Summary maps: Using eye tracking to investigate where students go wrong

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ABSTRACT

Worldwide, many students entering university are considered to be underprepared in terms of their academic literacy abilities. In order to support these students, the NWU offers two modules aimed at developing those academic literacy abilities that would enable students to access, process and produce academic information at tertiary level. As part of this offering, a basic Academic Literacy module focuses on summary mapping abilities, a summarising technique that is considered highly effective and valuable to students. However, despite ongoing efforts from lecturers, students continue to struggle with fully acquiring this skill to an adequate degree and therefore are not able to use this technique to its full potential.

To date, very little research has been done on the process of summary mapping in general. Even fewer studies make use of eye-tracking methodologies to investigate this process even though it can offer a unique way to gain insight into the process of mapping rather than focusing on the product or the final summary map only. Chapter 2 of this study provides an account of the theoretical framework of summary mapping, how it relates to reading in the context of academic literacy, eye-movement research and finally previous studies that used eye tracking to investigate the process of information mapping. The study set out to investigate the process of summary mapping one step at a time in order to determine possible challenges for participants. The impact of comprehension, selection of relevant information and information categorisation on summary mapping was determined in order to identify the possible challenges. For the empirical part of the study participants were asked to complete a comprehension test based on a relevant text. Thereafter they were required to identify all the important information in the text and complete a summary map of a section of the provided text. During this time, their eye movements were being recorded by an eye tracker in order to record the process followed when completing a summary map. By doing so a teaching model for summary mapping could be recommended towards the improvement of the teaching of this technique that could eventually ensure that students reap the full benefit of the summary mapping technique.

Statistical and qualitative comparisons indicated that participants generally had low comprehension of the text. A correlation was further identified between text comprehension and summary mapping but more specifically between vocabulary sections of the comprehension test and summary mapping as well as between participants' selection of relevant information and summary mapping. Furthermore, it was found that participants had significant difficulty with differentiating between essential and non-essential information and could moreover not categorise such information into a logical structure.

These challenges are addressed in Chapter 5 by providing a recommended teaching model for summary mapping that could be applied in academic literacy or other support modules.

Key words: Summary map, concept map, summarising, academic literacy, eye tracking.

OPSOMMING

Wêreldwyd word baie studente wat die universiteit betree, as ondervoorbereid beskou in terme van hulle akademiesegeletterdheidsvermoëns. Ten einde hierdie studente te ondersteun, bied die NWU twee ondersteuningsmodules aan wat daarop gemik is om spesifieke akademiese-geletterdheidsvermoëns te ontwikkel wat studente in staat stel om binne die tersiêre omgewing toegang tot inligting te verkry, dit te verwerk en dit te kan weergee. In die eerste semester word opsommingsbreinkaarte behandel. Hierdie opsommingstegniek word as ’n effektiewe en waardevolle hulpmiddel beskou om studente mee toe te rus binne ’n akademiese-geletterdheidsintervensie. Ten spyte van voortdurende pogings deur dosente, sukkel studente om die tegniek ten volle te bemeester en is hulle dus nie in staat om hierdie tegniek tot sy volle potensiaal te benut nie.

Tot op hede is baie min navorsing gedoen oor die proses wat gevolg word om opsommings-breinkaarte te voltooi. Selfs minder studies maak gebruik van oognaspeuring-metodologieë om hierdie proses te ondersoek terwyl dit die moontliheid inhou om op ’n unieke wyse die proses wat gebruik word om ’n opsommingsbreinkaart te voltooi, te bestudeer eerder as om slegs na die produk of die finale opsommingsbreinkaart te kyk. Hoofstuk 2 van hierdie studie bied ’n uiteensetting van die teoretiese raamwerk van opsommingsbreinkaarte, hoe dit verband hou met lees in die konteks van akademiese geletterdheid, oognaspeuringsnavorsing en laastens, vorige studies wat oognaspeuring gebruik het om die proses wat gevolg word vir die voltooiing van opsommingsbreinkaarte, te ondersoek. Die studie is daarop gemik om dié proses stapsgewys te ondersoek om sodoende die moontlike uitdagings vir deelnemers te bepaal. Die impak van begrip, selektering van relevante inligting en inligtingskategorisering op die voltooiing van opsommingsbreinkaarte is bepaal ten einde die moontlike uitdagings te identifiseer. Vir die empiriese deel van die studie is deelnemers gevra om ’n begripstoets, op grond van ’n relevante teks, te voltooi. Daarna is hulle gevra om al die belangrike inligting in die teks te identifiseer en ’n opsommingskaart van dieselfde teks te voltooi. Hulle oogbewegings is tydens die opsommingskaarttaak deur ’n oognaspeurder gemonitor om die proses wat gevolg is tydens die voltooiing van ’n opsommingskaart op te neem. Deur dit te doen, kan ’n onderrigmodel vir opsommingsbreinkaarte aanbeveel word ten einde die verbetering van die huidige onderrigstrategie. Dit kan uiteindelik verseker dat studente die opsommingsbreinkaarttegniek ten volle kan benut.

Statistiese en kwalitatiewe vergelykings het aangedui dat deelnemers oor die algemeen ’n lae begrip van die teks gehad het. 'n Korrelasie is geïdentifiseer tussen teksbegrip en die opsommingsbreinkaart, maar meer spesifiek tussen woordeskatafdelings van die begripstoets en die opsommingsbreinkaart, sowel as tussen deelnemers se vermoë om relevante inligting te idenfiseer en die opsommingsbreinkaart. Verder is gevind dat deelnemers probleme ondervind het om tussen noodsaaklike en nienoodsaaklike inligting te onderskei en dat hulle ook nie sodanige inligting in ’n logiese struktuur kon kategoriseer nie.

Hierdie uitdagings word in Hoofstuk 5 hanteer deur ’n onderrigbenadering vir opsommings-breinkaarte te verskaf wat in akademiesegeletterdheids- of ander ondersteuningsmodules toegepas kan word.

Sleutelterme: Opsommingsbreinkaart, breinkaart, opsomming, akademiese geletterdheid, oognaspeuring

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“There is no such thing as a leap into literacy.”

*- **David Petersen***

CHAPTER 1 INTRODUCTION AND CONTEXTUALISATION

1.1. Summary mapping and academic literacy

In South Africa, like in other countries, students face major challenges when they transfer from school to university. Students may not be aware of how demanding higher education can be in terms of the elevated workload, the level of independent learning required, and access to resources (Pargetter, 1999, 2000; Peel, 2000) or they may be under-prepared academically. According to Van Dyk *et al*. (2013) average academic performance and the under preparedness of students for the tertiary environment has enjoyed much attention in the literature possibly due to the pressure many universities face to maintain high throughput rates. The inability of students to deal with the high demands of tertiary education is reflected in high dropout rates during especially the first semester of university study (Brinkworth *et al*., 2009; Darlaston-Jones *et al*., 2003). South African data (Council for Higher Education, 2011) indicate dropout rates as high as 51% for a three-year programme over a period of three years.

According to Weideman (2003:56), one of the main causes for low success rates is the inability of students to use academic language effectively. Van Schalkwyk (2008:ii) also argues that one of the main aspects of under-preparedness is situated in students' academic literacy abilities and that such under-preparedness is often linked to poor performance at university. With the global rise in students pursuing qualifications at higher education institutions (Calderon, 2012), universities have put various support systems or interventions in place to support underprepared students, focusing mainly on strategies such as academic literacy (AL) modules (Butler, 2013; Weideman, 2006:82). According to Wingate (2018:350), academic literacy comprises "a student's ability to communicate competently in an academic discourse community" and involves "reading, evaluating information, as well as presenting, debating, and creating knowledge through both speaking and writing". In 2008, Van Schalkwyk (2008) referred to various scholars (Moore, Paxton, Scott & Thesen, 1998; Van Dyk & Weidemann, 2004; Woollacott & Henning, 2004; Fraser & Killen, 2005) and concluded that:

> dropout rates continue to rise across a broad spectrum of school achievement, and lecturers increasingly cite students' inabilities to read and write in a critical and analytical manner, to discern between fact and opinion, to recognize what is deemed evidence for an argument and to grasp the discourse of the discipline - in essence, academic illiteracy - as central to the problem (Van Schalkwyk, 2008:2).

In more recent research, Mavunga (2014) reiterates the same issue indicating that low academic literacy levels continue to be an issue. There seems to be a continued need for

intervention and support in this regard at tertiary level since an acceptable level of academic literacy ability is of crucial importance for academic success in a tertiary education environment (Van Schalkwyk, 2008).

A universal approach to the academic literacy problem has been to focus heavily on the development of academic writing, which does not seem to fully address the issue (Van de Poel & Brunfaut, 2004). According to Rose *et al*. (2008), the ability to autonomously learn from a text by reading is the key ability that is required for success at university. Millin and Millin (2014:30) highlight in their study that current standard academic practices at universities are inefficient because it is assumed that learners will be able to comprehensively read and understand all the prescribed supplemental texts that they are expected to read outside the classroom or after lectures. Due to this assumption, university lecturers simply synthesise these texts in their class discussions of the course content, while students have in fact not processed the necessary information from the supplemental material at all. (Rose *et al*., 2008). Millen and Millen (2014:30) further explain that the ultimate result is that students who cannot read well enough to fully understand the course content will furthermore not be able to produce written assignments based on the knowledge they were supposed to gain from the prescribed reading material. Students therefore fail to demonstrate any knowledge that they may have as a result of their inadequate academic literacy abilities.

The recommendation offered by Rose *et al.* (2008) to remedy this issue is to actively train students in class to access information from academic texts in such a way that a deep level of comprehension is achieved and to then guide students through the writing process. It is exactly at this juncture that a summarising strategy such as summary mapping[1] as part of an AL intervention becomes increasingly relevant. The effectiveness and versatility of mapping (mind mapping, concept-mapping, summary mapping or other similar mapping techniques) to specifically improve text comprehension, have been reported by numerous studies. Researchers, including Novak (1977), Beyerbach and Smith (1990), Horton *et al.* (1993), Hoz *et al*. (1990) as well as Chiou (2008), highlight how maps can be used as an instructional technique to ensure meaningful learning and effective teaching in various fields of study. According to Chang, Sung and Chen (2002:18), “concept-mapping strategy training not only improves reading comprehension skills but also benefits other linguistic skills related to comprehension, such as text summarization skills”. It therefore enables the student to see the

[1] In this study, the artefacts produced when people summarise the structure and content of a text into a drawing or structured diagram will be referred to as a summary map; and the action that the people perform will be called summary mapping. This technique is similar to what previous research may refer to as mind maps or concept-maps, among others. The explanation for the selection of this term as the preferred term follows in Section 2.2 of the study.

structure of the text and how parts of information and concepts are interrelated in the text, resulting in a better understanding thereof (Chimielewski & Dansereau, 1998; Griffin, Malone & Kamennui, 1995). The representation of important information in a diagrammatic structure not only teaches students to differentiate between essential and non-essential information like numerous other summarising techniques, but also enables the student to arrange the information into a structure that makes logical sense which, subsequently, makes it easy to recall (Novak & Gowin, 1984:49). Novak and Gowin (1984:7) also mention that if individuals want to learn in a meaningful way they need to be able to relate newly acquired knowledge to relevant concepts that are already known to them. What is referred to by these authors as concept mapping can make key concepts evident and also highlights linkages between new knowledge and what is already known (Novak & Gowin, 1984:23). It can therefore enable one to "develop new concept relationships in the process of drawing concept maps, especially if we seek actively to construct proportional relationships between concepts that were not previously recognized as related" (Novak & Gowin, 1984:17).

Using a strategy like summary mapping productively requires of the student to access information through reading, reach full comprehension of text by processing the information and then to practice writing skills by demonstrating their understanding through producing a diagrammatical map, showing visually how information is linked. It therefor makes a great deal of sense to teach such a strategy as part of an academic literacy intervention. If students are able to successfully produce an effective summary map from a provided texts in an academic literacy intervention, they should be able to use it productively for study purposes when confronted with other academic texts or theoretical content.

At the North-West University (NWU), students can receive academic literacy support in the form of two academic literacy modules based on their demonstrated level of risk in terms for academic literacy abilities. During the first semester of students' first year at the NWU students who show risk, based of the result they obtain in the Test for Academic Literacy Levels (TALL) developed by the Inter-institutional Centre for Language Development and Assessment (ICELDA) receive support in basic academic literacy abilities. These abilities are addressed in a scaffolded way in a first semester module, Academic Literacy Development (ALDE111). Students are introduced to various strategies that address accessing, processing and producing information respectively. This approach allows the student to focus on one ability at a time before being expected to integrate various abilities. During the second semester, a more integrated academic writing process receives attention in a second support module (Academic Literacy Development [ALDE122]). In this more advanced module, all first-year

students are expected to integrate abilities such as accessing of information and referencing skills mastered during the first semester into the writing process.

In the first semester module (ALDE111) the principal structure of the module is to focus on three major elements namely accessing information, processing information and producing information. Accessing information focuses on the two predominant ways in which information is accessed at university, namely listening and reading. Reading is addressed by introducing four practical reading strategies (scanning, skimming, comprehensive reading and critical reading). The comprehensive reading strategy is one of the main focuses of this module and abilities such as dealing with unfamiliar vocabulary and terms, understanding linking devices and the identification of main ideas are addressed.

Due to the nature of comprehensive reading, it is easy to see how this naturally moves into the realm of the second major element, processing information. The abilities addressed in comprehensive reading are then broadened into processing of the information to such an extent that it can be summarised in the form of a summary map. As a fourth reading strategy, critical reading also features in this module as students are prepared to use appropriate referencing techniques to locate and evaluate sources that can later be used to support their writing.

The final element addressed in the ALDE111 module is the production of information. Although students do practice this ability to a limited extent in the first semester in the form of summary mapping, answering assessment questions and writing shorter assessments, the complete writing process forms an introduction to the second semester (ALDE122) content. In the second semester students get the opportunity to work through the writing process in a scaffolded manner. The different parts of this process that are focused on are ultimately put together into a complete formal written assessment.

Figure 1-1 serves as a summary that illustrates how different components and abilities are approached in the two AL support modules (ALDE111 and ALDE122). A detailed discussion on the ALDE111 approach will, however, be provided in Section 2.3. The overall aim of these modules is to enable students to access, process and produce information in the academic environment in order to ultimately be able to successfully complete tertiary education.

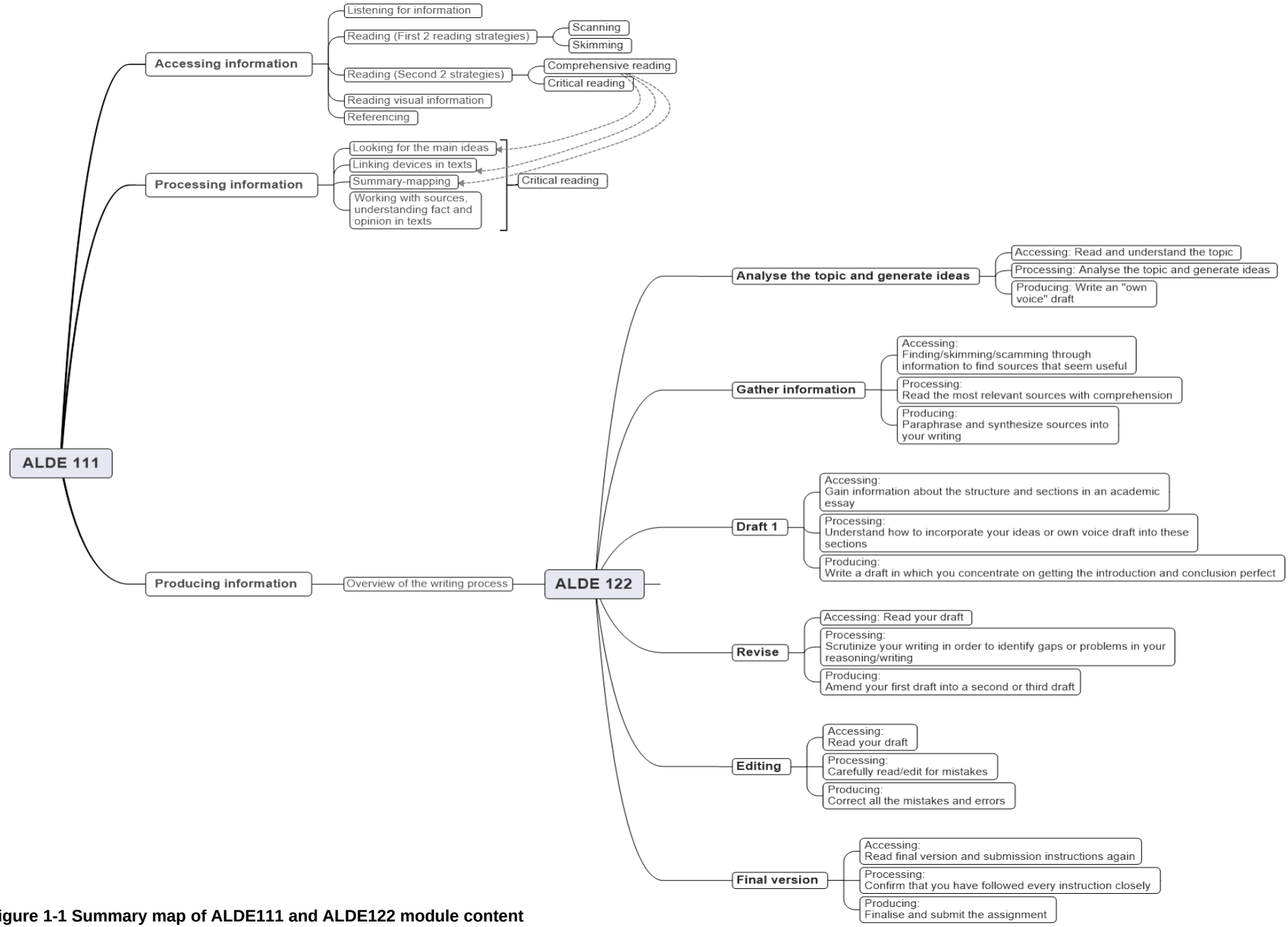


Figure 1-1 Summary map of ALDE111 and ALDE122 module content

As already mentioned, summary mapping is introduced in the first semester as a summarising strategy that involves all three academic literacy elements. Accessing of information is involved because students are required to read and fully comprehend what they are reading. Processing is required as students need to summarise the text, in other words, identify the essential information and then categorise the specific information into a logical structure. Lastly, students are required to produce information in the form of a diagrammatical map.

A summary map[2] is a graphic representation of summarised information which shows how different concepts or information chunks relate to each other. It is a structured diagram similar to what in other research is referred to by a number of other names. These other diagrams also often have different characteristics. The other names include graphic organisers (Estes, Mills & Barron, 1969), concept maps (Novak, 1990), mind maps (Buzan, 1993), knowledge maps (O'Donnell, Dansereau & Hall, 2002) and node link diagrams (Dansereau, 2005), to name a few. Of this list, concept map and mind maps seem to be the most well-known. Some researchers refer to concept maps as a graphic framework that allows one to depict knowledge in a visual way (Novak & Cañas, 2006; Novak, 1990). Such frameworks include information concepts and show the relationship between such concepts by means of what is referred to as cross links. The concepts are generally included in boxes with arrows or lines connecting them. Sometimes the lines are labelled with phrases that explain the relationship. Three basic elements that form part of Novak's (1990) definition of a concept map are present in most of the work concerning mapping (Rovira, 2016). These include: "graphs or frameworks, concepts or ideas and relationships or links" (Rovira, 2016:61). These elements characterise most of the maps found in the literature but look somewhat different from the summary maps that are used as summarising tool in academic literacy at the NWU.

