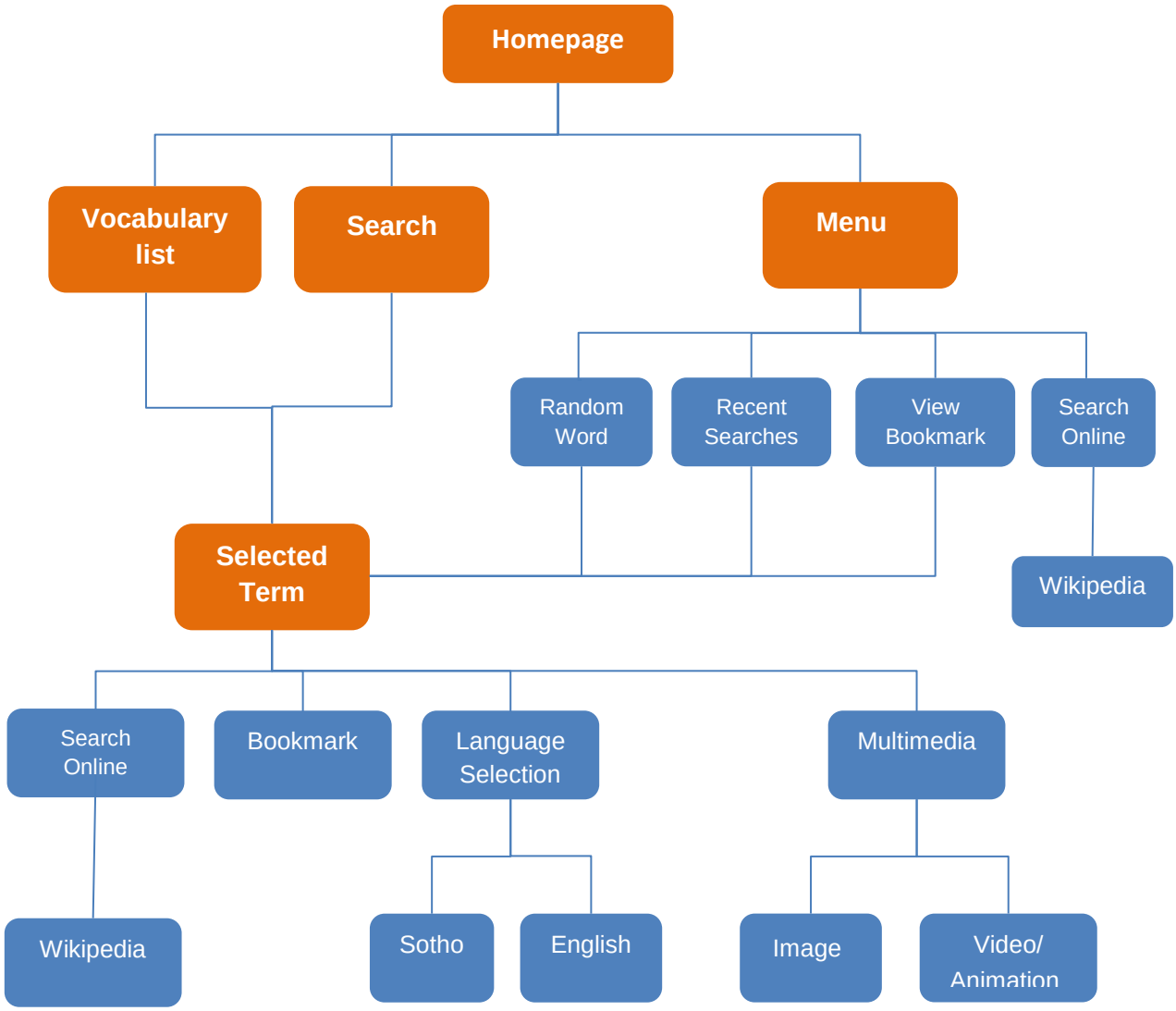


Figure 5.9: Flowchart depicting the navigation design of the SEADD application. The orange rounded rectangles represent major functions that lead to blue sublevels.

5.3.3 Application of functionality guidelines

The most important task for an e-dictionary user is to locate a term and its meaning. This primary function of dictionaries can be enhanced with multimedia and interactivity. The *SEADD* application includes various functions that were created to enhance a user's experience while using the e-dictionary. These functions are, homepage, menu

button, vocabulary list, term page, multimedia, online search, bookmarking, and language selection. The homepage is the first page that a user is presented with (Figure 5.10). The homepage contains a search function that allows users to look for a term in the vocabulary list. The homepage is also linked to all the other functions of the *SEADD* application.