What makes the summary map as it is presented at the NWU different is that it is ultimately a summarising technique, unlike the other maps mentioned. They only represent information that is presented in a text and does not require the users to fill the map with information from their frame of reference. Although not all texts have a hierarchical structure that can be presented in a diagram, texts that AL interventions aim to support students with generally have main ideas and supporting evidence that can be presented diagrammatically.

A summary map starts at a central point (usually on the lefthand side of the page) and branches out to show subordinate levels of information that flow logically from each point. Concepts or chunks of information are linked with lines or arrows, but these lines or arrows are not labelled. Relationships between ideas are not stated explicitly by labelling linking

[2] See Section 2.2 and Table 2-4 for full discussion on this term.

arrows or lines with words, but portrayed by the hierarchical structure of the diagram and/or by a word or phrase within the box that contains the concept information. An example has been included as illustration in Figure 1-2 below.

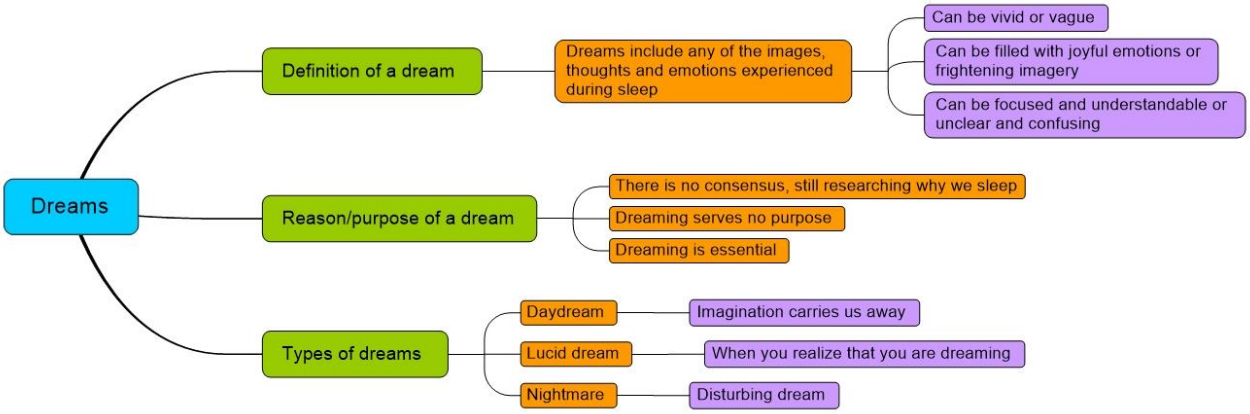


Figure 1-2 Summary map of 'Dreams' text

Even though summary mapping is taught on all campuses of the NWU in the aligned[3] ALDE111 module, Vanderbijlpark campus (VC) staff members specifically have collectively made a continuous effort to teach summary mapping effectively in a very uniform way, following even the exact same lesson plan and using the same class activities. Because of the uniform way teaching is approached at the VC, it made sense to situate the study at this specific campus. On the other two NWU campuses (i.e. the Potchefstroom Campus and the Mahikeng Campus), the way the content, with reference to summary mapping, is approached in a class may vary slightly. Although the assessments are aligned, the lesson plans are less rigidly aligned and lecturers may use their own discretion in terms of how they want to approach the summary mapping lesson. Despite intensive effort from VC lecturers, students still experience difficulty in utilising the strategy productively. Recorded scores reflect that over a three-year period (2017-2019)[4], students scored an average of 43% for summary mapping activities at the VC. These scores were determined by a scoring rubric, the summary map assessment rubric tool (SMART) that is reported in Butler, Butler and Schutte (2022) and was developed specifically for the scoring of summary mapping. Even though students can make use of other strategies to summarise information, it is relevant to mention that it is not practically viable to teach all summarising strategies in an academic literacy module. Summary

[3] An aligned module is a module that is offered across the three campuses in the same way. It addresses the exact same module outcomes using the same module content and assessments.

[4] Results for 2020 and 2021 were not taken into consideration because students submitted this assessment in a different format due to Covid-19 constraints.

mapping as a strategy should enable students to categorise and structure information in a way that illustrates the bigger picture and interrelatedness of knowledge to them, in line with the constructivist approach that according to Resnick (1989) conceptualises learning as a process that takes place when information is interpreted and related to what is already known[5]. The information thereby becomes knowledge. This suggests that it makes considerable sense to teach an information structuring ability like summary mapping as part of an academic literacy module.

1.2. Teaching summary mapping

Unfortunately, knowing that something is effective and only recognising its efficacy once you are able to do it well does not help students learn how to do summary mapping. Despite ongoing efforts from academic literacy lecturers at the VC, students persistently struggle with this ability. The way in which the ALDE111 module has been designed as well as how specifically summary mapping is currently being taught will be discussed comprehensively in Chapter 2. Students' difficulties with summary mapping from the VC has already been mentioned. In a study at the Cape Peninsula University of Technology, Wright (2006:34) found that maps

> tend to lack depth (in terms of levels of information); there are illogical links and unclear relationships among details; there is often duplication or overlap of categories (the names of categories differ but they should be included under one category, such as 'education' and 'schooling'); and there is often no clear visual separation of details in two adjoining categories, making it difficult to establish where a point belongs.

Wright made this observation while teaching mapping as a summarising technique as part of a generic academic literacy programme at the Cape Peninsula University of Technology.

Other studies explicitly stating that students struggle with this ability are limited. This is possibly due to the fact that maps are often used as a strategy to study content on which students are then assessed, but the map itself is rarely assessed on its own. Numerous other studies also make use of maps in their research without the maps themselves being assessed or used as summarising tools, but rather for brainstorming activities (Blommaert *et al.*, 2005; Parkinson *et al.*, 2007; Joubert *et al.*, 2015).

In a study originating from the United Kingdom, Hay, Kinchin and Lygo-Baker (2008) mention that the method for concept mapping (which in their article refers to a mapping technique

[5] This approach and how it relates to summary mapping is discussed extensively in Section 2.2

slightly different from summary mapping but fundamentally similar) can be taught in 10-20 minutes. This does not seem to be the case in the context of the current study and it is therefore imperative to determine why students continue to struggle with summary mapping in order to present an appropriate and effective teaching model for summary maps, the ultimate goal of the study. Rovira (2016:64) furthermore states that despite extensive research into concept maps, researchers are still not sure why they are effective and how they are to be used optimally. It is this optimal use of summary mapping that lecturers at the VC are in pursuit of since the purpose of the academic literacy support modules is to enable students to utilise the necessary abilities to succeed at their studies.

As already mentioned in Section 1.1, the production of a useful summary map entails combining a number of different academic literacy abilities that are all addressed in ALDE111. Firstly, students need to be able to read a text with a high level of comprehension. In other words, students need to read to understand not only the words or the vocabulary of the text, but they also need to understand how the structure and connections within the text convey meaning. Secondly, students need to make a selection as to what is important information and what is less important. Therefore, they need to differentiate between the fundamental concepts that they need to study and remember and the supplementary information they should be able to provide or generate themselves once they understand the fundamental concepts. In other words, if the textbook they are studying used an example to illustrate a fundamental concept, they need to identify the fundamental concept as important information to study because once they understand this concept, they should be able to generate applicable examples themselves. Thereafter, they need to organise the information into sensible structures and transfer it to a visual diagram. These steps often happen simultaneously or are integrated in a way that most people do not even realise that they are using multiple abilities to achieve one goal, but this does not mean that it can be taught as a single integrated ability. In order to efficiently teach this strategy, that is new for most students, it is broken down and taught as individual abilities in the AL module at the VC. However, apart from text comprehension, these individual abilities are not assessed individually. Only the final product, the completed summary maps, are assessed.

Investigating why students experience difficulty with summary mapping, the identified problem addressed in the study, will thus require that these separate abilities be investigated individually in order to determine whether students struggle with specific abilities, or if it is the integration thereof that creates a challenge. A greater understanding of the limitations and strengths of the students for each separate ability could inform the major focus and teaching methodology when teaching summary mapping abilities.

1.3. Eye tracking

Eye tracking as a technique for collecting data has been used for research in many fields. Broadly speaking, it is used to detect eye movements and analyse the processing of visual information. More specifically, Mele and Federici (2012:261) assert that: “Different fields such as neuroscience, experimental psychology, computer science and human factors can benefit from eye-tracking methods and techniques to unobtrusively investigate the quantitative evidence underlying visual processes.” Eye tracking is a technique that uses recording technology to track the eye movements of individuals by using a camera that measures the position of the eye and then records the reflections of infrared light on the eye’s retina, in order to gain an accurate understanding of where the attention focuses (Duchowski, 2007). Richardson and Johnson (2008) state that investigating eye movements is an unobtrusive and accurate way to gain significant insight into “psychological processes such as language processing, image processing, auditory processing, memory, social cognition and decision-making” (Richarson & Johnson, 2008:23). They further state that eye movements “are the result of an intimate and constant interaction between cognitive and perceptual processes” (Richardson & Johnson, 2008:23). Just and Carpenter (1976) suggest that the position where the eyes focus indicates what is being processed by the brain at that time. This is called the eye-mind assumption, an approach that assumes a link between what is focused on and what is processed by the brain (Hvelplund, 2014:209). Despite this assumption being contested by some researchers it is still regularly used as a basis for research. This eye-mind assumption and the criticism thereagainst will be discussed comprehensively in Section 2.6.

According to Anson and Schwegler (2012), recent eye-tracking research tends to focus more on reading and less on writing or producing texts. One reason for this could be due to the difficulty of studying text production which will be discussed in more detail in Section 2.5. It can however, be useful to study writing or the production of text with the use of eye tracking because it can “tell us ‘what’ writers are reading or looking at during pauses, and how their visual behaviour relates to other processes of text production” (Anson & Schwegler, 2012:161). As summary mapping combines reading and text production in a unique way, the use of eye tracking to study the process may yield valuable information about what students focus on when producing summary maps, how they select information and what they focus on in terms of structuring information.

1.4. Using eye tracking to study summary mapping

Despite the feasibility of using eye tracking to study summary mapping, not many scholars have attempted to do so. Rovira (2016) identified only 15 studies that have been published using eye tracking as a methodology to study mapping. After his review only two other studies could be found that made use of this methodology. This methodology, however, lends itself particularly well to the study of summary mapping because it involves reading, processing of information and visual abilities that have all been investigated previously using eye tracking[6]. The most notable advantage of using eye tracking to study summary mapping is that it enables the researcher to gain insight into the process of mapping and not just the final product (the summary map).

1.5. Research questions

The following two research questions as well as three sub-questions will guide the current study.

1. How (what process) do students (use to) create summary maps to summarise information for learning?
    a. How do students' comprehension levels of texts relate to their production of a summary map?
    b. How do students' ability to select the relevant information in a text relate to their production of a summary map?
    c. How do students' ability to organise selected information into a logical structure relate to their production of a summary map?

2. What are the implications of the findings for the teaching methods used to teach summary mapping abilities?

1.6. Research objectives

The study will set out to determine the relationship between text comprehension, the process applied by participants when completing a summary map task and the effectiveness the summary map they produced in order to optimise the teaching model for summary mapping abilities. The specific objectives of this study will be to determine: (1) how students' level of

[6] Eye tracking studies will be discussed comprehensively in Section 2.5.

comprehension of the texts they read and summarise relates to their summary mapping ability; (2) how students' ability to select the relevant information in a text relates to their summary mapping abilities; (3) and lastly, how students' ability to organise selected information into a logical structure relates to their summary mapping abilities. Once these objectives have been reached the implications of the findings will be considered in order to determine an optimal teaching model for summary maps that may result in the optimal teaching thereof.

1.7. Research methodology

The study includes empirical research of both a qualitative and quantitative nature that should illuminate possible difficulties which hinder students' their acquisition of summary mapping ability as it is currently taught in the academic literacy modules at the NWU.

Summary mapping requires the integrated use of mainly three separate abilities, namely reading and understating a text, identifying and selecting relevant information and organising the information into a logical pattern. In order to identify which of the integrated abilities may present difficulties, each of the identified abilities needed to be investigated in isolation, but still as closely as possible to a natural situation. Firstly, the comprehension of the text was tested by giving participants a comprehension test designed to test vocabulary, surface level comprehension, deep level comprehension and summarising skills. Secondly, the ability to identify and select relevant information was assessed. This ability can be tested by asking students to highlight the most important information in the text. However, this method will only ensure insight into the product and not the process taking place while students are engaged in the activity. Using eye tracking for this section of the research could ensure greater insight into the process that takes place during the selection of important information. This is confirmed by Glaholt and Reingold (2011:125) who state that: "eye movement monitoring is a valuable tool for capturing decision makers' information search behaviors". Eye tracking could, therefore, be a useful way of studying how these processes take place. The last ability that is assessed is the organisation of the information into a logical pattern, in other words, the ability to transfer the information to a graphic representation (in this case, a summary map). To test this, participants were asked to draw a summary map of the most important ideas contained in a section of the provided text. The effectiveness of these summary maps was then assessed.

In terms of data analysis, the main objective is to determine the relationships between the dependant variable, namely the summary map score which will be measured by assessing the drawn summary maps, and the independent variables for the study. The independent

variables will include participants' comprehension of the text, percentage of marked relevant information, eye-tracking measures (i.e. fixation duration and count, number of transitions and dwell time) that will be determined by the set areas of interest (AOIs) in the text as well as in the summary map; and patterns that may occur in terms of observed acts during the summary map drawing.

The first two independent variables (i.e. comprehension of the text and percentage of marked relevant information) represent parts of the taught steps of summary mapping in the academic literacy module discussed extensively in Section 2.3. The significance of these two variables relates to the notion that they might indicate specific areas of difficulty for students. Furthermore, the eye-tracking measurements will give insight into the process of summary map drawing. Such measurements are considered significant because they convey information about what is being processed and how difficult it is for students to process. Possible patterns that may emerge from the analysis could give valuable insight into how participants arrive at effective summary maps or why they produce ineffective summary maps.

1.8. Ethical considerations

Before any experimentation commenced, ethical clearance was obtained from the Ethics Committee for Language Matters at the NWU (Reference number: NWU-01124-20-A7) as well as from the NWU Gatekeeper Committee (Reference number: NWU-GK-21-025). The official letters from these committees are included as Annexures E and F. All participants were informed orally about the use and function of the eye tracker and what they can expect in the experiment before they participated. They were also reminded that their participation was completely voluntary and that they could choose to leave at any point during the experiment. It was furthermore emphasised that the collected data would be used anonymously and that the experiment would not influence their academic performance or marks in any way.

Participants were given an informed consent form (included as Annexure D) to complete. This form provided information about the study and what they could expect to experience during the experiment. Willing participants were requested to sign the consent form which gave the researcher permission to:

- Record all their scores for the different components;
- Record their reading of texts and construction of summary maps using the eye tracker; and
- Anonymously report all gathered data in the current study and any report or publication that will follow from the study.

1.9. Provisional chapter division

Chapter 2: Literature review

This chapter discusses the theoretical foundation of summary mapping, summary mapping and comprehensive reading and the use of eye tracking. The scarcity of literature that uses eye tracking to study various types of maps is emphasised. The usefulness of this methodology is also discussed despite the lack thereof in previous studies.

Chapter 3: Methodology

Chapter three includes a detailed description of the research methods used to reach the objectives outlined for this study. It discusses the design and execution of the experiment as well as the sampling procedure and methods for data collection and analysis.

Chapter 4: Analysis and interpretation of findings

In this chapter the findings of the experiment are analysed. The possible difficulties that prevent students from mastering summary mapping abilities are discussed. Furthermore, the implications that the results may have for the teaching of summary mapping abilities are also highlighted.

Chapter 5: A Proposed teaching model for summary mapping

In this chapter all the findings are combined in order to recommend a teaching model for summary mapping abilities.

Chapter 6: Conclusion

Concluding remarks are provided and avenues for further research are also discussed.

CHAPTER 2 LITERATURE REVIEW

2.1. Introduction

As alluded to in Chapter 1, the challenge of students entering into tertiary education without being fully prepared for it in terms of academic literacy abilities is being addressed by providing support in the form of academic literacy support modules. Summary mapping is taught at the NWU as part of this intervention because it provides students with a useful tool that can be employed to access and process information successfully. It furthermore provides an opportunity to present this information in a logical way that shows the interrelatedness of the information. Students however continue to struggle with mastering this tool. This study aims to present an effective and appropriate tool for teaching summary mapping by investigating the process of mapping and determining challenges faced by students during the completion of a summary mapping task. In order to investigate this process, eye tracking will be used as a methodology, an approach not many scholars have attempted to use to study mapping. This methodology could, however, be particularly well suited to the study of summary mapping because summary mapping involves reading, information processing and visual abilities that have all been investigated separately in previous eye-tracking research as discussed in Section 2.4. Eye tracking furthermore enables the researcher to investigate the process as it takes place (i.e. a student reading the text and marking important information as well as drawing the map), instead of only focusing on the completed summary map. This chapter aims to provide an overview of existing research conducted in the field of relevant types of information maps and eye tracking as well as the small number of studies combining these two fields. Furthermore, it aims to illuminate opportunities for further research as well as gaps in the available literature that are addressed in this study.

2.2. Reading and summary mapping

Rose *et al*., (2008), already referred to in Section 1.1, specified the ability to learn from reading as one of the most significant skills required at tertiary level. According to Pretorius (2002: 193): “Reading constitutes the very process whereby learning occurs and it lies at the roots of academic performance: if one wishes to improve academic performance at all levels of schooling, then one needs to improve reading ability”. Wagner *et al*. (2006:1112) state that comprehension requires the reader to unravel “the way in which the message is conveyed” and that this implies that the reader also interprets the linking devises used to organise the text to ultimately decipher the conveyed message. According to Pretorius (2000:37):

> The ability to make connections, to perceive possible relationships, to see likely links between text entities is a cornerstone of language processing. In reading, this ability to construct meaning via the making of inferences is particularly important, since the reader does not have access to other modalities that help meaning construction, such as intonation, speaker gestures, facial expressions or asking a speaker to repeat or clarify what has just been said.

The conclusion that can be drawn from the literature cited above is that reading ability is of the utmost importance for academic success at tertiary level. Based on this statement, South African students may be considered particularly vulnerable when entering university. According to Spaull and Pretorius (2019) “an initial survey of some foundational tenets of reading research show that while reading outcomes in South Africa improved between 2006 and 2011 they have stagnated between 2011 and 2016. The most recent PIRLS study (2016) showed that 78% of Grade 4 children cannot read for meaning in any language.” This problem of low reading ability seems to persist throughout secondary school level and into tertiary education. Pretorius (2000) reports that many first-year Psychology and Sociology students at Unisa were reading at an average comprehension level of 53%. Similar results have also been reported at other South African universities. Taking into consideration the low level of reading ability of South African students when they enter university, it therefore makes a great deal of sense that reading forms the basis of the academic literacy intervention offered at the NWU.

As already mentioned in Section 1.1, the three major elements that define academic literacy and are used as a structuring principle for the ALDE111 module at the NWU, are the ability to access, process and produce information in an academic context. With regard to these three elements, a major focus of the first semester module (ALDE111) is on the accessing and processing of textual information, in other words, reading and understanding. In order to address these elements, the module offering is structured as presented in Figure 2-4. The arrows illustrate the interrelatedness of the elements in terms of what is relevant to the study.

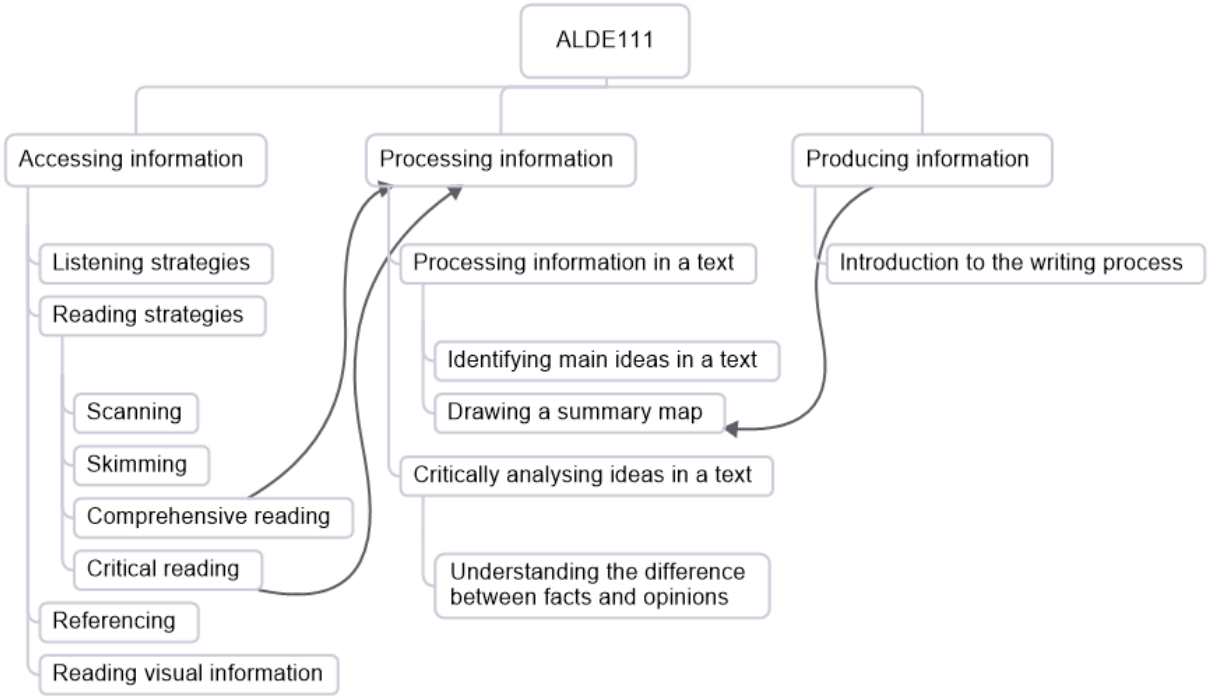


Figure 2-1 Structure of the ALDE111 module as it is currently offered

At the beginning of the semester, students are introduced to the two major ways of accessing information at a tertiary level, namely listening and reading. In terms of listening, three steps for learning optimally from a lecture/class (preparation for the lecture, active listening and taking notes) are addressed. Thereafter, reading is addressed by focusing on the definition of academic reading and the introduction of four practical reading strategies. The majority of the semester is spent on reading and processing of textual information. Regarding the focus on reading strategies, skimming and scanning are introduced first. Students are therefore taught how to skim-read a text in order to determine the overall idea discussed in the text as a starting point. Subsequently, they are exposed to scanning as a strategy for finding specific information in a text in order to address specific reasons or goals for reading. Comprehensive reading is addressed next. In this study unit students are firstly introduced to strategies for dealing with unfamiliar words, such as using the context to derive meaning or determining the root of the word to simplify it, in other words, vocabulary. Vocabulary knowledge is according to Carroll (1993) closely related to reading comprehension which is understandable as comprehension could not take place without an understanding of words. Research in this field has categorised vocabulary broadly into vocabulary breath which refers to the number of known words and vocabulary depth which refers to what is known about the word or the quality of the word knowledge (Perfetti, 2008). Qian (1999) investigated to what extent depth of vocabulary knowledge adds to the prediction of reading comprehension scores for specifically English

second language adults and found that vocabulary depth played a central role in comprehension processes of participants. He furthermore determined that participants with more depth of knowledge reacted differently to unknown words. These participants focused more on the meaning of the word whereas the participants with less depth of knowledge focused more on word forms. Since the Qian (1999) study, other researchers have duplicated the experiment in different settings and obtained the same results (Rashidi *et al*. 2010, Harkio & Pietilä, 2016). These studies point out how important it is to improve depth of vocabulary knowledge especially for second language learners.

What is very relevant for the current study is the evidence presented by Cain and Oakhill (2014) that points to vocabulary having a more influential impact of certain aspects of comprehension. They explain that vocabulary is more important to inference making than the literal comprehension of the text (Cain & Oakhill, 2014:658).

Linking to text comprehension as well as vocabulary, logical connectors and linking devices are introduced next in the semester to make students aware of the internal structure of sentences and paragraphs leading to an understanding of how words with specific meanings help to connect ideas that are presented in a text. Some researchers believe that coherence relations are a crucially important element for comprehension. Graesser *et al*. (2002:2) state that "based on years of research, processing coherence relations is a cornerstone of comprehension". They furthermore mention that:

> A text is perceived to be coherent to the reader when the ideas hang together in a meaningful and organized manner. How is this accomplished? Coherence relations are constructed in the mind of the reader with the help of linguistic and discourse markers. A marker is an explicit word, phrase, sentence, or feature that guides the reader in interpreting the substantive ideas in the text …". (Graesser *et al*., 2002:3)

In ALDE111 students are provided with lists of linking devices categorised by the type of relationship they indicate. Examples are also used to point out how relationships between ideas are portrayed with the use of these words or phrases.

Then students are guided in active reading that would lead to a comprehensive understanding of the text, as well as how to interpret and answer comprehension type questions on the text. This is done by read aloud demonstrations and practice activities in class. Lastly, the study unit focuses on critical reading where students are prompted to make a judgement about the information in the text after making sure they fully understood the text.

Reading comprehension research on its own is a rich field that has, according to Duke and Pierson (2002:107), progressed very rapidly since 1975. They further mention that research regarding the process of reading comprehension has been based in studies about what constitutes a good reader. According to Duke and Pierson (2002:206), a comprehensive review of the work on characteristics of good readers lead to the summary of how good readers go about reading, included in the left column of Table 2-5. The opposite column in the table contains explanations or content from the ALDE111 study guide as illustration of how these characteristics are addressed in the module:

Characteristics of good readers	Explanation or content from ALDE111 Study guide
Good readers are active readers (Duke & Pierson, 2002:206).	Comprehensive reading is explained as an active process. Students are encouraged to make notes, mark unfamiliar words and underline important information while they are reading.
From the outset they have clear goals in mind for their reading. They constantly evaluate whether the text, and their reading of it, is meeting their goals (Duke & Pierson, 2002:206).	When you scan for information, you usually have a specific purpose or a specific question in mind, and therefore do not have to read the whole text. Instead of reading the whole page, you let your eyes move quickly over the page, searching for what you need (Butler, 2019:14).
Good readers typically look over the text before they read, noting such things as the structure of the text and text sections that might be most relevant to their reading goals (Duke & Pierson, 2002:206).	Skimming is a reading strategy that allows you to get an overview of a text that you intend to read. The main purpose of the strategy is to save time and to help with understanding a text better (Buter 2019:18). As is the case with scanning, it is also helpful to understand the organisation of the text in order to skim more effectively. Make use of headings and sub-headings, opening paragraphs and conclusions and words in bold or italics (Buter 2019:19).
As they read, good readers frequently make predictions about what is to come (Duke & Pierson, 2002:206).	Predict the content of a text by making use of headings, sub-headings, first paragraphs and of a set of topic sentences (Butler:2019:11).
They read selectively, continually making decisions about their reading - what to read carefully, what to read quickly, what not to read, what to reread, and so on (Duke & Pierson, 2002:206).	Each strategy has a very specific function with respect to saving time, determining the relevance of information before reading a text comprehensively, making sure that one understands the essence of a text, and finally, making a judgement about the information in a text (Butler 2019:14).
Good readers try to determine the meaning of unfamiliar words and concepts in the text, and they deal with inconsistencies or gaps as needed (Duke & Pierson, 2002:206).	Words that are unknown to students or words that are misinterpreted can be a major obstacle to reading comprehension in academic texts. One can deal with unknown words by:

	- trying to work out the meaning from the context (making inferences); - using the root of the word to work out its meaning; and - using a dictionary if the other two strategies don't work (Butler, 2019:40).
They think about the authors of the text, their style, beliefs, intentions, historical milieu, and so on (Duke & Pierson, 2002:206).	When referencing and responsible source used is addressed, students are encouraged to think about these aspects in order to determine how relevant and useful the source will be to them (Duke & Pierson, 2002:206).
They monitor their understanding of the text, making adjustments in their reading as necessary (Duke & Pierson, 2002:206).	Students are often asked leading questions when comprehensive reading is demonstrated in order to show students how to think about their understanding of a text.
They evaluate the text's quality and value, and react to the text in a range of ways, both intellectually and emotionally (Duke & Pierson, 2002:206).	If we critically analyse an academic text, the first step is then to ask oneself what the factual information is in the text. Once identified, we further need to ask whether the facts are common, universally accepted facts (such as 'generally, human beings have the capacity to remember information'), or do the facts need verification that is provided (or not) in the text (e.g. 'people can normally hold up to 7 items in their short-term memory at any one specific time' is an idea that needs to be verified by research) (Butler, 2019:99).
Good readers read different kinds of text differently (Duke & Pierson, 2002:206).	Generally, different types of information are used by writers with regard to what specific type of message they wish to include and convey in a text. Sometimes it is required that you only provide a description of something. This is when, for example, you are asked to describe a specific approach to teaching in order to explain its effectiveness. In other cases, however, you might be required to argue a specific point, based on evidence. In the next section we will take a look at not only academic genres, but also more informal genres used by writers for specific effect. This is necessary so that you can compare writing in a more formalised academic environment with that of other more informal environments (Butler, 2019:37).
When reading narrative, good readers attend closely to the setting and characters (Duke & Pierson, 2002:206).	This is not relevant to the current study.
When reading expository text, these readers frequently construct and revise summaries of what they have read (Duke & Pierson, 2002:206).	One of the best strategies for making summaries of academic information that you could use in order to remember the main ideas is to draw a diagram of the keywords of the main ideas. The most important advantage of using such a summary map (diagram) is that it helps one to remember the ideas of a complete section of work because it condenses the information onto one or two pages. It also shows which and how ideas in the text are related to one another, and shows the importance of ideas as the most important ideas would lie closer to the centre of such a summary map (Butler, 2019:90).

For good readers, text processing occurs not only during “reading” as we have traditionally defined it, but also during short breaks taken during reading, even after the “reading” itself has commenced, even after the “reading” has ceased (Duke & Pierson, 2002:206).	Text processing is one of the major elements addressed in AL modules offered at the NWU.
Comprehension is a consuming, continuous, and complex activity, but one that, for good readers, is both satisfying and productive. (Duke and Pierson, 2002:206)	The goal of comprehensive reading explained in the AL module is to fully understand what you are reading and thereby being able to learn.

Table 2-1 Characteristics of good readers and how these characteristics are addressed in the AL module

Duke and Pierson (2002) furthermore emphasise two important characteristics that specifically highlight the importance and value of a tool such as mapping. These characteristics are also mentioned above in the good reader studies: “Good readers draw from, compare and integrate their prior knowledge with the material in the text” (Duke and Pierson, 2002:206) and “good readers frequently construct and revise summaries of what they have read when reading expository texts” (Duke and Pierson, 2002:206). The last characteristic mentioned also refers to the link between reading or reading comprehension and summarising. According to Westby *et al*. (2010:276) summarisation is seemingly one of the most successful techniques for text comprehension and retention. Rinehart *et al.* (2010:424) furthermore explains that teaching summarisation creates awareness of text structure and the organisation of ideas, which in turn enables the student to evaluate their reading and understand the processes involved in text comprehension. Additionally, summarisation tasks offer a way to intersect reading and writing in an academic setting (Hirvela, 2004:92). This statement illustrates how teaching an ability like summary mapping touches on not only reading (as one of the ways to access information) but also on processing and producing of information, elements that are interrelated and very seldomly occur in isolation in the academic context.

Processing of information is the next major outcome that is focused on in the ALDE111 offering. Drawing on comprehensive and critical reading strategies, students are introduced to the processing and deeper understanding of texts. This is done by guiding students to recognise the main ideas in a provided text (usually one that they have read previously in the semester). Then they are introduced to summary mapping as a summarising strategy and guided through the process of reading and marking main ideas in sections of the complete text. Thereafter they are given the opportunity to practice the drawing of a summary map after the lecturer has demonstrated the process of selecting main ideas and the drawing of a

summary map by using a very simple text. They are lastly introduced to the scoring system that would be used to assess their summary maps and characteristics of an appropriate summary map are discussed. Depending on the time allotted for summary mapping in the teaching plan of the semester this process usually takes two to three sessions of 60 minutes each. The process of drawing the map is thus broken down into smaller sections and scaffolded in such a way that it builds students' ability to draw an appropriate summary map from any text. Students are then given a different text and have an opportunity to attempt the whole process on their own.

As can be seen in Figure 2-4, a number of other abilities are also addressed in ALDE111. These include referencing skills, reading visual information, understanding facts and opinions and an introduction to the writing process. From this discussion it should be evident that summary mapping speaks to each of the major outcomes addressed in the module as it entails comprehensive reading, processing of ideas in the text and the production of a new, unique "text" (diagram) by the student. The inclusion thereof in the ALDE111 offering is pedagogically sound and appropriate and the content that is presented in this module and should enable students to master this ability. If students can demonstrate the ability to produce an effective summary map, they have demonstrated that they have mastered to some extent the outcomes of the module including:

- access academic information effectively in order to understand academic texts;
- process academic information successfully; and
- produce academic information responsibly and appropriately (Butler, 2019:v).

As will become evident in Section 2.3 mapping can be used in many forms and for many purposes. There is ample research in the literature that emphasise how mapping can be used to improve comprehension. The current study, however, aims to determine if text comprehension presents significant challenges to students in their drawing of summary maps. The focus of this study is, in other words, the cause-and-effect relationship between comprehension (as well as other aspects) and summary maps. Duke and Pearson (2002:112) also mention this ubiquitous back and forth characteristic of mapping, stating that "the point about visual representations is that they are *re*-presentations; literally, they allow us to present information again. It is through that active, transformative process that knowledge, comprehension and memory form a synergistic relationship - whatever improves one of these elements also improves the others." It is important to bear this characteristic of mapping in mind in this discussion that points out the value and need for a skill such as summary mapping. However, the specific research question posed in this study in terms of comprehension seeks

to determine whether there is any relationship between students' comprehension levels of texts and their production of a summary map. Students for whom comprehension is a major challenge can benefit from a summary map teaching method that includes instructional techniques proven to help students improve their reading comprehension skills and strategies.

According to Duke and Pearson (2002:107), there are a number of instructional techniques that prove effective in improving students' reading comprehension. They for example recommend teaching collections or packages of comprehension techniques to ensure that students become comprehenders of many kinds of texts. Further strategies to improve text comprehension will be elaborated on in more detail in Section 5.4 of the study.

2.3. Theoretical foundation of summary mapping

Information maps come in many different forms and have various uses. They can be applied in various situations such as creative writing, problem solving, brainstorming for new ideas and business management, but the majority of the research on their use lie within the realm of teaching and learning (Rovira:2016:62).

The summary map in the context of this study, originated from the theories of David P. Ausubel which relates to his research on meaningful learning (Ausubel, 2012; Ausubel *et al*., 1968; Ausubel, 1963). As a main tenet he advocated a theory of cognitive organisation. For him, knowledge is a system of ideas and concepts that are interlinked in an orderly fashion. He reasoned that the learning of new knowledge is very dependent on a students' background knowledge in a particular field and that if this background knowledge is stored in a well-organised and structured way, the learning of new knowledge will take place more easily. This relationship between new knowledge and structured background knowledge was described as follows by Ausubel (1963:24-25):

> The model of cognitive organization proposed for the learning and retention of meaningful materials assumes the existence of a cognitive structure that is hierarchically organized in terms of highly inclusive conceptual traces of less inclusive subconcepts as well as traces of specific informational data. The major organizational principle, in other words, is that of progressive differentiation of trace systems of a given sphere of knowledge from regions of greater to lesser inclusiveness, each linked to the next higher step in the hierarchy through a process of subsumption. Irrespective of how they were acquired in the first place (inductively or deductively), new materials are incorporated into total cognitive organization in accordance with the same principle of progressive differentiation.

Corkill (1992:34) explains that Ausubel believed “that new material could be incorporated into cognitive structures as long as it was subsumable under relevant existing concepts”. Therefore, even unfamiliar material could be learned with ease if relevant subsuming concepts were introduced in advance. With regards to the theory of cognitive subsumption Ausubel was of the assumption that cognitive structures were organized hierarchically in terms of "highly inclusive concepts under which are subsumed less inclusive subconcepts and information data" (Ausubel, 1960:267). Following this assumption Ausubel attempted “to provide appropriate and relevant subsuming concepts for the reader, via advance organizers, to see if learning and recall of unfamiliar material could be substantially enhanced” (Corkill,1992:34).

Ivey (1998:37) compares Ausubel’s theory of how the mind works to learn something new to a Chinese puzzle box, with small “boxes” of information, being contained in larger “boxes”. In other words, the big boxes are the general higher-level categories around which we organise our knowledge, and chunks of new information are represented by the smaller boxes that then get included into the appropriate larger boxes. Furthermore, Ausubel and Robinson (1969) compared structures of knowledge to pyramids, highlighting the hierarchical nature of the structures. According to them: “Fields of inquiry are organised like pyramids with the most general ideas forming the apex, and more particular ideas and specific details subsumed under them” (Ausubel & Robinson, 1969:47). Learning therefore takes place when new information is scaffolded into existing structures that are created in the mind. Ausubel believes that “having a clear and well-organised cognitive structure is also in its own right the most significant independent variable influencing the learner’s capacity for acquiring more new knowledge in the same field” (Ausubel *et al*., 1968:130). The basic principle advocated by Ausubel’s theory is, in other words, that new knowledge can only be acquired if it can be linked to or organised under what a person already knows.