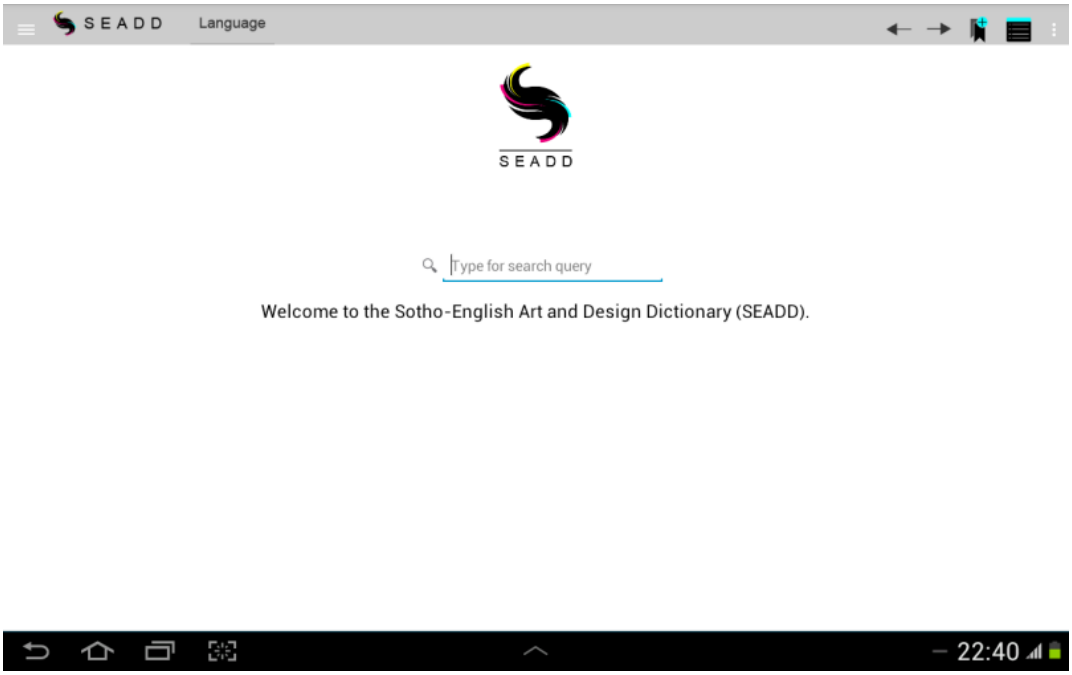


Figure 5.10: Screenshot of the SEADD application homepage.

A menu button was added to the *SEADD* application to provide the user with access to various functions. *Random word*, *recent searches*, *online search*, and *view bookmark* can be access by selecting the menu button (Figure 5.11). The *random word* function randomly generates a term from the word list that is embedded in the application. *Recent searches* provide a user with a list terms that they have recently searched for. O*nline search* allows a user to cross reference a term on *Wikipedia*. *View bookmark* allows users to *view bookmarked* entries.

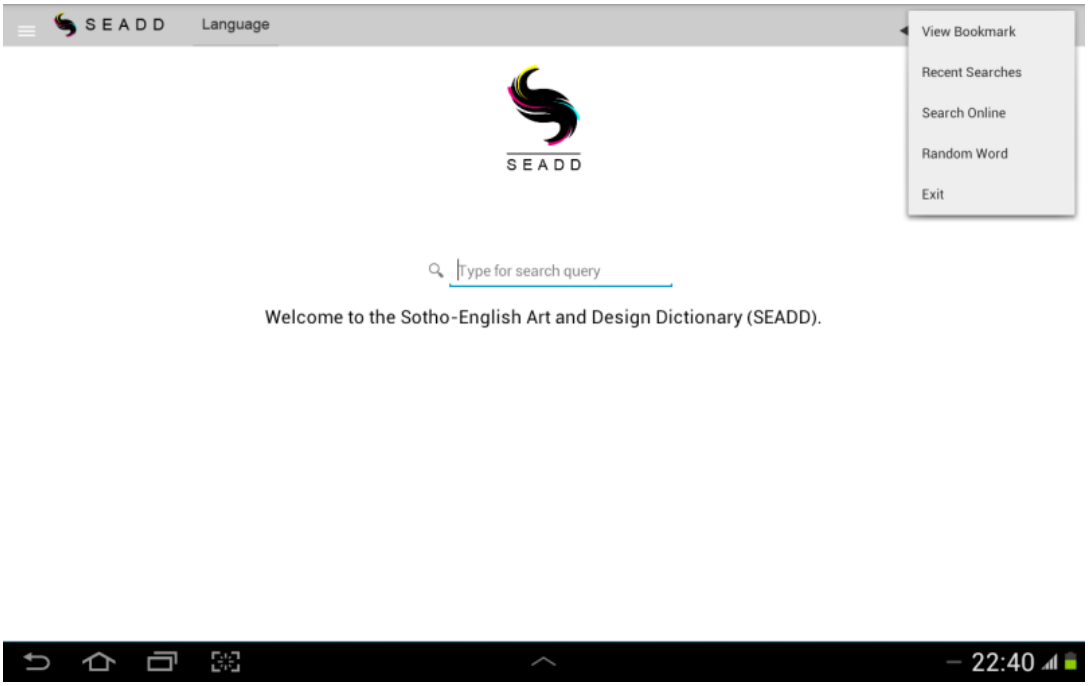


Figure 5.11: Screenshot of the activated menu button in the SEADD application.

The vocabulary list menu contains all the terms in the *SEADD* application's database (Figure 5.12). The vocabulary list database contains both the English and the Sotho art and design terms and concepts.