Ausubel subsequently developed a technique that he called ‘advance organisers’. Mayer (1979) explains that advance organisers allow for the building of a platform for new learning. Such a platform should enable students to identify essential information and organise knowledge in such a way that would allow them to link new knowledge with previously learned background knowledge. An advance organiser can be defined, in short, as a general introductory paragraph that includes concepts that are close to the subject matter at hand but within the realm of what the student already knows. Estes *et al*. (1969) compare an advance organiser to a more inclusive chapter summary or overview written in more general terms. This seems far removed from what is considered a summary map for this study, but it is easy to see how it has formed a theoretical foundation for studies in mapping if the original theory of cognitive organisation is considered.

Ausubel's work established the theoretical grounding for three major lines of investigation as well as for most of the subsequent mapping research in teaching and learning (Rovira, 2016:62). Rovira (2016) describes these three lines of research according to the kind of map it uses: graph-organisers, concept maps or knowledge maps. He further explains that concept maps were derived from advanced organisers which later evolved into "graphic organisers". This term is however considered to be very confusing as it covers a broad spectrum of graphs that aim to depict relationships between pieces of information (Rovira, 2006:63). Knowledge maps and concept maps can be considered types of graphic organisers each with their own set of characteristics (Rovira:2006).

If the stated definition of a summary map for this study is considered (see footnote 1 in Section 1.1), it is evident that the first two lines of research involving graph-organisers and concept maps are particularly relevant to the current study as the characteristics overlap in the sense that they are used to facilitate learning by the creation of graphic representations of information. Although it can be argued that summary mapping and what is considered a knowledge map (third line of research) mentioned above are also similar in that they both aim to address issues of learning by map reading, it is important to point out that in terms of characteristics, a knowledge map and a summary map are very different. A knowledge map is a good example of what is considered to be a high-directed map. High-directed maps refer to maps that propose a structure (users will only need to fill in relevant information into a drawn structure) whereas low-directed map are maps that require the users create their own structure. A concept map and a summary map are examples of low-directed maps. The rationale for using a low-directed type of map (as in the AL module at the VC) is highlighted by Ruiz-Primo *et al*. (1997), who determined that low-directed maps most accurately reflect differences across students' knowledge structures compared to high-directed maps. Low-directed maps are therefore better suited for the intended purpose of summary map teaching in AL, which is to afford students the opportunity to develop their own summary maps from any text.

In terms of the first line of research, Estes *et al*. (1969) compared the use of Ausubel's advance organisers to what they refer to as a structured overview. A structured overview can be defined as "a chart which uses content vocabulary to help students anticipate concepts and their relationships to each other in the reading materials" (Vacca, 1981 as referred to by Flint, 1984:4). An example of a structured overview is included in Figure 2-2.

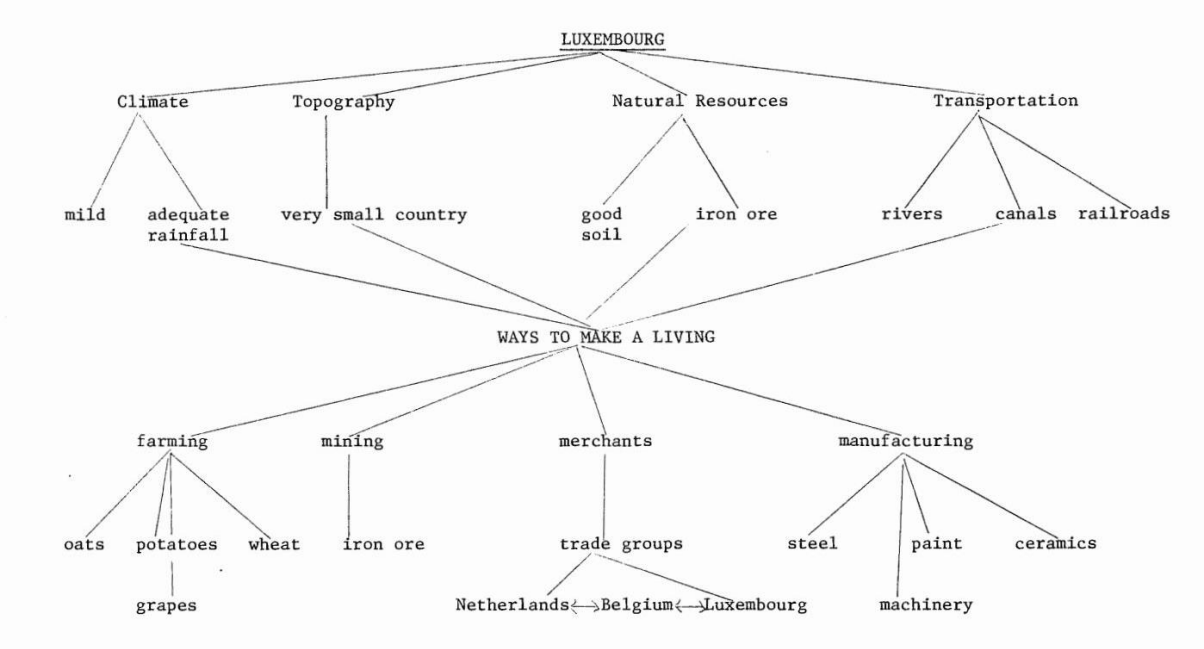


Figure 2-2 Example of a structured overview (Flint, 1984:52)

Estes *et al*. (1969:41) describe a structured overview as "a visual and verbal representation of the key vocabulary of a learning task in relation to more inclusive or subsuming vocabulary concepts that have previously been learned by the student". To put it differently, it is a diagram of terms that are new to the student in relation to words or concepts that already form part of the student's frame of reference. According to Estes *et al*. (1969), it serves a dual purpose. Firstly, the overview demonstrates how the vocabulary instruction in content subjects is structured in such a way as to illuminate for students the relevance and the level of importance of the words being taught. Secondly, like the advance organiser, it aims to help the student relate unfamiliar material to concepts that they already know. A very simple example would be to relate the less familiar word "credenza" to the category of furniture. These scholars, like Novak (discussed below), introduced a graphic element to the organisation of concepts which resulted in the term evolving into graphic organiser, and which is closer to what is considered a summary map today and specifically for this study.

Concept maps, as defined by Novak (1990), build on Ausubel's original theory that learning will only take place successfully if new knowledge is related to the background knowledge of the student. Novak and colleagues conducted a study to investigate changes in children's knowledge of science. According to Novak and Cañas (2006:29), "it was out of the necessity to find a better way to represent children's conceptual understanding that the idea of representing children's knowledge in the form of a concept map emerged. Thus was born a new tool not only for use in research …". The concept map in Figure 2-3 illustrates the characteristics of concept maps as defined and illustrated by Novak and Cañas (2006:30). These key features include the following:

- Concepts – Key ideas and information presented as a single word of phrase included in a square block.
- Links - Words depicting the relationship between key ideas and phrases that appear within the linking line.
- Cross links - Relationships within the concept map that show how the concepts relate and allows the readers trace the connections.

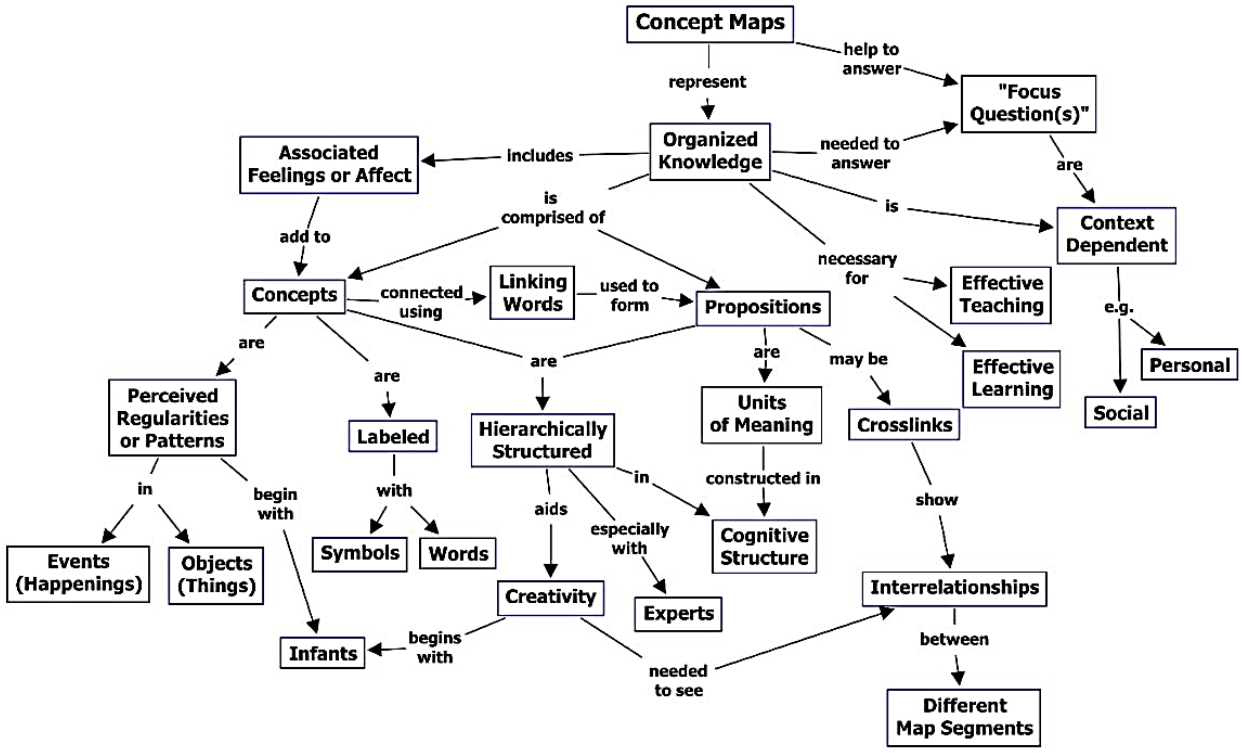


Figure 2-3 Key features of a concept map (Novak & Cañas,2006:30)

Based on the same principle, a mind map can be defined as a visual representation of information that shows how different concepts or chunks of information relate to each other. It is drawn hierarchically, starting with a relevant word or image in the centre of a blank page. From this central word or image subordinate ideas are then added. Although this technique has been used for many years, it was popularised by Tony Buzan in 1991. Figure 2-4 shows a typical example of a mind map as defined by Buzan.

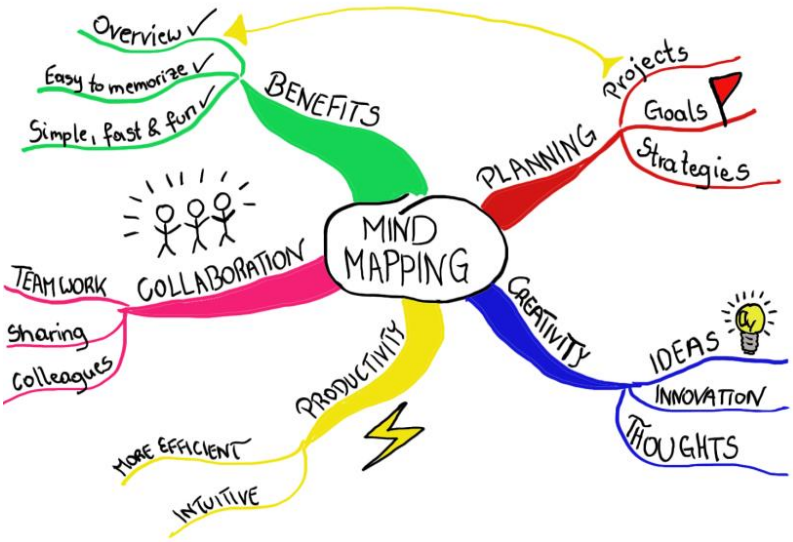


Figure 2-4 Typical mind map as defined by Buzan (Bradner, 2019)

Buzan (1993) advocates that there are many advantages to what he calls mind maps over conventional, linear note making. Some of these advantages include that it places emphasis on the logical structure of information and the relationships between ideas that are presented in the diagram rather than a list of seemingly unrelated facts. Therefore, connections between ideas and similarities are easier to identify. In addition, sketches can make the map easier to recall than conventional notes because drawing can enhance memory of the drawn object when compared to writing (Wammes *et al.,* 2017).

As already stated, Rovira (2016), mentions that three fundamental elements in Novak's (1990) definition of a concept map are present in most of the work concerning mapping, namely: "graphs or frameworks, concepts or ideas, and relationships or links" (Rovira, 2016:61). Concept mapping and mind mapping are, in other words, closely related. In an article reviewing mind maps as a useful teaching strategy for students in the medical field, Abdel-Hamid (2017) mentions both concept maps and mind maps as valuable tools for learning. The article, however, critiques concept maps by mentioning various disadvantages of concept maps including that "they are not suitable for developing practical skills, they present difficulties in presenting a large number of items because of the arrows and boxes formatting, among others" (Abdel-Hamid, 2017:76). No disadvantages were mentioned for mind maps although the colourful seemingly unstructured nature of a mind map may be considered a disadvantage.

In a comparative study, Eppler (2006) reviewed Novak's concept mapping technique and compared it to mind maps, conceptual diagrams and visual metaphors in order to see if a combination of the techniques could be used "in complementary ways to enhance motivation, attention, understanding and recall" (Eppler, 2006:202). A summary of the comparison between mind maps and concept maps as well as the main advantages and disadvantages

of the two strategies have been included in Tables 2-2 and 2-3 below. Conceptual diagrams and visual metaphors are discussed directly after the tables.

Format parameters	Concept map	Mind map
Definition	A concept map is a top-down diagram showing the relationships between concepts, including cross connections among concepts, and their manifestations (examples).	A mind map is a multicoloured and image centred, radial diagram that represents semantic or other connections between portions of learned material hierarchically.
Main function and benefit	Shows systematic relationships among sub-concepts relating to one main concept.	Shows sub-topics of a domain in a creative and seamless manner.
Typical application context	Classroom teaching in a more formal way than personal notes, self-study and revision.	Personal note taking and reviewing.
Application guidelines	Use it as a learning support tool for students, that is, to summarize key course topics or clarify the elements and examples of an abstract concept.	Use it for pre-analytic idea jostles or rapid note-taking, or to structure the main contents of a course or topic hierarchically.
Employed graphic elements	Boxes/bubbles with text and labelled connector arrows.	Central topic bubble and coloured (sub-) branches with text above branches, pictograms.
Reading direction	Top-down.	Centre-out.
Core design rules or guidelines	Start with main concept (at the top), and end with examples (bottom, without circles); boxes/bubbles designate concepts, arrows represent relationships; include cross-links among elements.	Start with main topic (centre) and branch out to sub-topics, employ pictograms and colours to add additional meaning. Write text above the branches.

Table 2-2 Summarised comparison of concept maps and mind maps (Eppler, 2006:202)

Format	Concept maps	Mind maps
Main advantages	Rapid information provision.	Easy to learn and apply.
	Systematic, proven approach to provide overview.	Encourages creativity and self-expression.
	Emphasizes relationships and connections among concepts.	Provides a concise hierarchical overview.
		Easy to extend and add further content.
Main disadvantages	Not easy to apply by novices; requires extensive training.	Idiosyncratic, hard to read for others.
	Concept maps tend to be idiosyncratic.	Represents mostly hierarchical relationships.
	The overall pattern does not necessarily assist memorability.	Can become overly complex (loss of big picture).

Table 2-3 Summary of main advantages and disadvantages of concept maps and mind maps (Eppler, 2006:202)

The other two techniques that Eppler (2006) focuses on in the comparative study is the creation of a conceptual diagram and a visual metaphor. A conceptual diagram “employs a graphic conceptual framework to visually structure information or learning content with the help of pre-defined categories. The categories are usually derived from a (domain-specific) theory or model” (Eppler, 2006:204). This mapping technique is similar to high-directed maps discussed earlier in that it imposes pre-defined categories, as a high directed map imposes a pre-defined structure on a map and is therefore far removed from what is considered a summary map for this study. For this reason it is not further included in the discussion. The visual metaphor, Eppler (2006) defines as “graphic structures that use the shape and elements of a familiar natural or manmade artefact or of an easily recognizable activity or story in order to use the typical associations to convey additional meaning about the content” (Eppler, 2006:204). This technique may be useful in connecting new knowledge with what students already know but such graphic structures are not suitable for this context as they could prove to be too rudimentary and are also far removed from how summary mapping is approached in this study.

Eppler (2006) does not intend to illustrate that one technique is superior to the other but rather argues that a combination of techniques can play to the strengths of each other. He further states that the "combined use of different methods should compensate for the limitation of the individual techniques and enable a richer learning experience for students" (Eppler, 2006: 202).

A summary map seems to fit in somewhere between the two most popular techniques (i.e. concept-mapping and mind mapping) in that it shares the same basic principles but with slight differences in format. The biggest difference is that a summary map is ultimately a summary of a text and not a complete map of knowledge whereas concept maps and mind maps can include both content summarised from texts as well as known information or background knowledge of the creator. A summary map is primarily a summarisation technique that could be expanded into a more comprehensive map of knowledge like a concept map or a mind map but is not taught that way initially in ALDE111. Relationships are not presented in the linking lines and students are not explicitly taught to use colour and pictures, although they are not restricted from doing so. In order to further illustrate the differences between the three types of maps, Table 2-4 is an extended version of the Eppler (2006) table that includes summary maps as a category. Additions have been highlighted for easy reference.

Format parameters	Concept map	Mind map	Summary map
Definition	A concept map is a top-down diagram showing the relationships between concepts, including cross connections among concepts, and their manifestations (examples).	A mind map is a multicoloured and image centred, radial diagram that represents semantic or other connections between portions of learned material hierarchically.	A summary map is a graphic representation of information which shows how different chunks of information relate to each other.
Main function and benefit	Shows systematic relationships among sub-concepts relating to one main concept.	Shows sub-topics of a domain in a creative and seamless manner.	Shows a hierarchically structured, summarised version of a text.
Typical application context	Classroom teaching, self-study and revision.	Personal note taking and reviewing.	Study and revision.

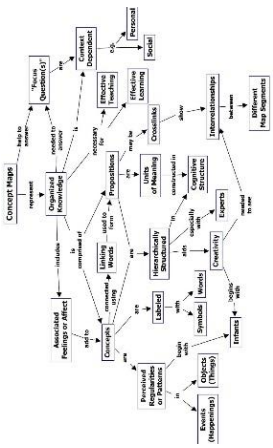
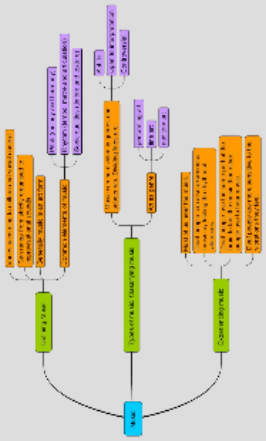
Application guidelines	Use it as a learning support tool for students, that is, to summarize key course topics or clarify the elements and examples of an abstract concept.	Use it for pre-analytic idea jostles or rapid note taking, or to structure the main contents of a course or topic hierarchically.	Use it to summarise the main ideas of a text hierarchically.
Employed graphic elements	Boxes/bubbles with text and labelled connector arrows.	Central topic bubble and coloured (sub-) branches with text above branches, pictograms.	Central topic presented in a box/bubble/cloud and subordinate levels of information boxes/bubbles/clouds branching out form central topic.
Reading direction	Top-down.	Centre-out.	Left to right or centre-out.
Core design rules or guidelines	Start with main concept (at the top), and end with examples (bottom, without circles); boxes/bubbles designate concepts, arrows represent relationships; include cross-links among elements.	Start with main topic (centre) and branch out to sub-topics, employ pictograms and colours to add additional meaning. Write text above the branches.	Start with main concept (on the left or centre), and end with examples/3rd level information (far right/ periphery boxes/bubbles/cloud); boxes/bubbles/clouds contain concepts/ideas, lines or arrows represent relationships among elements.
Example			

Table 2-4 Extended version of the Eppler (2006:202) table including summary maps

To investigate the process of summary mapping, eye tracking has been identified as a useful methodology and therefore a discussion of this technique is included in the literature review. Sections 2.4 and 2.5 that follow will give an overview of eye movement research and how it is measured.

2.4. Eye movement research

In order to fully understand eye movement research, it is important to understand the reasons the eyes move the way that they do in the first place. According to Holmqvist *et al*. (2011:21), the eye lets in light through the pupil and projects it onto the retina. The retina is filled with cells called cones and rods. These cells are extremely sensitive to light, which they then transduce into electrical signals that subsequently get processed in the visual cortex. In a small area in the eye called the fovea that spans less than 2° of the visual field, "these cone cells are extremely over-presented while they are very sparsely distributed in the periphery of the retina. This results in humans having full acuity only in a small area, roughly the size of a thumb nail at arm's length" (Holmqvist *et al*. 2011:21). In order to see an object clearly, the eyes need to be moved to a position that allows light reflecting from the object we are looking at to fall directly onto the fovea. According to Bridgeman (1992), eye movements are considered to be one of the most frequent of all human movements. Despite it being such a common thing humans do, eye movements have, according to Wade (2010:33), not enjoyed as much attention in research as would be expected. He furthermore explains that "the study of eye movements has, perforce, addressed the integration of vision and action", and that this integration pertains to "the clues that patterns of eye movements provide for examining visual and cognitive phenomena" (Wade 2010:33). In his review of the history of eye movement research, Wade (2010) outlines the contributions of who he refers to as pioneers in the field, starting with Aristotle more than 2000 years ago.

There seems to be consensus in the literature that research into eye movements could generally be divided into two categories – the one is gaze stability and the other is gaze shift (Wade, 2010; Leigh & Zee, 2006; Walls, 1962). Scott *et al*. (2019:1245) explain these two categories in the following way:

- gaze shift "directs the fovea to a stimulus (e.g. saccades and smooth pursuits)," and
- gaze stability "maintains the eye fixed on a stationary stimulus (e.g. fixations)".

Related to this the two most reported events in eye-tracking data are fixations and saccades. The following section offers a general explanation of these two terms and the history

surrounding the coining of these terms. A more technical definition of these and other relevant eye-tracking measures as they are used currently will be discussed in Section 2.6.1.

According to Wade (2010:50), the term “saccade” was introduced in the 1870s by Louis Émile Javal, who was a French ophthalmologist. The term “saccade” is derived from “a French word that refers to certain rapid movements of a horse during dressage (Wade, 2010:50). Płużyczka (2018) also mentions that there seems to be consensus in the literature that Javal was indeed the first researcher to determine how the eyes move during reading. The closest English translation of the word “saccade” would be “jerk”, and in 1879, Crum Brown recognised that the eyes always move in a jerklike, saccadic fashion and not in a smooth continuous pattern as was the general consensus previously. Crum Brown (1895:4-5) described it as follows:

> [O]ur eyes move like the seconds hand of a watch, a jerk and a little pause, another jerk and so on; only our eyes are not so regular, the jerks are sometimes of greater, sometimes of less, angular amount, and the pauses vary in duration, although, unless we make an effort, they are always short. During the jerks we practically do not see at all, so that we have before us not a moving panorama, but a series of fixed pictures of the same fixed things, which succeed one another rapidly.

The term saccade is now widely used to refer to scanning movements of the eyes, typically occurring 3 to 4 times every second (Richardson *et al*., 2007). According to Holmqvist *et al*. (2011:23), saccades are the fastest movement that can be made by the human body and are typically 30 to 80ms long. The reason for this frantic movement is that the large volume of available visual information would be impossible to process in detail all at once. Our eyes therefore seem to rather deal with small amounts of information in quick succession. (Richardson *et al*., 2007).

Instances where the eye stops or focuses (usually lasting 200-300 milliseconds) in between these saccades are called fixations (Holimqvist *et al*., 2011:22). According to Duchowski (2007:46), “fixations stabilise the retina over an object of interest, which is stationary”. Pollatsek and Rayner (2006:614) define fixations as “periods when the eyes are relatively still and during which new visual information is encoded”.

From the discussion on eye movement above, it appears as if researchers have known for a considerable time that how the eyes move and what they look at are not only interesting but can offer valuable information about processes other than observation. Eye movements need to be measured in a reliable way if one is to draw conclusions about what they mean. The

following two sections include detailed discussions about how the two overarching categories of gaze shift and gaze stability or more precisely fixations and saccades are measured and how these measurements can be interpreted.

2.5. Measuring eye movement

In order to accurately investigate eye movement, the pioneers mentioned in Section 2.4 had various methods for arriving at their conclusions. Some of the earlier methods for tracking eye movements were invasive, some of which involved instruments physically touching the eyes.

According to Jacob and Karn (2002:1), the first researchers to develop a non-invasive technique reflecting light from the cornea for eye tracking was Dodge and Cline (1901). Their technique recorded horizontal eye movements using a technique similar to film photography, while the subject kept his/her head perfectly still. Thereafter, Judd, McAllister and Steel (1905) used motion picture photography to record a white speck that was inserted into a participant's eye. After that, other researchers used combinations of these two techniques in various ways to further the research in the field. Due to these and various other, more advanced technological developments, eye movement can now be measured in an accurate and non-intrusive way using eye tracking.

Eye tracking is a technique used to study what the human eye looks at, and for how long, during a specific task. Carter and Luke (2020:50) define it as "an experimental method of recording eye motion and gaze location across time and task". It accurately measures what the fovea (the small area in the eye that makes up the visual field) focuses on during a specific task. Although an eye tracker basically records only fixations and saccades, there are many measures that can be applied once all the fixations and saccades have been recorded. Holmqvist *et al*. (2011) describe four major groups of measures but also emphasise that there are about 120 or even more measures that can be applied to eye-movement data. The major groups categorised by Holmqvist *et al*. (2011) are:

- Movement measures (different properties refer to direction, amplitude, duration, velocity and acceleration);
- Position measures (these refer to properties such as where participants look, if they look at the same place and to properties such as duration of fixations and dwells at the position);
- Numerosity measures (refers to counting the quantity of eye-movement events like saccades, fixations, blinks, dwells and transitions or regressions); and

- Latency (measures the difference in time between two events) and distance measures (compare the simultaneous spatial positions of two separate entities).

These measurements are usually applied to the data in relation to one or various areas of interest (AOIs). Holmqvist *et al*. (2011) define an AOI as a tool that can be used to analyse eye-movement data in terms of certain identified regions in the viewed stimulus. The researcher can define areas that are of particular importance to the study and gather specific data pertaining to movements within and between these areas. Usually in eye-tracking studies, researchers are particularly interested in specific parts of a stimulus which could include anything that can be considered pertinent like a particular word contained in a text or an object included in a scene. When this is the case, this area is determined using eye-tracking software that allows the user to define AOIs. Thereafter the software can also provide descriptions or counts on how each participant interacted with these AOIs. For the current study, two sets of AOIs will be defined, one set for the text and one set for the summary map. The AOIs in the text will include the different paragraphs that the participants in the experiment have to read and the AOIs in the summary map to be drawn by participants will be defined as the content boxes that form the map. Measures of numerosity and position, like how often participants looked at the text vs the map and for how long should provide insight into the process followed by participants while performing the task.

Using eye tracking as a data collection technique has become more popular over the past two decades and the use thereof spans several disciplines. According to Carter and Luke (2020:50), a literature review spanning from 1968 to 2018 of studies using eye tracking to conduct research offered the following breakdown in the respective fields, as demonstrated in Figure 2-5.

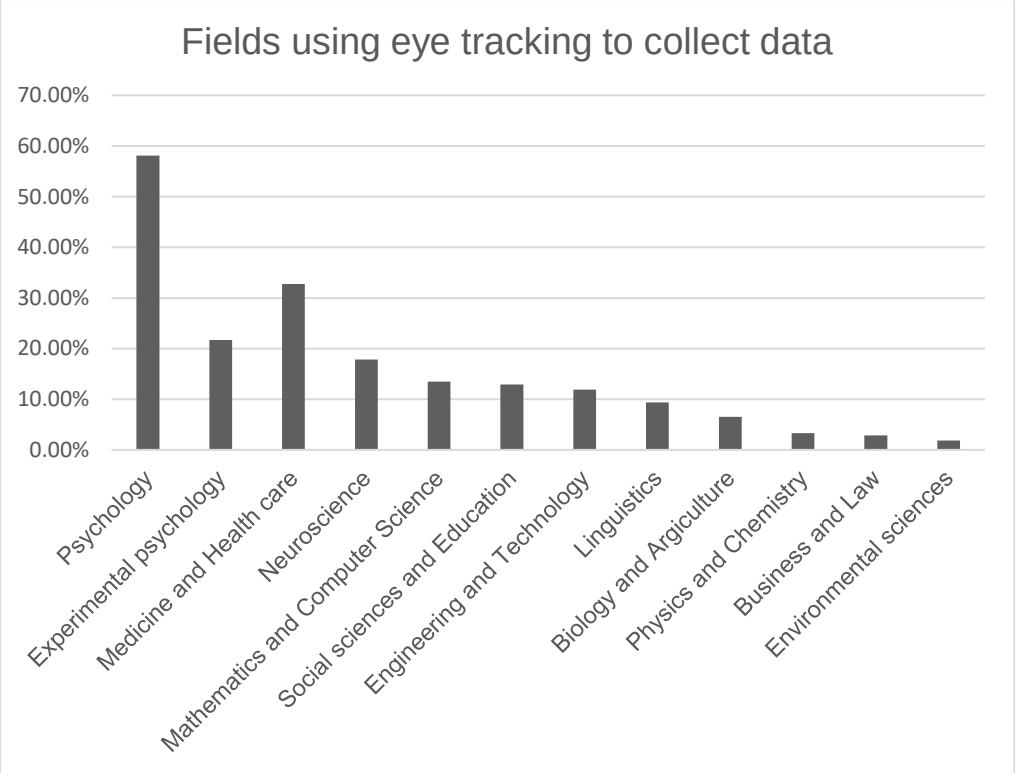


Figure 2-5 Fields conducting eye-tracking research as presented by Carter and Luke (2020:50)

From this figure it is evident that eye-movement data can be applied to many fields. According to Orquin and Holmqvist (2018), many new disciplines have been making use of eye-movement research since the early 2000's. They further state that "this diversification of eye-movement research has largely been driven by technological development: Modern video-based eye trackers drastically simplified eye tracking, often with a 'plug-and-play' approach" (Orquin *&* Holmqvist, 2018:1645).

In his comprehensive survey, Duchowski (2002) reviewed eye-tracking methodologies within the specific disciplines of neuroscience, psychology, and computer science. The current study seems to fall within his description of the psychology discipline as he includes reading and scene perception under this category.

If focusing on these two fields of research within the psychology discipline, it seems clear that reading research is the oldest and most well-established application of eye tracking. Rayner (1998:375-376) did a comprehensive review of reading and information processing studies spanning over a 100 years and summarised the characteristics of eye tracking research over this period of time. From this summary the following conclusions could be drawn in terms of reading research:

1. Eye movements differ when one reads silently compared to when one reads aloud;
2. When reading in English, the average fixation duration is 200-250 milliseconds and the average saccade length is about 8 letter spaces;
3. Readers sometimes make saccades that move from right to left called regressions, meaning that they move their eyes back to previously read words or lines;
4. Readers will generally fixate 5-7 letter spaces from the ends of a line they are reading;
5. Although average values for fixations and saccades can be obtained, there is variation between readers;
6. The quality of print, like the line length, and letter spacing used can influence the way the eyes move during reading; and
7. Processing difficulty can influence both fixations and saccades in reading.

These insights are valuable in that they provide general conclusions about reading research in eye tracking. The research, however, focuses on general reading for information or entertainment and not reading for a specific purpose like studying or remembering. According to Yeari *et al*. (2015) the reading goal can have a significant impact on how participants read. They reference various researchers (Linderholm & van den Broek, 2002; Linderholm & Zhao, 2008; Narvaez, van den Broek, & Barron-Ruiz, 1999; van den Broek, Lorch, Linderholm, & Gustafson, 2001), stating that there is ample evidence to prove that "readers adjust their reading strategies and engage in different cognitive processes as a consequence of their reading goals" (Yeari *et al*., 2015:1073) In their study, which built on the mentioned research they furthermore reported differences in text processing like longer reading times and more fixations based on the goal of reading. When studying a text or reading in preparation for a test participants read more thoroughly and directed more attention to peripheral ideas.

Although the current study does not focus explicitly on general reading like the descriptive studies reviewed by Rayner (1998) or reading for retention or test taking specifically like many studies cited by Yeari *et al*. (2015), reading is a key part of the summary mapping task and entails reading for a very specific purpose. These studies can therefore be used as a point of departure for developing a relevant methodology for the current study.

As part of his survey Duchowski (2002) mentions that "in addition to descriptive studies, in which eye movements are simply recorded during the reading, advances in eye trackers have been used to control or change the stimulus in real time, depending on where the reader is looking. Three experimental paradigms were subsequently developed namely 'moving window', 'boundary' and the 'foveal mask' (Duchowski, 2002:457)". These will, however, not

be elaborated on here as they focus on word or letter level reading research which is far removed from the scope of investigation for the current study. Although these paradigms were initially developed for reading research, they have more recently been adapted for other contexts. One such context is that of scene perception, in terms of which Duchowski (2002:457) mentions that “although certain reading patterns are easily recognised, such as left to right and top to bottom for English readers or right to left for Hebrew readers, there are no such apparent strategies for scene viewing”. Kennedy (1992) states that the contexts for reading and scene viewing research may be different and furthermore that no recognised pattern exists for scene viewing scanpaths whereas the scanpaths for reading can be considered more standardised. Henderson and Hollingworth (1998), however, list the following three reasons that stipulate why it is important for researchers to understand eye movements on scene viewing. The first is that eye movements are important if one is to gain insight into which eye movements are manipulated in order to attain the required visual information when performing complex visual cognitive tasks. Secondly, patterns in eye movement that may occur during scene viewing can bring researchers to a better understanding of how information in the visual environment is attained and represented. Lastly, eye movement can provide a measurable way of tracking or investigating how visual and cognitive information is processed.

Taking the preceding discussion into account, the current study cannot be placed fully within either reading research or scene perception research because the study does not involve collecting word level data. Furthermore, both reading and scene perception research involve reception or processing whereas summary mapping involves the production of a visual diagram that, in its structure, reflects meaningful links. According to Wengelin *et al.* (2009) text production can be considered more complex to study because the process is more difficult than reading or comprehension. This process needs to be studied in real time and “require sophisticated methods for both determining and describing writers’ spontaneous text production behaviour” (Wengelin *et al.*, 2009:339). This can be particularly challenging because text production involves many intertwined acts such as formulation, transcription and reviewing. Wengelin *et al*. (2009) investigated methods that can be used to study text production. They believe that a combination of keystroke logging and eye tracking could provide valuable insights. They draw on existing eye tracking reading research to demonstrate that the “[s]tudy of when and where the writer fixates his or her developing text therefore has the potential to inform theories about the complex cognitive processes that underlie written production” (Wengelin *et al.*, 2009:339).

Latif (2019:26) completed a review of available eye tracking research that focus on “processes employed in learning language and performing linguistic tasks” of second language learners. In the cited studies that involve specifically written text production and eye tracking, eye tracking data was mostly used as a supplemental data set to investigate reading behaviours while producing a text or translating a text. Two studies by Prichard and Atkins (2016,2018) investigated reading strategies of students during summary writing. They used eye tracking to determine how often and for how long participants focused on headings, topic sentences, paragraphs, main ideas, and supporting sentences. They found that participant summaries were generally poor. There was a significant, but weak correlation between the participants’ summary scores and their fixation duration of the body text while previewing.

The summary mapping task can, in other words, be considered a complex writing or production task that involves an element of visual perception along with reading. It is therefore difficult to determine one specific methodological approach to the eye-tracking data of the current study as it lies somewhere between these fields. As a result, elements of all these fields of research were taken into consideration in an investigation into eye movement during summary mapping that could yield very rich data. The data did however need to be analysed and interpreted with a very specific context in mind

2.6. Interpreting eye movement measurements

As is evident from the discussion above, researchers have been studying eye movements since before computers were available; their advent simplified the procedure significantly. At present, vast amounts of data can be retrieved from eye-tracking experiments with the help of computer software but in order to draw conclusions from the data, the data still needs to be interpreted with very specific questions in mind. Carter and Luke (2020) state that the origins of eye tracking as we know it today can be traced to Charles Bell.

He maintained that the brain is responsible for eye movement control. Moreover, he “classified eye movements and described the effect of eye movement on visual orientation. This defined a physiological connection between the eyes and the nervous system, connecting their motion to neurological and cognitive processes and thereby opening a potential window into the inner workings of the mind” (Carter & Luke, 2020:50). Various researchers (Just & Carpenter, 1980; Rayner, 2009; Rayner & Reingold, 2015) believe that we are generally inclined to move our eyes so that the fovea is pointed at the object currently occupying our thoughts because we have such a small field of accurate vision. In other words, we tend to focus on whatever it is that we are thinking about or trying to understand. This is known as the eye-mind

assumption, and according to Carter and Luke (2020:50), “it makes eye tracking a reliable tool for exploring questions concerning the allocation of visual attention. Where we look, and for how long, is influenced by cognitive processes beyond attention, such as perception, memory, language, and decision making”. In one of their earlier studies, Just and Carpenter (1976:139) summarise it as follows:

> The critical assumption that underlies our analysis is that under certain circumstances, the eye fixates the referent of the symbol currently being processed. (...) If a number of symbols are processed in a particular sequence, then their referents should be fixated in the same sequence, and the duration of gaze on each referent may be proportional to how long the corresponding symbol is operated on.