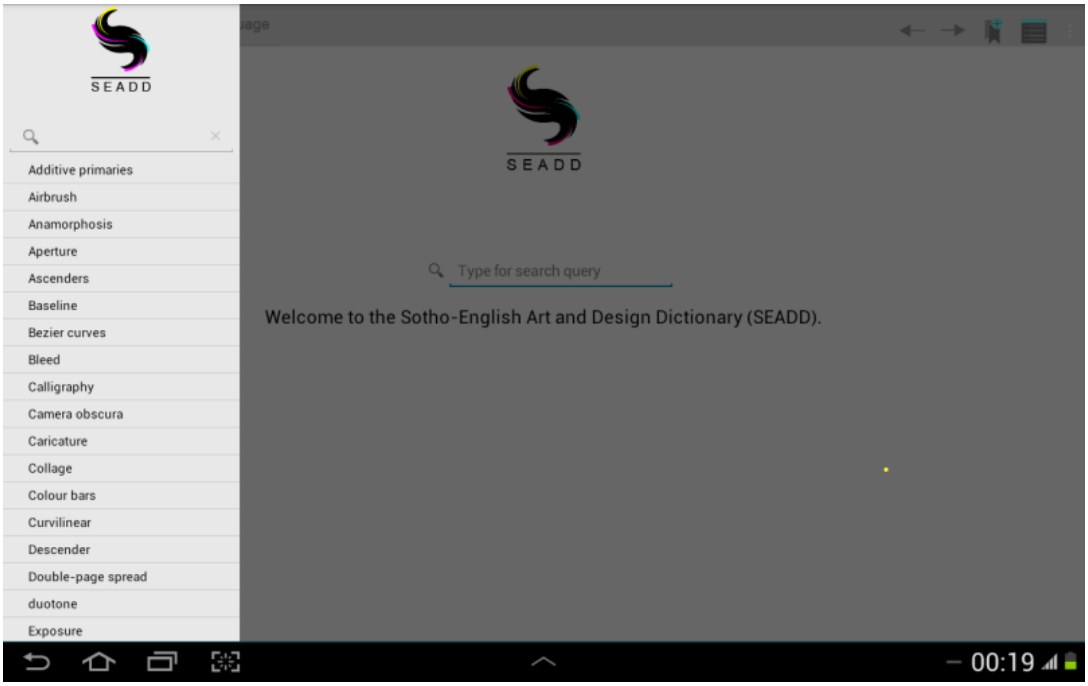


Figure 5.12: Screenshot of the vocabulary list in the SEADD application.

The term page contains information about the word which the user has selected. The user is provided with a definition and the following options: search online, view image and/or play video, language selection, and related terms (Figure 5.13). The *search online* option allows a user to cross reference a term in Wikipedia. The *view image* or *play video* options open the multimedia content for a selected term. The *language selection* option allows a user change the language of the term. The *related terms* function provides a user with links to other terms, which are connected to the term that the user has selected (Figure 5.13). For example, when viewing the definition for *lithography* the user will also be provided with links to *intaglio*, *relief printing*, and *screen printing*.

Figure 5.13: Screenshot of the term page in the SEADD application.

5.4 Discussion

A conceptual framework was developed for the design of the *SEADD* application's user interface. The conceptual framework focused on improving the experience of an e-dictionary user. An effective use- interface is one that is invisible to the user, because it does not get in the way of their experience (Silver, 2005; Scheinderman & Plaisant, 2010). The conceptual framework informed the development of the beta version of the *SEADD* application. By considering the interface design guidelines, the needs of users were considered by providing an easily accessible menu structure. The design ensured that a user could focus on content and not become entangled in navigation (Hong *et al.*, 2017). The *SEADD* application makes it possible for a user to access the vocabulary and then select which route to follow. A user is able to search online, view an image, play a video and find related terms. The user is also able to toggle between English and Sotho equivalent art and design terms and concepts

Chapter 6 – Testing the Sotho-English Art and Design E-dictionary

6.1 Introduction

The testing of the *SEADD* application was divided into two phases. In Phase 1, an online comprehension test was created to evaluate the effectiveness of the *SEADD* application in promoting learning. The comprehension test was created according to Bloom's revised taxonomy of educational objectives (Anderson & Krathwohl, 2001). The online comprehension test was also used to source supplementary information about the participants' personal information and prior knowledge of art and design.

The *SEADD* application was then tested by undergraduate students from the Department of Design and Studio Art at the CUT-FS. The students were divided into two groups. The first group, Group A, was the control group that did not have access to the *SEADD* application. Group B, the multimedia group, did have access to the *SEADD* application while studying the art and design terms and concepts.

In Phase 2, semi-structured interviews were conducted with purposefully sampled Sotho speaking participants. The semi-structured interviews were used to source the participants' experience while using the *SEADD* application.

6.2 Demographic information of participants

The online comprehension test was used to gather the personal information from the 34 participants. All participants were first year students in the Department of Design and Studio Art. The personal information included their name, gender, and home language. The comprehension tests also probed the Sotho proficiency of the participants, as well as their prior knowledge of art and design. It was assumed that all the participants can speak English, because it is a requirement when enrolling at the CUT-FS. All recorded information was logged and kept confidential.

The two groups differed in terms of their gender demographic composition. The different genders were more or less equally represented in Group A, while in Group B there was approximately double the number of males when compared to the number of females. The pie charts in Figure 6.1 indicate the gender demographic of the participants.

a. Pie chart indicating the gender demographic for Group A.

b. Pie chart indicating the gender demographic for Group B.

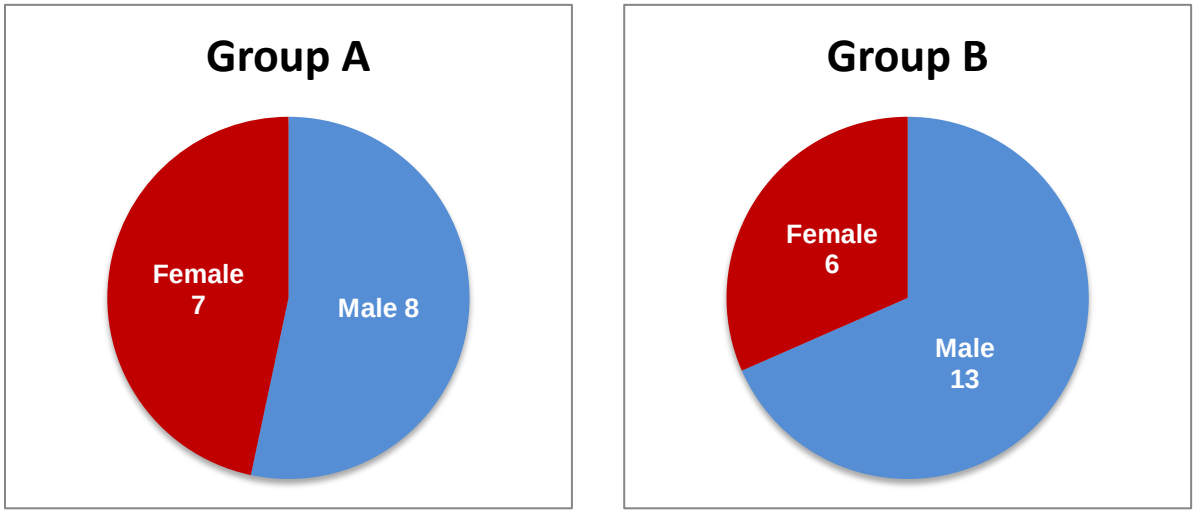
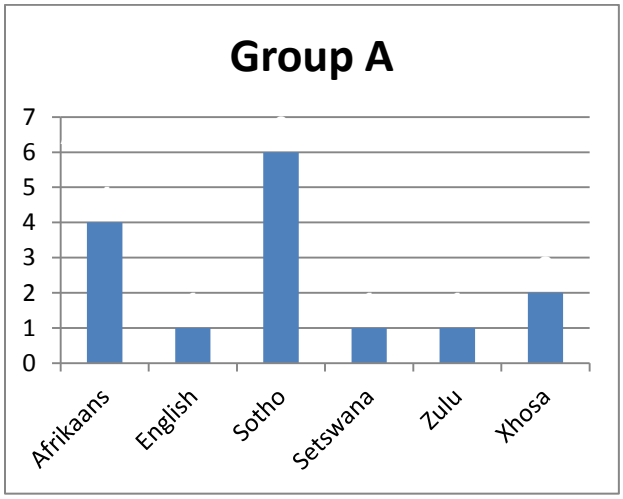


Figure 6.1: Gender demographics for Group A, the control group, and Group B the multimedia group.

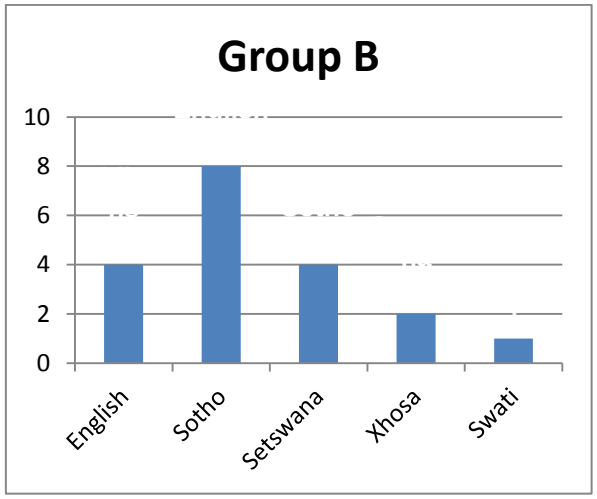
The participants were from diverse language backgrounds. The majority of the participants in both Group A and Group B considered Sotho as their home language. Figure 6.2 shows the home languages of both participant groups. None of the participants in Group B considered Afrikaans their home language, while in Group A Afrikaans was the second highest home language amongst the participants. None of the participants in Group B regarded Zulu as their home language, however one participant regarded Swati as their home language.

a. Home languages of the participants in Group A.



N= 15

b. Home languages of the participants in Group B.



N= 19

Figure 6.2: Home languages of Group A, the control group, and Group B the multimedia group.

The participants' proficiency in Sotho was also sourced. The Sotho language proficiency question required that the students rate their Sotho speaking, reading, and writing ability on a 5 point rating scale. Figure 6.3 depicts the average Sotho language proficiency of both participant groups. On average the participants in both groups rated their Sotho speaking ability much higher than their reading and writing ability.

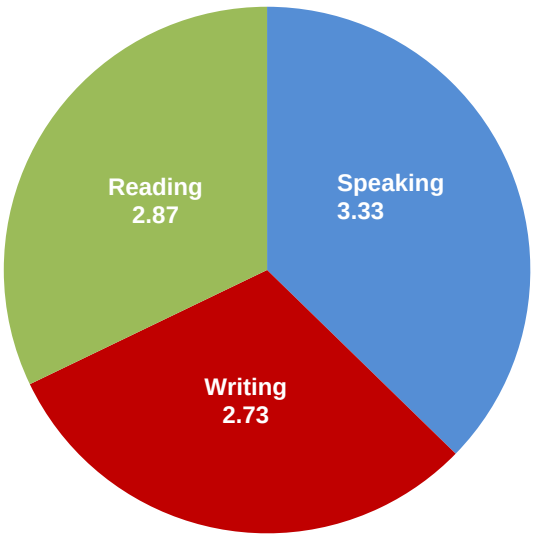
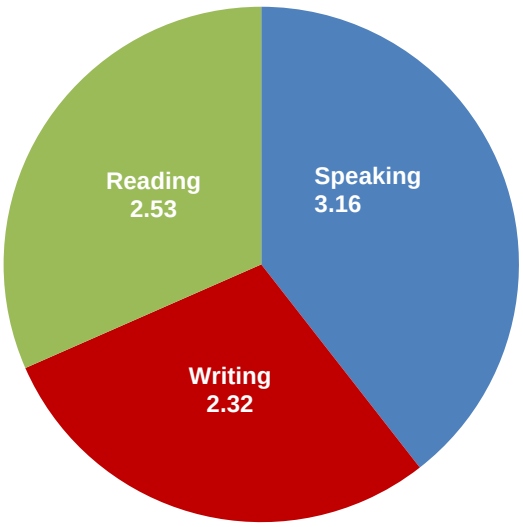
a. Average Sotho language proficiency of participants in Group A.	b. Average Sotho language proficiency of participants in Group B.
Group A  N= 15	**Group B**  N= 19

Figure 6.3: Average Sotho language proficiency for Group A, the control group, and Group B the multimedia group.