Just and Carpenter (1980:831) suggested “on the basis of studies of eye movements in reading, that there is no appreciable lag between what is being fixated and what is being processed at a cognitive level”. After having processed eye fixation data they arrived at the following conclusion, which rests on two assumptions:

> The first, called the immediacy assumption, is that a reader tries to interpret each content word of a text as it is encountered, even at the expense of making guesses that sometimes turn out to be wrong. Interpretation refers to processing at several levels such as encoding the word, choosing one meaning of it, assigning it to its referent, and determining its status in the sentence and in the discourse. The immediacy assumption posits that the interpretations at all levels of processing are not deferred; they occur as soon as possible, a qualification that will be clarified later. The second assumption, the eye-mind assumption, is that the eye remains fixated on a word as long as the word is being processed. So the time it takes to process a newly fixated word is directly indicated by the gaze duration. Of course, comprehending that word often involves the use of information from preceding parts of the text, without any backward fixations. So the concepts corresponding to two different words may be compared to each other, for example, whereas only the more recently encountered word is fixated. (Just & Carpenter, 1980:330)

The eye-mind assumption has, however, also been criticised by scholars. According to Orquin and Holmqvist (2018), it has even been falsified in some instances. Hvelplund (2014:209) points out that we may not necessarily always focus on what our minds are processing. We sometimes daydream or think of completely different things while we are, for instance, completing tasks like washing the dishes. Such mind wandering is not a unique or uncommon occurrence (Smallwood & Schooler, 2006:946). It is stated that the eye-mind assumption “perhaps only provides an approximation of the relationship between visual focus and

cognitive focus" Hvelplund (2014:209). Posner (1980) furthermore states that: "[…] it is important to distinguish between overt changes in orienting that can be observed in head and eye movements, and the purely covert orienting that may be achieved by the central mechanism alone […]" (Posner, 1980:5). Posner distinguishes here between changes in our behaviour that can be observed, and covert cognitive changes, which are not apparent and cannot be observed. An important limitation of the eye-mind assumption is thereby highlighted, namely that eye movements and cognitive focus can function independently and may not be influenced by one another. While eye trackers can very accurately identify where the eyes are focusing, it offers no insight into the object occupying our thoughts. Further critique of the immediacy assumption includes research that suggests the mind focuses attention on an object up to 250ms before it enters into visual focus (Holmqvist *et al*. 2011: 379).

Hvelplund (2014), however, still asserts that, at least for translation studies research, the eye-mind and immediacy assumptions is a reasonable basis for assuming that there is some sort of relationship between how the eyes move and what is being processed during a translation task. He explains that although we may not always focus on what is being processed we cannot disregard the many instances where the object or in the case of translation, the word, that was focused on was indeed also the object of cognitive focus. Researchers focussing on reading research (Inhoff & Rayner 1986; Ehrlich & Rayner, 1981) have also provided support for assuming a link between visual and cognitive focus in concluding that longer fixation durations are often indicative of an increase in perceived difficulty.

Psychology research also indicates that mind wandering is less likely to happen when one is engaged in a difficult task that demands full attention (Smallwood & Schooler, 2006: 947, 956). It would be safe to cautiously argue that the task of translation, just like the task of summary mapping, can be considered cognitively challenging and would not leave much of an opportunity for mind wandering. On the basis of the above discussions, summary mapping could therefore also have a basis for assuming a relationship between eye movements and processing.

Schindler *et al*. (2019) indicate that mathematics studies in education also often adopt the eye-mind assumption. Obsteiner and Tumpek (2016:257) state that in this field of study, "eye movements are assumed to correspond to mental operations" and "cognitive processes are 'inferred' from gaze patterns without further explanation or reflection about the relation of mind and eye". It is assumed that eye movements are indicative of internal cognitive processes (e.g. Köning *et al,* 2016:207), which can, according to Gerrig (2013:207), be understood as "higher mental processes, such as perception, memory, language, problem solving and abstract

thinking". This is particularly relevant in the current study because the research mentioned by Shindler *et al*. (2019) pertains specifically to geometry, a field that also lends itself well to eye tracking and bears a number of similarities to the current field of summary mapping in that geometry, like summary mapping, "typically include diagrams providing spatial information combined with written descriptions" (Shindler *et al*., 2019:126). Solving geometry problems involves both accessing information presented in the form of a diagram and using prior knowledge to apply the relevant formula for solving the problem. Levav-Waynberg and Leikin (2012:76) emphasise that a combination of visual skills and required abstract and logical reasoning skills are a necessity in the geometry field. This is very similar to what is required during summary mapping, where reasoning is used to categorise information into a logical structure after the information has been extracted from a text.

With regard to the validity of the eye-mind assumption in research, Orquin and Holmqvist (2018) suggest a signal detection assumption, rather than and eye-mind assumption. They explain that "the question is whether fixations to an object imply that the object has been processed, and whether the absence of fixations implies that the object has not been processed" (Orquin & Holmqvist, 2018:20). They also offer example instances that could make either assumption true. For example, if the object was not fixated on but was processed, it could be an instance of "peripheral processing, i.e., an observer detects and identifies an object without fixating it" (Orquin & Holmqvist, 2018:20). In the current study, care was taken to rule out peripheral uptake that is often caused by the stimulus being crowded or by the size and contrast of the object. Both the text and clean page provided in the eye tracking phase of the experiment was set up in a way and size that would make it possible to clearly distinguish objects and AOIs, as is discussed in Section 3.4.

If there is fixation but the object was not processed, it could be an instance of "selective feature extraction" (Orquin & Holmqvist 2018:21) where the observer is unaware of the object or only processed parts of the object that was fixated on. Orquin and Holmqvist (2018:21) state that "it has been demonstrated that observers typically fail to extract or encode all possible features from visual objects, only extracting or encoding the task-relevant features". For the current study it can be argued that all viewed objects are task-relevant and that the possibility of selective feature extraction is therefore low.

Orquin and Holmqvist (2018:21) mention a third instance that they call inappropriate AOI definitions. According to them:

> If the AOI around an object has a narrow margin, e.g < .5° beyond the object border, we may fail to detect fixations falling outside the object, leading to false negatives. On the other hand, when objects are placed close to each other, we risk assigning fixations that fall outside an object to a neighboring object leading to false positives for the neighboring object.

In the current study care was taken to set up AOIs in such a way that this risk is mitigated as far as possible.

Furthermore, Orquin and Holmqvist (2017:22) mention that including other data sources in the analysis could help to determine the level of processing. These alternative sources of data could, for example, include "choice data, verbal protocols and retention tests, which can suggest whether the object was processed" (Orquin & Holmqvist, 2017:22). Holmqvist *et al*., (2011:95) states that "this is known as methodological triangulation". As is discussed in Section 3.5, multiple data sets were also collected in the current study in order to obtain a range of results that could be analysed in conjunction with one another.

In summary, Hvelplund (2014:219) states that "eye tracking data can potentially be misrepresentative of actual cognitive processing if caution is not exercised when collecting it. (…) With respect to interpreting eye tracking data as manifestations of cognitive processing, the link from eye movement to cognitive processing is intuitively sound; however, there are issues that make the link less straightforward." He recommends that all factors are taken into account when the researcher interprets the data.

Despite the criticism against the eye-mind assumption, eye tracking is still considered an effective tool for researching eye movement patterns as they occur during a summary mapping task. It allows the researcher to gain insight into the process as it unfolds rather than just focusing on the result of the product produced in the task. The eye movement data, when considered with the other data collected during the study should provide valuable insights if handled in a mindful way according to the guidelines discussed above.

2.6.1. Terms and types of measurements used in eye tracking

As already stated in Section 2.4, the two widely used measurements in eye tracking are fixations and saccades. These phenomena can be grouped and studied in a number of different ways.

2.6.1.1. Fixations

Fixations can be studied in terms of duration or count. Fixation duration is considered the most relevant eye-tracking data because it can be considered indicative of processing difficulty (Just & Carpenter, 1980; Perego, 2008). Fixation count refers to the number of fixations situated in an AOI (Holmqvist *et al*. 2011). A higher number of fixations in a particular area of interest could indicate either a lack of search capacity of a participant or it could indicate that the stimulus is poorly structured. Conversely, Poole *et al*. (2006) mention that if a participant fixates more on a particular AOI it may indicate that the participant finds the AOI to be more important and/or more noticeable compared to the others. As mentioned previously, for the current study, paragraphs in the text as well as sections of the summary map will be considered relevant AOIs and fixations on these AOIs should give some insight as to the processing difficulty of the task.

2.6.1.2. Saccades

Depending on the task being performed, the size and duration of a saccade can vary significantly. Typically, saccades performed during reading are relatively small (a 2° rotation) and last about 30 milliseconds. During scene perception saccades are known to be larger (about 5 degrees of rotation) and usually last 40 to 50 milliseconds (Abrams *et al*., 1989; Rayner, 1978). Andrychowich-Trodanowska (2018) defines a saccade count as the number of saccades that is recorded in a specific trial. “The number of saccades is strictly related to the spatial organization of information in the stimuli, i.e. the poorer the organization, the more saccades” (Grobelny *et al*. 2006 as cited by Andrychowich-Trodanowska, 2018). Measuring saccade count could be very informative for the current study since the categorisation and organisation of information is important for the construction of a relevant summary map.

2.6.1.3. Transitions

Another parameter that can give insight in the current study is the frequency of transitions between the AOIs. According to Andrychowich-Trojanowska (2018), frequent transitions can take place when the participant is inefficiently scanning the stimulus while in search of a particular element. Transition patterns can be used in the current study to gain insight into the process followed when participants are completing a summary mapping task. It is anticipated that participants will move their gaze between the text and the summary map, but possible patterns that may emerge in the way different participants move their gaze coupled with the accompanying data could yield interesting results.

2.6.1.4. Dwell time or visit duration

The terms “dwell time” and “visit duration” can be used interchangeably depending on the software that is used to extract the eye-tracking data. Dwell time, or visit duration, is defined as one visit in an AOI and is calculated by adding the duration of all fixations and saccades in a specific AOI (Holmqvist *et al*. 2011). In other words, it is the total amount of time that the participant spent moving their eyes within a particular AOI. According to Andrychowich-Trojanowska (2018:128), “[a] higher dwell time may also be an indicator of uncertainty and poorer awareness of situation, of difficulty in extracting information from a display. In the eye-tracking research of reading processes, longer dwell time is often related to less frequent words”. In other words, participants tend to dwell longer on words that are less frequently used. For the current study, average dwell time or average visit duration can be investigated in order to determine specific phases of the summary mapping task that participants found particularly challenging.

Eye movement is considered to be indicative of processes that involve more than just vision or observation and the measurement thereof by the technique of eye tracking has allowed many researchers to gain insight into these processes. The current study aims to use this technique to gain understanding into processes that occur during the complex task of summary mapping. The relevance of this technique for the current study will be discussed in the following section.

2.7. Using eye tracking to study mapping

Rovira (2016) notes that although the use of eye tracking to study mapping is a relatively new field of study, it has considerable potential. As already mentioned in Chapter 1, Rovira (2016) lists only 15 published studies using eye tracking as a methodology to study mapping. Among the published research, 10 studies focus predominantly on the reading or processing of maps (Nesbit *et al*., 2007; Amadieu *et al*., 2009; Bisra, 2010; Liu *et al*., 2011; Bisra & Nesbit, 2012a; Bisra & Nesbit 2012b; Van-Amelsvoort *et al*., 2013; Liu, 2014; Ponce & Mayer, 2014a). A further review of the literature also offered two more studies published after the Rovira (2016) review, but both of these studies also focus on reading of pre-constructed concept maps in order to solve a problem (Malčík *et al*., 2018) and studying the representation of a crime scene investigation process in the form of a mind map (Durugbo, 2021).

The research conducted by Amadieu *et al*. (2009:379) sheds light on “the effects of prior knowledge and map structure on disorientation, cognitive load and learning from hypertext.

Second, it explored the added value of combining different process measures, that is, using overall subjective ratings of disorientation and cognitive load as well as more detailed measures such as eye movement and navigation data". With this study, participants were required to study pre-constructed concept maps. The eye-tracking data analysis the researchers focused on was fixation count and fixation duration. They furthermore conducted analysis on the viewing behaviour of the participants determining the percentage of the total time participants fixated on areas of interests that corresponded with the different levels in the maps. They believe that "the percentage of time spent fixating on the anatomic information nodes is an indication of the attention allocated to information required to understand the material, whereas the percentage of time spent fixating on the macro-information nodes is an indication of the attention allocated to the main categories of the document" (Amadieu *et al*. 2009:381).

The Nesbit *et al*. (2007) study investigated the order in which learners viewed nodes as they begin interpreting the meaning of a concept map. They recorded the location and sequence of every saccade and fixation as participants read the concept maps and examined the first few seconds of fixation data for each map and the initial fixation on each node and calculated the median number of fixations before the first arrival at each node. They believe a low median for a node indicated that it received attention early. Furthermore, they created and analysed scan path diagrams that showed that nodes in the centre, upper centre and upper left of the maps received early attention. They believe that the reason for this is a manifestation of transfer from acquired reading skills and may also indicate that participants are searching for interconnected nodes of relevant information. Their findings lead to a recommendation for concept map designers that can help them place information in regions of the map that could reduce unnecessary cognitive load.

The Nesbit *et al*. (2007) results therefore suggest that concept map designers can plan for the approximate reading order of nodes, and place nodes intended to be read early in the centre, upper centre and upper left regions of the map. Designing maps to present central or superordinate information at easily found locations may reduce unnecessary visual search and extrinsic cognitive load. Rovira (2013) reached comparable results in his study. This observation is in line with the format taught in AL modules at the NWU, and although students are not penalised for using different formats such as top-down diagrams or those radiating from the centre, the examples shown by lecturers when they teach summary mapping start on the left-hand side of the page branching to the right as shown in the Figure 1-2 example in Chapter 1.

Rovira (2013) and Van-Amelsvoort *et al.* (2013) also investigated the way students consult concept maps when doing tasks. The Van-Amelsvoort *et al.* (2013) study divided the concept map diagram into 24 look zones, one for each header and body cell. These look zones were identified as AOIs and the following variables were included in the analysis of the data: average fixation duration, cumulative fixation duration, and sequence. They were particularly interested in determining the reading sequence participants followed while they were studying the provided diagram. In other words, they wanted to determine if the participants studied the diagram using a top-to-bottom technique or if they used a left-to-right sequence and whether the sequence was based on any perceptual cues. Their results showed that people are influenced by both types of cues, but that the processes are unrelated (Van-Amelsvoort *et al*. 2013:845). In the application of their results, they were concerned with guidance in terms of the design of learning material. The Van-Amelsvoort *et al.* (2013) study is, however, not comparable to the current study because it uses phrases in a matrix form that is similar to a table rather than a concept map or mind map.

In her masters study, Bisra (2010) investigated the eye movements of students using computer-based concept mapping to complete an argument and to identify information that was relevant to the argument. She defined each node and link as an AOI:

> Fixation duration and fixation count were measured for each AOI. Individual differences in eye gaze, fixation duration, and fixation counts suggested that the eye movement data should be treated as dependent or related samples. Therefore, data from the same participant were paired and each subject acted as his or her own control. Paired samples t-tests were used to test the null hypothesis that the differences between two measures have a value of zero. In this case, FD totals for selected and unselected nodes for each participant were paired. The paired samples t-test between the FD totals revealed fixation duration was longer on the selected nodes for each of the maps ($p < 0$ .001). Fixation frequencies were also statistically detectably greater on the selected nodes ($p < 0.001$) (Bisra, 2010:52).

In this study, she concluded that the processing of nodes required more time than to process linked phrases and that the participants were guided by the lines joining concepts rather than the directions the arrows pointed towards (Rovira:2006). Her results together with the findings of Nesbit and Rovira mentioned earlier in this section provide insight into how participants read or use provided maps, but does not investigate the process that takes place when the participants need to produce the maps themselves.

These studies, although insightful, focus on how participants made use of already constructed maps and are not as helpful in researching ways to help students gain summary mapping abilities (and, therefore, the construction of summary maps). Although the remaining studies

do focus on some form of text production, they are far removed from the type of summary map referred to in the present study. The oldest study (Molinari *et al*., 2008) investigated behaviour during a collaborative effort between students working in pairs, focusing on the effects of interrelated knowledge when creating mind maps. In terms of eye-tracking data they used fixation duration and transition count between maps to conduct their analysis. Group work or collaborative efforts, however, are not encouraged in the context of the current study because the purpose of summary mapping as defined for this study is to select and summarise large amounts of information during studying, an action that is usually highly individual and based upon individual preference and understanding. Another study prompted participants to fill in a graphic organiser after reading a text (Ponce & Mayer, 2014b), thus asking them to use a specific structure. Giving students a structure to use when completing a summary map seemed to be a logical step in teaching summary mapping abilities when it was first attempted by lecturers at the campus where this study is situated. It was, however, quickly discontinued because it became evident from the information that students wrote into the mind maps and the time it took them to complete the summary maps that they found dealing with an imposed structure more difficult than having to draw their own structure.

The studies that have not yet been mentioned focus on cognitive analysis and eye movement analyses in the mapping processes of novices vs experts (Dogusoy-Taylan & Cagiltay, 2014; Dogusoy-Taylan, 2012; Dogusoy-Taylan, 2010). Although participants in these studies were asked to draw (what they refer to as) concept maps, it was not a summary of a text but a summary of accumulated knowledge that they have about a certain topic. In other words, they were asked to construct a knowledge-based map. Although the focus in these studies is different from that of the current study, they do offer valuable insights with regard to methodology, which are discussed in detail in Chapter 3.

Importantly, Dogusoy-Taylan and Cagiltay stress the fact that “the nature of the CM [concept map] development process is not a well-studied issue for researchers ...” (Dogusoy-Taylan & Cagiltay, 2014:82). It is at this juncture specifically where the current study could yield valuable insights into the way students develop summary maps and subsequently explore potential optimal teaching methods thereof.

2.8. Conclusion

This chapter has pointed out that the importance of reading ability for academic success coupled with the low reading abilities demonstrated by students in South Africa necessitates an intervention. Currently such an intervention is offered in the form of academic literacy

support modules at the NWU that strive to enable students to access, process and produce texts in a tertiary environment. As part of this endeavour a summarising technique like mapping is discussed as a relevant inclusion in an academic literacy intervention and the development of this ability is an important part of supporting underprepared students at university level. The origin of mapping tools in general is subsequently discussed and the efficacy of summary maps as a tool to improve text comprehension and ultimately reading-to-learn is also explained. Despite continuous efforts in the academic literacy support modules to enable students to fully master summary mapping, it remains challenging for most students, resulting in a failed opportunity for them to use summary mapping optimally as a study tool. Understanding why this ability remains so challenging for students is the fundamental problem addressed in the study.

In an attempt to address the problem, the study set out to investigate the process of summary mapping in order to identify challenges and ultimately suggest a teaching strategy that could aid in students successfully gaining the ability to use summary maps optimally. In order to gain insight into the process of summary mapping, eye tracking was discussed as a research methodology. This chapter explained the relevant eye-tracking terminology and pointed out that although eye tracking has been used successfully in a number of fields to investigate reading and scene perception it is less common in the field of applied linguistics and specifically in research pertaining to text production. It is nonetheless considered an effective and useful data collection tool that affords the researcher the ability to gain valuable insights about the process of summary mapping as was done in a limited number of cited studies.

The final part of this chapter focused on these small number of studies that use eye tracking to study mapping. The consensus seems to be that “the amount of literature regarding the application of eye-tracking methodology in concept maps is somewhat scarce and the sources are dispersed and difficult to locate, despite the fact that eye-tracking methodology lends itself naturally to the study of concept maps” (Rovira, 2016:60).