The prior knowledge of all the participants was also sourced through the online questionnaire. Information about the participants' past education in art and design subjects was obtained by posing two prior knowledge questions. These questions were: Question 1 (Q1) - *Did you have any art or design subjects in secondary school (Grade*

8-12)? Question 2 (Q2) - *Were you enrolled into any art or design courses before registering as a student at the CUT-FS?* The results showed that for both groups the number of participants with prior knowledge were substantially less then participants without prior knowledge (Figure 6.4). The responses to Question 1, showed that the percentage of participants with prior knowledge obtained during secondary schooling were around 30-40%. These participants were enrolled for subjects such as visual art, arts and culture, technical drawing, engineering graphics and design or engineering graphics. The responses to Question 2 showed that few students, 10-20%, had enrolled for one or another art and design course at institutions that were not responsible for their secondary schooling.

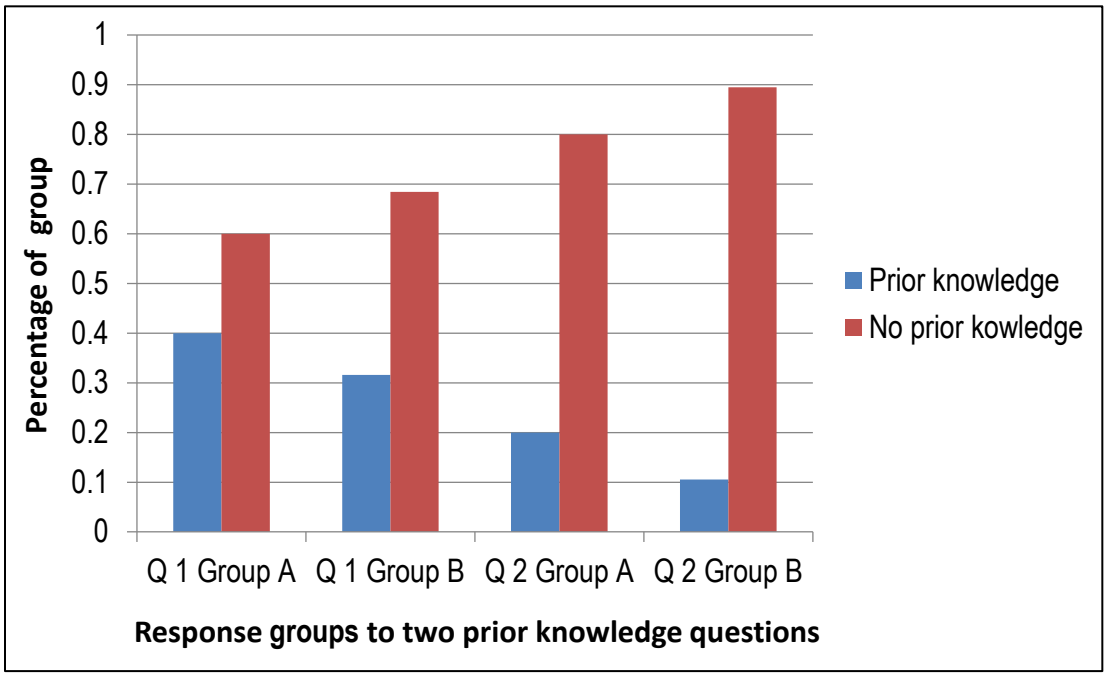


Figure 6.4: Percentage of participants with prior knowledge or without prior knowledge before enrolling at the CUT-FS.

6.3 Comprehension test

The questions of the online comprehension test were divided into groups according to their level of difficulty. There were a total of 15 questions, which were divided into three sections as follows; 10 of the questions probed remembering (Bloom's taxonomy level of remembering), three probed understanding (Bloom's taxonomy level of comprehension), and two probed application (Bloom's taxonomy level of application). The remembering questions tested students' ability to retrieve knowledge from their memory. The understanding questions required students to demonstrate comprehension of facts and ideas by linking their understanding with new knowledge to prior knowledge. The third category of application required that the participants solve

problems by applying acquired knowledge. Table 6.1 shows the questions of the online comprehension test, together with their Bloom's taxonomy category.

Table 6.1: Online comprehension test questions and Bloom's taxonomy category.

Question number	Question	Blooms taxonomy category	Mark allocation
Question 1	**Define the following terms**	**Level 1 - Remember**	**10**
1.1	Additive primaries	Level 1	1
1.2	Aperture	Level 1	1
1.3	Caricature	Level 1	1
1.4	Curvilinear	Level 1	1
1.5	Exposure	Level 1	1
1.6	Monochromatic	Level 1	1
1.7	Four-colour process	Level 1	1
1.8	Gutter	Level 1	1
1.9	Halftone	Level 1	1
1.10	Initial letter	Level 1	1
Question 2		**Level 2 - Understand**	**9**
2.1	Select three typefaces that fall under the same type family.	Level 2	3
2.2	Explain the screen printing process.	Level 2	3
2.3	Why do lithographic printing plates have to be chemically treated?	Level 2	3
Question 3		**Level 3 - Apply**	**6**
3.1	Contrast relief printing to intaglio.	Level 3	3
3.2	You recently used a camera obscura to help you trace an object directly from nature and the image was upside down. How could you have ensured that the image was the correct way up?	Level 3	3
		TOTAL	**25**

6.4 Comprehension test results

6.4.1 Overall performance of participants

The overall mean performance of the two groups in the online comprehension test differed substantially. A t-test revealed that the online comprehension test scores of Group A (control group) differed significantly from the online comprehension test scores of Group B (multimedia group) (p = 0.0007). Table 6.2 shows the overall performances of the two test groups, showing clearly that the minimum and maximum of scores for Group A (11 to 22) were lower than those of Group B (15 to 25).