Considering the dire need for effective interventions that address the low level of academic literacy abilities of students, coupled with the problem of students not being able to fully master and use summary mapping abilities despite it being taught in an AL support module, point to a research gap in the literature that this study intends to address with regard to investigating, through eye tracking, the process students use in their construction of summary maps. This study, therefore, illuminates challenges in the process of summary mapping, informing an optimal teaching strategy for summary mapping.

CHAPTER 3 METHODOLOGY

3.1. Introduction

The preceding chapter has shown that although not many studies on mapping have been conducted using eye tracking, this methodology could be used productively for the present study in conjunction with other research methods. Using eye tracking could provide insight into the process that takes place during selection of important information in a text and the actual drawing of the summary map, instead of only having to assess the final product (the summary map itself). A better understanding of the process employed by students could then ultimately inform an optimal teaching model for summary mapping.

The aim of this chapter is to describe in detail the method that was followed in order to answer the research questions set out in Chapter 1 and possibly determine an optimal teaching methodology for summary maps.

The study includes both qualitative and quantitative empirical research that illuminate challenges for students that hinder the acquisition of mapping ability as it is taught currently in the academic literacy modules. All participants were provided with a text to read as part of the experiment used for data collection in this study. The reading of this text was accompanied by different tasks and outcomes. Firstly, text comprehension was tested by asking participants to complete a comprehension test after reading the text. Secondly, the participants' ability to identify and select important information was assessed by asking them to highlight the most important information in a section of the text, while simultaneously using the eye tracker to track their eye movements during this process. Lastly, the participants' ability to organise information into a logical structure, by transferring the information onto a graphic representation (in this case, a summary map), was tested. Participants were asked to draw a summary map that included the most important information from the text section. While they were completing this task the eye-tracking equipment was again utilised to record the data with regards to their eye movements.

3.2. Participants and sampling

3.3.1. Recruitment

An advertisement was sent out to all students enrolled for ALDE111 to invite them to partake in the study. This population was considered for the study because these were the students who had most recently been exposed to academic literacy teaching and especially then, the

teaching of summary mapping. The number of first-year students enrolled for 2021 was approximately 2461 of which 80% was required to take the ALDE111 support module. Students who were enrolled for this module had either been identified as potentially at risk by the Test of Academic Literacy Levels (TALL), a test developed by The Inter-institutional Centre for Language Development and Assessment (ICELDA) or had been required by their faculty to complete the module.

3.3.2. Participants

Participants expressed their interest to participate in the experiment by responding to a Google Form indicating when they would be available. After multiple advertisement attempts only 17 students were willing to participate in the study. Of the initial 17 collected sets, 13 data sets were considered valid. Three of the participants' processes did not record fully and one participant turned out to be a second-year student.

All of the participants were in other words first-year students at the North-West University on the Vanderbijlpark Campus and enrolled for the support module ALDE111. All participants indicated that they were English second language speakers. The participants' age, gender and fields of study are summarised and presented in Table 3-1 below.

Participant details	
Number of female participants	8
Number of male participants	5
Average age of participants	22
Number of participants in Economics field	6
Number of participants in Education field	4
Number of participants in Humanities field	3

Table 3-1 Age, gender and field of study of participants

In terms of education, these participants all share the basic education level of Grade 12 and have gained access to university study. This group was considered to be fairly homogenic in the sense that they were more or less the same age, were exposed to the same academic module and were all in their first year of study.

The sample size for the current study is small considering the large population it was drawn from. Due to the specific focus of this study, data collection could only take place in a specific, limited period of time that also coincided with a period during which certain Covid-restrictions were still in place. This could have influenced the number of participants that were prepared to participate in the study. However, the number of supporting sets of data presented still provide valuable insights into the process that could be used as a point of departure for additional research on the topic. According to Lewandowski & Kammerer (2021:1506), it is common for eye-tracking sample sizes to vary greatly and to be relatively small. They reported a median of 28 participants, but also acknowledge that the low sample sizes place the validity of studies at risk and calls on researchers using this methodology to increase their sample sizes. This could be challenging considering that eye-tracking research is quite intensive in that participants are tested individually, and data processing can be incredibly time consuming.

3.3.3. Ethical considerations

As discussed in Section 1.8 all the necessary steps were taken to ensure that the research was conducted in an ethically sound manner. Participants were informed beforehand that the experiment would hold very little to no risk or discomfort and that they were free to leave any time they wanted. They were furthermore informed that their participation would not influence their ALDE111 mark in any way. Although this is considered an ethically sound approach to the experiment it could also have had an adverse effect because it may have negatively impacted on the motivation of the student to do well in the tasks. However, since participants were informed of this beforehand and given the opportunity to leave at any moment it seemed that the participants who chose to complete the experiment were engaged in the tasks and attempted to complete them in a proper way. Some participants seemed genuinely intrigued by the eye-tracking equipment and took part in the experiment because they were interested in the technology (the advertisement included a picture of a man wearing eye-tracking glasses).

If the use of external motivators like extra credit or prizes were less restricted by ethical guidelines more participants may have opted to take part in the experiment and may have been more motivated to perform well in the tasks. Since research needs to be governed in this way there is little that can be done outside of appealing to the curiosity of participants and relying on their willingness to partake.

The experiments furthermore included no time constraints. Participants were afforded the opportunity to take their time in both the comprehension test and the selection and summary

map tasks. An effort was made to not influence their performance by including a stressor like a time limit. None of the participants spent an excessive amount of time on either tasks.

3.3. Setting

The different phases of the experiment took place in a lecture room and the eye-tracking laboratory at the VC of the NWU. Participants were seated in the lecture room for the completion of the comprehension test and directly afterwards were escorted to the eye-tracking laboratory to complete the selection of the most important information in the text and drawing of the summary map. The eye-tracking laboratory was specifically designed and equipped to conduct eye-tracking experiments. The laboratory is safe, clean and quiet. Participants were tested individually, with only the assistant/researcher present in order to set up the experiment and make sure the equipment was functioning properly during the experiment. Participation was completely voluntary and the participants booked a specific time that suited them. In the eye-tracking laboratory, a drawing board was set up on a table in the room with two sheets of paper pinned to it. The one sheet was the section of text that needed to be read and summarised and the other a blank sheet of paper on which participants would later draw their summary map. The pair of eye-tracking glasses was fitted to each participant as they entered the laboratory for the experiment. The glasses were then connected to a laptop computer behind the participant that collected the data. The diagram (Figure 3-1) shows the configuration of the space.

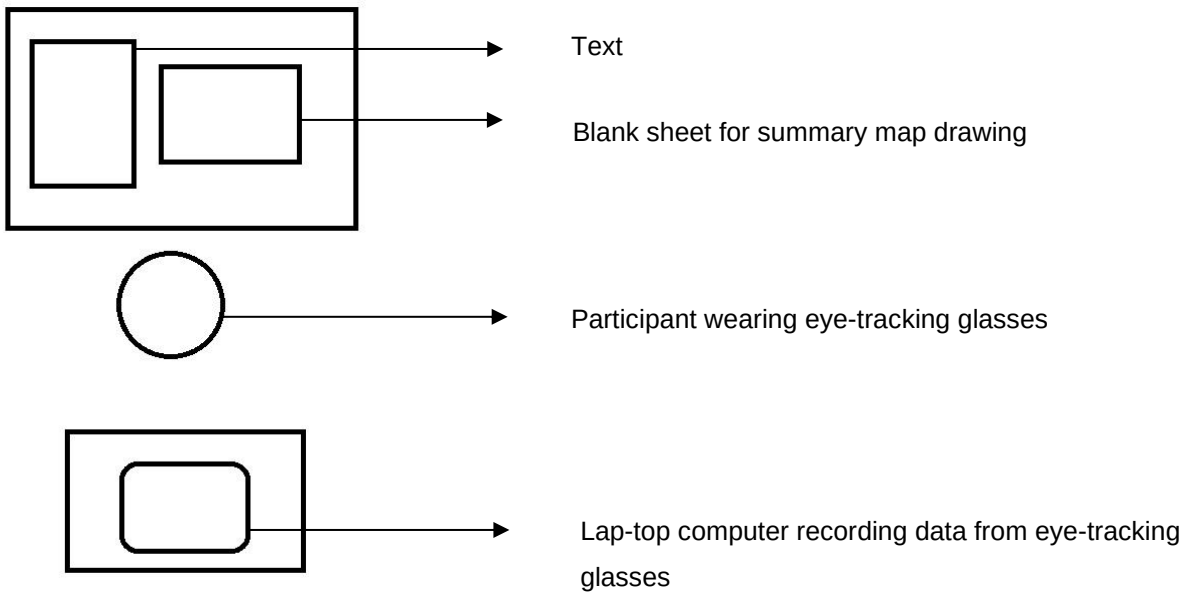


Figure 3-1 Configuration in the eye-tracking laboratory with a participant seated in front of the board and the eye tracker recording data

3.4. Materials

3.4.1. The text

The selected text was adapted from a previously used semester test of ALDE111. It is a text with a word count of 944 words called: *Our vanishing night - most city skies have become virtually empty of stars*. In terms of readability, the text scored 10.5 on the Flesch-Kincaid grade level and 12.7 on the Gunning Fog index. The Flesch reading-ease score is 51.6. These scores are in line with what a secondary school graduate should be able to read and understand. In terms of readability it is, therefore, a fair text to use for first-year university students. According to Duke and Pearson (2002), it is very important to consider the level and demand of texts used for comprehension instruction. They state that students "should encounter texts that do not make heavy demands in other respects, such as background knowledge, vocabulary load, or decoding" (Duke & Pierson, 2002:109). The text used in the experiment explains the impact of light pollution on animals, and specifically mentions three groups of animals under distinct subheadings, namely birds, nocturnal mammals and reptiles. It also mentions how to deal with light pollution and the effect it has on humans (see Annexure A for the full text).

The text was used in two ways in the experiment. Firstly, the comprehension questions used in the comprehension phase of the experiment are based on this text and participants used the text to answer the comprehension questions. For this phase, the text was provided as an addendum to the comprehension test in a similar font and size than the test. Secondly, a section of the text (specifically the sections about the impact on animals) was enlarged and provided to students during the selection of important information and summary map drawing phases of the experiment in order to mark important information and draw a summary map. The text was provided on an A3 sized piece of paper in 15pt. font size. The reason for using the larger paper and font sizes was to ensure that the relevant data could be collected using the eye-tracker since a pilot experiment indicated that a smaller font size would make it impossible to accurately determine relevant AOIs. The participants were asked to situate themselves at a comfortable distance behind the drawing board to complete the task. This turned out to be 40 to 60 cm from the text, but it would have resulted in AOIs being situated too closely together if a smaller font size was used. AOIs that are very close together was discussed in Chapter 2 as a possible threat to the validity of eye-movement data. If was therefore vital to make sure that AOIs could be identified comfortably so as to not cause inaccurate recordings of fixations in those AOIs. Using a bigger font size for the text therefore mitigated this challenge.

3.4.2. The comprehension test

The provided comprehension test was based on the text discussed in Section 3.4.1. In terms of reading comprehension tests, the literature offers several reading comprehension taxonomies. These have been developed in an attempt to categorise the abilities that reading comprehension assessments aim to test (Barrett, 1976; Català, Català, Molina, & Monclús, 2001; Herber, 1978; Swaby, 1989). With regard to such taxonomies, Cadime *et al*. (2013:385) state that:

> Essentially, these taxonomies seem to converge in four domains designated by Català and colleagues (2001) as literal comprehension (LC), inferential comprehension (IC), reorganisation (R), and critical comprehension (CC). LC entails the recognition of information explicitly stated in the reading selection. IC emerges when the reader's prior knowledge is activated, and expectations and assumptions about the text contents are made based on clues provided by the reading. R implies a new way of organising information through synthesis, schemes or summaries. CC includes making judgments with subjective answers, relating to the characters or the author's language and personal interpretations. This conceptualisation can allow teachers to design specific instructional activities to promote each type of comprehension.

With regard to a validation of the comprehension test in terms of its appropriateness for the specific task and group of respondents, this study utilises the same reading comprehension taxonomy that was employed by Cadime *et al*. (2013:385). In their study these researchers aimed to develop and test a valid, formal reading comprehension instrument. Essentially, they made use of the reading comprehension taxonomy of Català *et al*. (2001) as the theoretical guideline for setting the questions (in order to address one of the most fundamental validity measures, that of construct validity). According to Cadime *et al*. (2013:385), "this taxonomy was chosen because it synthesizes previous taxonomies and presents a clear operationalisation of each comprehension type".

A subsequent validity study showed that the test they constructed based on the proposed taxonomy could be considered valid based on the results obtained during the research. Cadime *et al.* (2013:385) conclude that: "The present investigation provides validity evidence for the three test forms that constitute the TCL (*Teste de Compreensão da Leitura*/ Reading comprehension test)".

With reference to the application of the Català *et al*. (2001) categorisation to the current study, the test contains questions that belong to the categories of literal comprehension, inferential comprehension and reorganisation. Although the category of critical comprehension forms part of the categorisation, it was not required at this point specifically for students to be able

to draw an appropriate summary map. The AL students are, however, introduced to critical reading as a reading strategy later in the semester and this is tested in a different way.

The comprehension that was assessed for this study also included the testing of vocabulary. According to Read (2000:1), it is necessary to test vocabulary knowledge of second language learners because:

> words are the basic building blocks of language, the units of meaning from which larger structures such as sentences, paragraphs and whole texts are formed. For native speakers, although the most rapid growth occurs in childhood, vocabulary knowledge continues to develop naturally in adult life in response to new experiences, inventions, concepts, social trends and opportunities for learning. For learners, on the other hand, acquisition of vocabulary is typically a more conscious and demanding process. Even at an advanced level, learners are aware of limitations in their knowledge of second language (or L2) words.

Another issue in this regard is the fact that new and unfamiliar academic vocabulary can be challenging for any student, and even more so for L2 students that may already struggle with general English. Various researchers (Corson, 1997; García, 1991; Snow & Kim, 2007) believe that a lack of academic vocabulary knowledge has been one of the most persistent obstacles to student success. It is therefore considered an important part of reading comprehension and academic literacy.

As part of the AL module, students are introduced to various strategies they could use to deal with unfamiliar vocabulary. One of these strategies entails using context to derive meaning. The effective use of this strategy is then assessed as part of the testing of comprehension. According to Pearson *et al*. (2007: 289) "[a]ny word can readily and easily be assessed in a decontextualized format. But simply assessing a word in a contextualized format does not necessarily mean that context is required to determine its meaning. In order to meet the standard of assessing students' ability to use context to identify word meaning, context must actually be used in completing the item." The vocabulary items included in the comprehension test used for the study did exactly as asserted by Pearson *et al.* (2007) above, in that the students had to refer specifically to the text in order to answer those specific questions in the comprehension test. The vocabulary section included basic questions that required one-word answers as well as more complex items that required an explanation of meaning.

The complete comprehension test is included as Annexure B and a list of comprehension categories included in the comprehension test as well as the specific items categorised under each is included in Table 3-2:

Category	Question item
Basic vocabulary	Section 1 – Questions 1a, 1b, 2a and 3
Complex vocabulary	Section 1 – Questions 2b and 4
Literal comprehension (LC)	Section 2 – Questions 1, 2, 4 and 5
Inferential comprehension (IC)	Section 2 – Questions 3, 6, 7 and 8
Reorganisation (R)	Section 2 – Question 9

Table 3-2 Categories included in the comprehension test

The comprehension tests used in the AL module as a whole are always moderated internally to ensure that all relevant criteria are tested. The same therefore applies in the context of the current study, as the comprehension test was used in the AL module in previous years. The moderator's report indicated that the following assessment criteria were tested by the comprehension:

- apply different reading strategies (scanning, skimming, comprehensive reading and critical reading) in order to effectively access academic information; and
- understand academic vocabulary in context.

The comprehension test utilised for the current study could therefore be considered a valid and useful instrument to test the appropriate skills and content of the selected group of participants.

3.4.3. The blank page for drawing the summary map

For the summary map drawing phase, students were provided with a blank A3 sized piece of paper in landscape orientation on which to draw their summary maps. The size of the provided sheet of paper is firstly in line with what Buzan's (1993) recommends. He advocates that bigger than normal page sizes can help the student to be more creative and break away from the boundaries of commonly used page sizes. Secondly, landscape orientation is also used when demonstrating summary mapping to students as part of the AL content. It is demonstrated in this way to show students how to optimally use the space provided and using the page in the landscape orientation creates more space to express ideas logically. Thirdly, it was important to make sure that the AOIs were not situated too closely together as this could influence the validity of the data as mentioned in Section 2.6.

3.4.4. Eye-tracking glasses

Advancements in eye-tracking technology, such as the fully mobile gaze-tracking device developed by SMI SensoMotoric Instruments in 2012, enable researchers to study eye movements in real-life settings and in a way that closely mimics normal situations (Mele and Federici, 2012). Systems like these eye-tracking glasses are non-invasive and can be worn like a common pair of glasses. With a weight of 75 g, the SMI Eye-Tracking Glasses provide binocular eye-tracking data observations in real-time and can also record data using a high definition (HD) scene camera with a 1,280 × 960 p resolution (Mele & Federici, 2012). The SMI Eye-Tracking Glasses 2 Wireless (SMI ETG 2w) were used to collect data while the participants selected the relevant information and drew their summary maps.

As opposed to static or screen-based eye trackers, eye-tracking glasses mimic a normal situation much more closely as participants are able to move their heads freely and reading/writing behaviour across two different sheets of paper could therefore be recorded without any restrictions and with allowance for natural movement. The SMI Eye-Tracking Glasses 2 Wireless (SMI ETG 2w) is a hi-speed system that use optical tracking of corneal reflections known as pupil centre corneal reflection (PCCR) to collect data (SensoMotoric Instruments GmbH, 2014). According to Farnsworth (2018), “this technique entails that near-infrared light is directed towards the centre of the eyes (pupil), causing detectable reflections in both the pupil and the cornea (the outer-most optical element of the eye). These reflections, the vector between the cornea and the pupil, are then tracked by an infrared camera”. The SMI ETG 2w has a sampling rate of up to 120 Hz and measures six corneal reflections (Cognolato *et al*. 2018). Figure 3-2 illustrates what these eye-tracking glasses look like.

Figure 3-2 SMI Eye-Tracking Glasses 2 Wireless (SMI ETG 2w) eye tracking (Zimmermann *et al*. 2020)

During this phase of the experiment, participants were individually seated in front of the drawing board and the eye-tracking glasses were fitted to them. Participants were encouraged to move their heads around, look up and down and adjust the headband of the eye-tracking glasses to make sure that they were comfortable with the equipment. The height of the chair

and distance from the drawing board were also adjusted according to the height of each participant to make sure the participants were seated comfortably, and that the two pages were within the recorded field of view. Thereafter, a 3-point calibration procedure was completed to ensure the accuracy of the recording. According to Tatsuya (2019:60) “Calibration is the process whereby the geometric characteristics of a subject’s eyes are estimated as the basis for a fully-customized and accurate gaze point calculation”. During this process the participant is instructed to look at specific points on the stimulus while the eye-tracking software records a series of images. These images are then used to ensure that the eye-tracker accurately detects the eye-movements of that particular individual, compensating for anatomical differences between participants.