Table 6.2: Overall test scores of the participants of Group A and Group B.

Comprehension test results			
Group A (control group)		**Group B (multimedia group)**	
Participant number	**Score**	**Participant number**	**Score**
1	20	1	25
2	21	2	22
3	15	3	22
4	21	4	19
5	18	5	18
6	14	6	19
7	13	7	19
8	11	8	18
9	15	9	22
10	14	10	18
11	15	11	22
12	16	12	19
13	16	13	19
14	18	14	19
15	19	15	18
		16	16
		17	15
		18	18
		19	20
Mean score	**16.4**	**Mean score**	**19.4**

6.4.2 Performance of participants for Bloom's level 1 questions

Ten questions of the online comprehension test probed knowledge, Bloom's level 1. The ability of Group A to retrieve knowledge from their memory appeared to be poorer than the ability demonstrated by Group B, who had access to the *SEADD* application. Table 6.3 shows the average performance of Group A, the control group, and Group B, the multimedia group.

Table 6.3: Performance of Group A and Group B participants in the remembering section of the online comprehensions test.

Question 1 - Remembering			
Group A (control group)		Group B (multimedia group)	
Participant number	Score (Total out of 10)	Participant number	Score (Total out of 10)
1	8	1	10
2	9	2	10
3	9	3	10
4	9	4	10
5	9	5	9
6	8	6	10
7	10	7	10
8	8	8	9
9	9	9	10
10	8	10	9
11	10	11	10
12	10	12	10
13	4	13	8
14	9	14	10
15	10	15	9
		16	10
		17	7
		18	9
		19	8
Mean score	**8.7**	**Mean score**	**9.5**

6.4.3 Performance of participants for Bloom's level 2 questions

Three questions of the online comprehension test probed comprehension, Bloom's level 2. Similarly to the results of the performance of the participants with the level 1 question, the ability of Group A to link their understanding of facts and ideas with new knowledge or prior knowledge was poorer than the ability of Group B. Table 6.4 shows the mean performance of Group A, the control group, and Group B, the multimedia group.

Table 6.4: Performance of Group A and Group B participants in the understanding section of the online comprehensions test.

Question 2 - Understanding			
Group A (control group)		**Group B (multimedia group)**	
Participant number	**Score (Total out of 9)**	**Participant number**	**Score (Total out of 10)**
1	6	1	9
2	9	2	9
3	6	3	9
4	6	4	6
5	6	5	6
6	6	6	9
7	3	7	6
8	3	8	9
9	6	9	9
10	6	10	6
11	5	11	9
12	3	12	6
13	9	13	8
14	9	14	6
15	9	15	6
		16	6
		17	5
		18	6
		19	9
Mean score	**6.1**	**Mean score**	**7.3**

6.4.4 Performance of participants for Bloom's level 3 questions

Three questions of the online comprehension test probed application, Bloom's level 3. Similarly to the results of the performances of the participants with the level 1 and level 2 questions, the ability of Group A to solve problems by applying acquired knowledge was poorer than the ability of Group B. Table 6.5 shows the mean performance of Group A, the control group, and Group B, the multimedia group.

Table 6.5: Performance of Group A and Group B participants in the application section of the online comprehensions test.

Question 3 - Application			
Group A (control group)		Group B (multimedia group)	
Participant number	Score (Total out of 6)	Participant number	Score (Total out of 6)
1	6	1	6
2	3	2	3
3	0	3	3
4	6	4	3
5	3	5	3
6	0	6	0
7	0	7	3
8	0	8	0
9	0	9	3
10	0	10	3
11	0	11	3
12	3	12	3
13	3	13	3
14	0	14	3
15	0	15	3
		16	0
		17	3
		18	3
		19	3
Mean score	**1.6**	**Mean score**	**2.7**

6.5 Interview questions

Purposeful semi-structured interviews were conducted with five Sotho speaking participants of the multimedia group to gather qualitative data about their experience with the *SEADD* application. Five participants were purposefully selected for the interviews. Only Sotho speaking participants were selected, because most of the participants where Sotho speaking and a large component of the project involved the development of Sotho equivalents for the English terms and concepts. The participants were asked a total of nine questions that were audio recorded (Appendix A). The responses to the interview questions were mostly positive. However, the participants expressed that having access to Sotho equivalents of the art and design terms and concepts had a minor effect on their learning. Furthermore, the participants offered recommendations for future developments of the *SEADD* application. Participants' answers to the interview questions are provided in Table 6.6.

Table 6.6: Responses to the semi-structured interview questions that were conducted with five participants from the multimedia group.

Question	Responses to semi-structured interview questions
1	***How was your experience using the application?***
	Four out of five participants responded positively. One student explained that, "I would recommend it to people that want to do graphics..." Four students expressed that studying from a digital device was not a new experience. They related it to being lectured with slides. Another participant stated that, "I've gotten used to studying with a computer. It wasn't really a new experience for me…because we use slides in this course…" However, one student did not like studying from a screen for fear of her eyesight being negatively affected. She preferred studying from a book
2	***Would you like a similar app in other modules?***
	Four out of five participants wanted to have access to a similar application for their other modules. One student recommended a similar application for painting terms specifically. He stated that, "It would be cool to have an app like that to explain words like impasto…" Another student expressed that, "It would be an upgrade, because apps are more reliable whereas websites can crash…an app runs on a program…" One out of the five participants did not want a similar application in their other modules. Her reason was the same as in the first question. She was afraid that a digital screen would affect her eyes negatively.
3	***Was the instructional multimedia helpful?***
	Four out of the five students found the multimedia useful. The students expressed that the multimedia greatly influenced their comprehension, because they are visual students. There was one student that preferred studying with words as

	opposed to multimedia such as images and animations. She stated that, "I only used 20% of it [multimedia], because I really didn't use the pictures. I am a words person. So I just basically read the words and wrote them down…" The student had art as a subject in high school which meant that she was familiar with some of the terms.
4	***Did having access to Sotho equivalents of art & design terms improve your comprehension?***
	The responses to this question were mostly negative. All the students did not find the Sotho terms helpful (five out of five). They expressed the following sentiments: "I can speak Sotho slightly…when it comes to reading and writing that means that everything has to be done in English and Afrikaans." "To be honest I did not use Sotho, because it was tricky for me. Transferring some of the terms from English to Sotho I wouldn't understand what they mean in Sotho." "I find myself comfortable reading in English…Sotho is kind of hard for me to read and understand at times…" "It's as if it didn't make sense when I read it in Sotho…I think it's, because we are English medium from a young age." The participants' responses indicated that they were more confident in their ability to speak Sotho as opposed to reading and writing it. English seemed to be their preferred medium of instruction.
5	***How often did you switch the English terms to Sotho?***
	Two of the students did not switch at all, two of them did not switch often, and one student did switch regularly. The language selection option was not greatly utilised by the students. They mostly switched to Sotho for interest's sake and not really to learn new words. One student elaborated, "I did it only once to see long terms. To see if I could read it in the first place. I couldn't even remember some of the words in Sotho." The answers in the previous question are indicative of this sentiment.
6	***Can you remember any of the Sotho terms?***
	Two of the participants could remember only the terms that sounded like English terms, such as "aphetjha" which refers

	to “aperture” in English. The rest of the participants could not remember any of the Sotho terms.
7	***How does having access to Sotho terms in your field of study make you feel?***
	For this question all the students expressed that they preferred learning in English (five out of five). They felt that way, because their writing and reading abilities in Sotho were not developed very well. They expressed the following: “I guess it would be helpful to have them in Sotho at some point just to learn…” “For me personally it doesn’t really matter, because I don’t know how to read Sotho I don’t know how to write Sotho…” “For other people it would be a good thing so they can understand it better.” “For some people it can be fine. I prefer English over Sotho. If I was talking basically everyday talk I can talk Sotho, but academically I can’t get used to Sotho.” The overarching sentiment was that for the sake of connecting with one’s “roots” it is important. However, it did not seem viable to use the Sotho terms academically as the students preferred English.
8	***Are there any improvements that you would like to recommend?***
	The following improvements were recommended: • Make it available on mobile and to high school learners. • Provide the application in more languages. • Make the dictionary available in printed form.
9	***Would a multimedia e-dictionary application motivate you to study?***
	The responses were positive. Four students expressed that the e-dictionary application would motivate them. One student still preferred to study with paper only. She did, however state that if the dictionary were available in book form then she would find it motivating. The students expressed that the convenience of having all the information in one central place was good. They explained that: “It’s a great way to start learning. The app comes with the words so it can

	help save on data costs" "Although I prefer studying in the old school style [textbook] I wouldn't mind adapting to the new style [digital]." "Unlike slides where you have to download this and that with the app everything is there in one place." The positive responses were mainly concerned with convenience and ease of access to information.

6.6 Discussion

The *SEADD* application was tested amongst students that were likely to use it. The results of this test revealed that the *SEADD* application successfully facilitated learning amongst these students. The group of students that had access to the *SEADD* application significantly outperformed the group of students that did not have access to the application (p = 0.0007). The online comprehension test showed that the performance of the students that had access to the *SEADD* application improved in all three sections of the test, namely, knowledge, comprehension and application. These results thus suggest that the *SEADD* application improved students' ability to retrieve knowledge from their memory, to link their understanding of facts and ideas with new knowledge or prior knowledge and to solve problems by applying acquired knowledge. The semi-structured interviews that were conducted with a few Sotho speaking students that had access to the application also supported the success of the *SEADD* application. These students recommended that such an application should be developed for wider use; for example for secondary school learners, for other fields of study and in other languages. A print version of the *SEADD* application was also recommended. One important outcome of this study was that Sotho equivalents of terms and concepts art and design were not essential in enhancing learning. This finding supports other studies that reveal a similar result (Gupta, 1997; Roy-Campbell, 1998; Banda, 2000)

Chapter 7 – Discussion and Conclusion

7.1 Introduction

South African tertiary institutions have to cater for students of diverse backgrounds and from many different ethnic groups. At most South African tertiary institutions English is the language of instruction. When students enter the tertiary institution environment, many students experience difficulties. Because many students do not have English as their mother tongue, they find learning difficult, particularly because they are confronted with unfamiliar disciplines, which are rich in terminology and concepts that they have never seen in their past. At the Central University of Technology, Free State (CUT-FS), the National Diploma offered by the Department of Design and Studio Art, comprises of a number of subjects that are rich in many unfamiliar terms and concepts. Students enrolled for this qualification find it difficult to grasp many of these terms and concepts, making it difficult for them to perform satisfactorily (Seepe, 1998: 244). The problem is further exacerbated because the mother tongue of most students is Sotho, which does not have equivalent terms and concepts. Several studies have shown that multimedia e-dictionaries and glosses can be used as learning aids (Chun & Plass, 1996a, 1996b; Yeh & Wang, 2003; Chun & Payne, 2004; Yanguas, 2009). Therefore, in this study a multimedia e-dictionary was designed for terms and concepts that first year students in the Department of Design and Studio Art, at CUT-FS, encounter in their studies.

7.2 Multimedia e-dictionary

Several multimedia items were developed for the multimedia e-dictionary application, *SEADD*. The development of the multimedia e-dictionary items were all based on the guidelines proposed by Mayer (2009) to ensure that the final items would facilitate learning. The development of the e-dictionary application (*SEADD*) user interface was informed by principles proposed in human-computer interaction research (Silver, 2005; Lazar *et al.*, 2010; Scheiderman & Plaisant, 2010). Understanding how people interact with user interfaces can greatly enhance how they learn using technology (Narayanan & Hegarty, 2002; Hegarty, 2004). Earlier studies have shown that instructional multimedia, as learning aids; do facilitate learning of difficult concepts (Narayanan & Hegarty, 2002; Mayer *et al.*, 2005; Mayer, 2009). Thus, students that have access to multimedia aids, when learning new information, usually perform better than those that do not (Tversky *et al.*, 2002; Hegarty, 2004).

In this study, the multimedia e-dictionary items that were designed were tested through the development and application of a comprehension test. Two groups of first year students in the Department of Design and Studio Art were exposed to a comprehension test of several of the terms and concepts for which multimedia items were developed. The development of the comprehension test was based upon the assessment guidelines of CUT-FS, which requires that assessment questions should cover the first three levels of Bloom's taxonomy; knowledge, comprehension and application. The control group did not have access to the multimedia e-dictionary, while the multimedia

group did have access. The mean performance of the multimedia group (77.5%) was significantly better (p = 0.0007) than that of the control group (65.6%). The students found that access to a multimedia e-dictionary facilitated their learning of art and design terms and concepts beneficial. These results are in line with several studies focusing on the benefits of multimedia in learning (Mayer & Gallini, 1990; Carney & Levin, 2002; Tversky *et al.*, 2002; Mayer, 2003; Mayer *et al.*, 2005, Mayer, 2009; Höffler & Leutner, 2011; Wong *et al.*, 2012).

Instructional multimedia has proven to be particularly beneficial in helping students with problem solving and transfer tasks (Mayer & Gallini, 1990; Hegarty, 2004; Mayer *et al.*, 2005; Mayer *et al.*, 2005). Sweller (2006: 166) explained that, “Working memory cannot be expected to handle the amount of processing required by the random components of problem solving in a timely manner.” Therefore, instructional multimedia can act as an aid to working memory by providing “worked examples” (Sweller, 2006: 166-167). A worked example simplifies the process of developing relational connections between the different components of a system (Sweller *et al.*, 2011: 99). Being able to solve problems is an indication that meaningful learning has taken place, because the learner is able to select, organise, and integrate information (Schnotz & Lowe, 2003; Höffler & Leutner, 2007). In this study two questions of the comprehension test particularly address the ability of students to apply their knowledge. The students that had access to the multimedia e-dictionary performed substantially better than the control group. This outcome strongly supports the notion that access to multimedia was able to facilitate meaningful learning according to the active learning assumption (Mayer, 2003; Mayer,

2009; Fiorella & Mayer, 2015). It could further concluded that the dual representation of text and images in multimedia items had proven to reduce the cognitive load required when attempting to comprehend terms and concepts (Lowe, 2003; Hegarty, 2004; Höffler & Leutner, 2007).

The participants that had access to the multimedia e-dictionary expressed their satisfaction with having access to the learning aid. They stressed that such an aid could be beneficial to their studies. Because all students that participated in this study were in their first year of tertiary studies, they had little prior knowledge of their disciplines. It has been shown that learning by low prior knowledge learners is benefitted by access to multimedia instructional messages (Mayer & Gallini, 1990; Mayer & Anderson, 1991; Lewalter, 2003; Schnotz & Bannert, 2003; Mayer, 2009). In contrast, high prior knowledge learners utilise less cognitive resources in understanding a given topic (Höffler & Leutner, 2007: 724). This means that they are able to effectively develop their own mental models without the aid of multimedia. These students, did however mention, that they felt that the Sotho equivalents to the different terms and concepts did not enhance their learning. Because their learning instructional language was English, they preferred only English terms and concepts. Although it is widely argued that people need to be educated in their home language, because that leads to increased comprehension (Prah, 1998; Seepe, 1998), this study does not support this idea. In general, the use of multimedia in second language learning has shown positive results even for non-native speakers learning academic content in a second language (Yeh & Wang, 2003; Chun & Payne, 2004; Sung & Mayer, 2013; Mayer *et al.*, 2014).

7.3 Concluding remarks

The *SEADD* application has proven to successfully facilitate learning of difficult terms and concepts by first year art and design students. This application, as a learning aid, reduced the cognitive load required to learn new terms and concepts by providing learners with existing mental models (Höffler & Leutner, 2007; Kühl *et al.*, 2011) and by reducing extraneous cognitive load while enhancing learning (Sweller, 2006; Sweller *et al.*, 2011).

This study did reveal that access to mother tongue explanations or words may not be useful. However, only a few students were interviewed making it a small sample. Therefore, further studies are needed to reveal what the impact would be of mother tongue supplementation of a multimedia e-dictionary, and what type of mother tongue supplementation should be included.

Finally, the *SEADD* application will greatly benefit from audio additions. Having access to audio pronunciations of terms in an e-dictionary can lead to increased comprehension of particularly difficult terms and concepts (Lew, 2010).

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Appendix