3.5. Data collection procedure

Data collection took place over a period of three weeks during which participants could book a time that suited them best. Participants were tested individually in a three-phased experiment of which the phases took place consecutively. For phase 1 they were asked to first read the complete text and answer comprehension questions about the text. After completing the comprehension test, they were escorted to the eye-tracking laboratory for phases 2 and 3 where they were asked to first read the text selection and mark all the important information, and secondly, to draw a summary map of that section of text in which they marked the most important parts while their eye movements were being recorded.

3.5.1. Phase 1 – Completing the comprehension test

When participants arrived at the lecture room, they were welcomed and given a short explanation of how the experiment was going to be conducted. The informed consent form was explained and they were given the chance to read and sign the form. Thereafter, they were given two separate pieces of paper. One was the text that they had to read and the other was the comprehension test containing the questions with space for the answers to be completed in hard copy. The participants were then requested to answer the questions. Thereafter the participants were taken to the eye-tracking laboratory where the eye-tracking equipment was explained to them.

3.5.2. Phases 2 and 3 – selecting important information and drawing the summary map

After briefly explaining the set-up and use of the eye-tracking glasses, the laboratory assistant fitted the glasses to each participant, ensuring that the glasses were comfortable and

functioning optimally. As mentioned above, the glasses were calibrated using a 3-point calibration that is available in the SMI Experiment Centre 3.7 software. Thereafter the participant was asked to read the provided section of the text and to mark the most important information with the stationery provided. The participant was then requested to draw a summary map, summarising the information they marked in the form of a summary map.

3.6. Data analysis

This section discusses the method of data analysis used for the different data sets collected in the study.

Firstly, statistical correlation analyses were used to determine the relationships between the dependant variable, namely the summary map score which was measured by assessing the drawn summary maps and the following independent variables for the study:

- test score for text comprehension, including vocabulary items; and
- percentage of relevant information selected.

The results of the correlation analyses were used to ultimately answer research sub-questions a and b as outlined in Section 1.5. These two independent variables represent parts of the steps of summary mapping that are taught in the ALDE111 module. The importance of these variables for the study relate to the fact that they might indicate areas of difficulty for students in developing appropriate summary maps. If students are unable to fully comprehend the text, they may not be able to draw appropriate summary maps and may even struggle with the selection of relevant information. On the other hand, if students fully comprehend the text but are unable to select the relevant information this could also influence their mapping ability.

Secondly, the eye-tracking measurements as well as the qualitative analysis provide insight into the process of summary map drawing, which is the last step in the summary mapping process. The eye tracking measurements are considered significant because they convey information about what is being processed and how difficult it is for participants to process. Possible patterns that emerge from the analysis could give valuable insight into how participants arrive at effective summary maps, or why they experienced difficulty.

Furthermore, the videos obtained during the eye tracking experiment were coded using computer assisted qualitative data analysis software called ATLAS.ti. This software enables researchers to locate and code features or instances in texts or videos. The codes used during this process represents the frequently observed acts as indicated in Table 4-14 in the following

chapter, but these acts were broken down into more detail for the purpose of the coding to refer to certain sections in the text and summary map. A list of codes and definitions are included in Table 3-3.

Act	Detailed code
Comprehensive reading	CR T1 (Critical reading text paragraph 1) CR T2 (Critical reading text paragraph 2) CR T3 (Critical reading text paragraph 3) CR T4 (Critical reading text paragraph 4)
Rereading	RR T1 (Rereading text paragraph 1) RR T2 (Rereading text paragraph 2) RR T3 (Rereading text paragraph 3) RR T4 (Rereading text paragraph 4)
Constructing concept boxes	MID (Constructing centre box) M1 (Constructing box with T1 information) M2 (Constructing box with T2 information) M3 (Constructing box with T3 information) M4 (Constructing box with T4 information) ADD (Constructing additional box – information not in text)
Writing into concept boxes	MID (Writing into centre box) M1 (Writing into box with T1 information) M2 (Writing into box with T2 information) M3 (Writing into box with T3 information) M4 (Writing into box with T4 information) ADD (Writing into additional box – information not in text)
Writing notes	Notes
Referring and writing into concept boxes	RW MID (Referring writing into centre box) RW M1 (Referring writing into box with T1 information) RW M2 (Referring writing into box with T2 information) RW M3 (Referring writing into box with T3 information) RW M4 (Referring writing into box with T4 information)
Checking	SM (Checking summary map) Text (Checking text)
Fixing mistakes	Fixing (Revising or erasing and rewriting concepts)
Linking	Linking (Drawing linking arrows or lines between concepts or boxes)
Selecting information	Selecting (Selecting relevant information in the text)
Selecting while reading	SWR (Selecting relevant information in a simultaneous fashion, switching quickly between the two tasks)

Table 3-3 Coded acts and definitions

After all of the videos were coded, a detailed sequence diagram could be drawn for each participant using GitMind software for drawing Unified Modelling Language (UML) sequence

diagrams. UML is a modelling language that is used often for software engineering, but it has many other uses as well. This type of sequence diagram details how tasks are or should be carried out. Sequence diagrams are organised chronologically, with time progression shown vertically. The objects involved, or in this case the categories of observed acts, are listed from left to right, and switching between these categories is shown horizontally and numbered as can be seen in Figure 3-3.

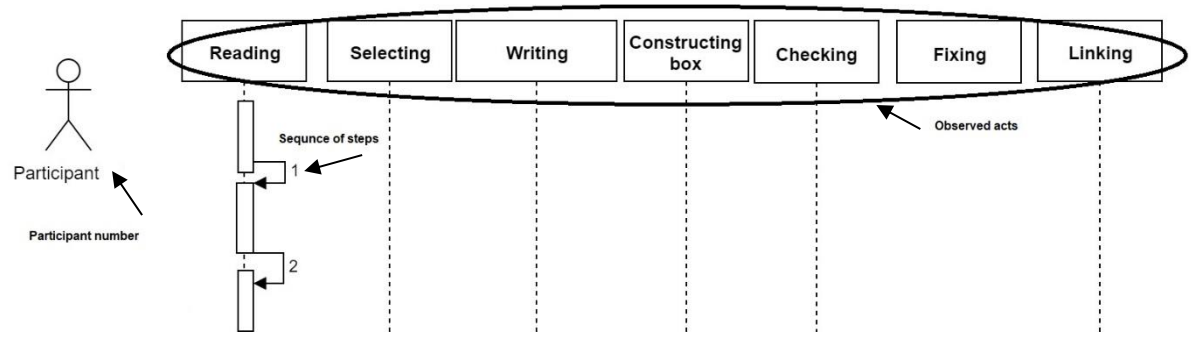


Figure 3-3 Example of how the UML diagram works

Illustrating the summary mapping process in this way enables the researcher to compare the processes visually in the sequence that they occurred and identify any patterns that may have emerged and allows for better and more accurate comparison.

The analysis of the various sets of data that speak to the different sub-question, collectively enabled the researcher to answer the two main research question 1 and 2 as outlined in Section 1.5.

3.6.1. Data set 1 – Summary map score

The point of departure for the data analysis was the analysis and ranking of the summary map scores of participants. These scores were determined by using the summary map assessment rubric tool (SMART) as developed by Butler, Butler and Schutte (2022) to assess the summary maps of participants. This tool was developed to address the very specific need for a relevant and accurate assessment tool for summary maps that could ensure inter-marker reliability and provide useful feedback to students. The tool has already been presented at teaching and learning conferences (LSSA/SAALA/SAALT Joint Annual Conference, 2015; The 1st Annual Teaching and Learning Conference, 2018) and the feedback received has generally been positive. It has further been used successfully for a number of years within the Subject Group: Academic Literacy at the VC. This tool caters for the assessment of what students need to achieve with mapping as a strategy for summarising a text, namely: (i) to distinguish between essential and non-essential information, in other words, to test if they can identify and then summarise meaningful phrases as main ideas; and (ii) to recognise meaning that is conveyed

by the argument structure and logical flow of the text and then reproducing it in the form of a diagram that links or groups the information correctly. SMART allows for a scaled mark reflecting the content (the meaningfulness of the phrase or chunk of information) and logical link (how well it reflects the structure of the text) for each level of information (main ideas, supporting ideas, lower-level examples). Each main idea is scored out of a maximum of 5 and a minimum of 2 marks, each supporting idea is scored out of a maximum of 4 and a minimum of 1 mark, and if there is any third level information or examples, they are scored out of a maximum of 3 to zero. Table 3-4 shows the rubric as it is used for the scoring of summary maps.

Structure	Logical link	Content (meaning)	Score
Main ideas	Correct level/link	Sensible phrase	5
	Correct level/link	Too cryptic/Too much information	4
	Wrong level/link	Sensible phrase	3
	Wrong level/link	Too cryptic/Too much information	2
Supporting ideas	Correct level/link	Sensible phrase	4
	Correct level/link	Too cryptic/Too much information	3
	Wrong level/link	Sensible phrase	2
	Wrong level/link	Too cryptic/Too much information	1
3rd level ideas/examples	Correct level/link	Sensible phrase	3
	Correct level/link	Too cryptic/Too much information	2
	Wrong level/link	Sensible phrase	1
	Wrong level/link	Too cryptic/Too much information	0

Table 3-4 The SMART rubric used for scoring summary maps

For the current study, the summary map had a total score of 71 marks consisting of three main ideas (5 x 3, marked in purple), seven supporting ideas or categories (4 x 7, marked in yellow) and eleven 3rd level examples (3 x 11, marked in green). The ideal memorandum including the colour indicators referred to above has been included in Figure 3-4 as illustration.

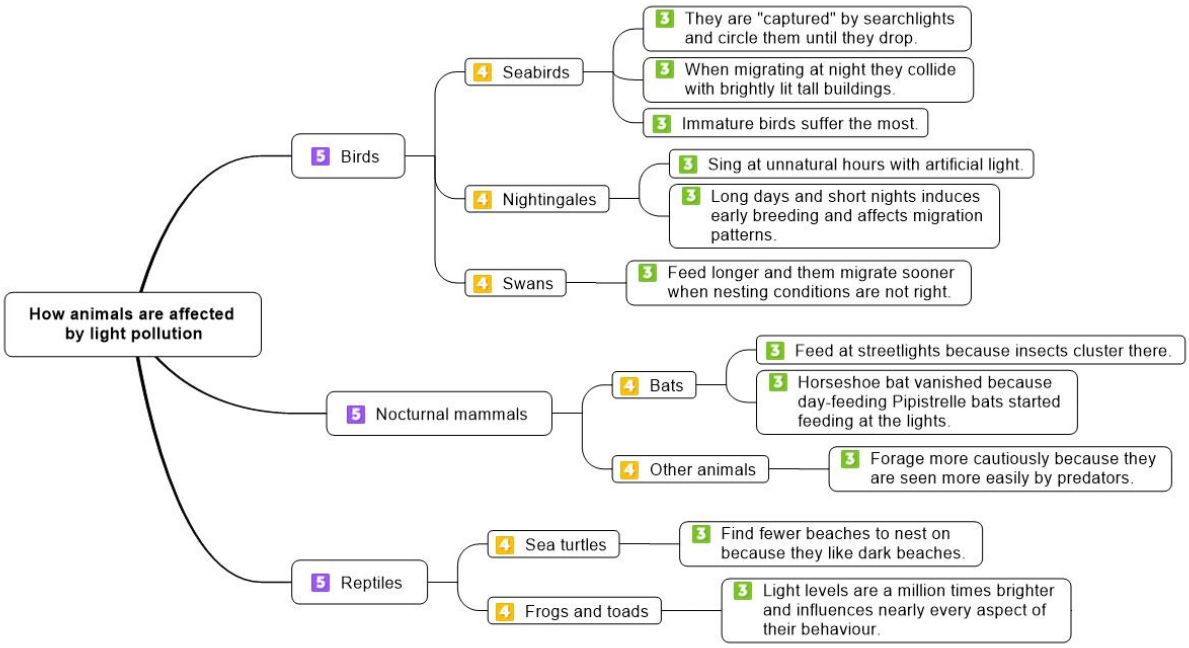


Figure 3-4 Summary map memorandum

As already mentioned, the goal of the data analysis is to use the summary map score as the dependant variable in a series of correlation comparisons to determine which/if any part of the summary mapping process is challenging for the participant.

3.6.2. Data set 2 – Selecting important information

In order to determine whether there is a correlation between the selected information and how well students fared in the summary map, selected information was assessed by determining the percentage of relevant information selected. Relevant information is considered information that should be included in the summary map. If the memorandum for the summary map (Figure 3-4) is considered, it is evident that there are three parts of relevant information on level one, seven parts of relevant information on level two and 11 parts of relevant information on level three. A maximum of 21 marks could therefore be obtained for each part of information that a participant selected (high-lighted or underlined). If participants mark irrelevant information or too little information in any selection of information the selection will not be awarded a mark. For example: The first level of information consists of three parts of relevant information namely: “Birds, Nocturnal mammals and Reptiles”. If the participant only high-lighted “Reptiles”, this would result in a score of 1/3 (one out of a total of three) for level one. This should illustrate to what extent the participants were able to select the most relevant information from the text.

3.6.3. Data set 3 – Eye-tracking and process data

The objective of the analysis of the eye-tracking data was to determine possible difficulties experienced by participants and to determine patterns by referring firstly to eye behaviour metrics (fixation counts, fixation duration, transitions and dwell time/visit duration) and secondly, by referring to frequently observed acts, for example, arrangement, reasoning and controlling checking as was used by Dogusoy-Taylan and Cagiltay (2014:86-87) in a similar study. If any discernible patterns can be identified and compared to scores from other collected data sets (summary map and information selection scores), this could provide valuable insight into an optimal process for summary map construction for participants as well as possible difficulties they may have experienced. If an optimal process and experienced difficulties can be determined, a teaching model that focuses on teaching an optimal process and addressing difficulties can be developed.

The Dogusoy-Taylan and Cagiltay (2014) study will be taken as a point of departure for the eye-tracking data analysis because, as discussed in Chapter 2, it is one of very few studies that used eye-tracking to investigate mapping in a way that is relevant to the current study. Dogusoy-Taylan and Cagiltay (2014) used eye-tracking measures to investigate the act of map drawing successfully. Furthermore, similar to the current study, the study by Dogusoy-Taylan & Cagiltay (2014) also focused on the process of map development. These scholars contend that: “The CM [concept map] development process itself includes a chain of cognitive acts such as arranging, constructing, deleting or changing concepts, all of which need to be investigated” (Dogusoy-Taylan & Cagiltay, 2014:82). In their study, they compared experts to novices in order to see how the concept map development process differed between these groups, what differences could be observed in their eye behaviour or movement, and whether they used specific strategies in the development process. The ultimate aim of the study was therefore to reach a better understanding of “the CM development process in depth, leading to practical advice for practitioners and researchers while determining contributing reasons for the development of effective or ineffective CMs” (Dogusoy-Taylan & Cagiltay, 2014:84). The distinction that these researchers make in terms of novices and experts in their study may be a relevant reference for the current study since, for summary mapping ability, 1st year students could also be considered novices.

In their study, Dogusoy-Taylan and Cagiltay (2014) used eye-tracking data to determine fixation duration, fixation count and visit duration for the entire exercise of concept map construction as well as for specific acts during the process. Three main acts were identified, namely cross-linking, controlling and checking and reasoning. These were used to gather additional information about the mapping process used by participants. Drawing on this initial

study conducted by Dogusoy-Taylan and Cagiltay (2014), specific measures that are relevant for the current study were determined. These measures and descriptions thereof have been included in Table 3-5. The measures will be analysed in relation to the various sets of data obtained in in the experiment.

Eye-tracking measure	Description
Average fixation duration	To measure the average fixation time on each area of interest (AOI) - these AOIs will consist of information from levels one and two in the text and corresponding chunks of information in the summary maps
Total fixation count	To measure the total number of fixations on each AOI
Transition matrix	To measure the way transitions took place between AOIs
Average dwell time/visit duration	To measure the average time spent in AOIs

Table 3-5 Measures for eye movement used in the current study

In addition to the quantitative measurement and investigation of eye-tracking metrics mentioned above, the eye-tracking video data was also be analysed qualitatively to determine the frequently observed acts for the current study. The process followed by each participant was coded using ATLAS.ti and then used to draw sequence diagrams for all the participants. This facilitated the detailed investigation and comparison of the processes followed by participants. These processes were compared to all the other data sets already mentioned to create a holistic view of the summary mapping process.

3.7. Conclusion

The observations stipulated in the chapter provided insight into possible difficulties experienced by participants when constructing summary maps, providing answers to the research questions posed in Chapter 1 of the study. In order to reach the main objective of the study, insights gained was used to determine an optimal teaching model for summary mapping abilities. The next chapter will present the findings of the study, after which a discussion of all the results from the analyses will follow in Chapter 5.

CHAPTER 4 ANALYSIS AND INTERPRETATION OF FINDINGS

4.1. Introduction

In this chapter, the results of the conducted experiment are presented. This experiment was designed to investigate the process followed by participants when completing summary maps. An analysis of these results ultimately answers the research questions outlined in Section 1.5. The findings are presented in two main sections, with Section A referring mainly to the following three sub-questions presented in Chapter 1:

a. How do students' comprehension levels of texts, relate to their production of a summary map?
b. How do students' ability to select the relevant information in a text relate to their production of a summary map?
c. How do students' ability to organise selected information into a logical structure relate to their production of a summary map?

The second section (Section B) of the chapter includes findings and discussions on the two main research questions of this study:

1. How (what process) do students (use to) create summary maps to summarise information for learning?
2. What are the implications of the findings for the teaching methods used to teach summary mapping abilities?

All the test data was collated into one Excel spreadsheet for statistical analysis. These included the summary map scores, comprehension test results and information selection scores. In order to answer the first three sub-questions of the study, a correlation analysis between the summary map results and other variables was carried out. A Spearman correlation analysis was used to indicate practically significant correlations between variables. As the study relied on a convenience sample, p-values are only reported for the sake of completeness and will not be interpreted. Effect sizes will be interpreted where ~0.1 will be considered a small or no practically significant correlation, ~0.3 will be considered a medium or practically visible correlation and ~0.5 will be considered a large, practically significant correlation. Means and standard deviations are included in Table 4-1 for the sake of completeness.

Descriptive statistics of correlation analysis			
	N	Mean	Std. Deviation
Basic Vocabulary	13	61.538	16.506
Complex Vocabulary	13	60.577	22.734
Literal comprehension questions	13	75.641	22.169
Inferential comprehension questions	13	35.897	12.343
Reorganisation question	13	65.385	19.792
Comprehension Test Total	13	56.213	8.461
Information Selection Level 1	13	15.385	37.553
Information Selection Level 2	13	30.769	27.259
Information Selection Level 3	13	54.545	23.177
Information Selection Total	13	33.966	18.524
Fixation - Processing	13	1119140.289	235310.545
Summary Map (SMART score) Level 1	13	52.308	37.991
Summary Map (SMART score) Level 2	13	24.725	21.698
Summary Map (SMART score) Level 3	13	32.168	21.765
Summary Map (SMART score) Total	13	33.401	20.662
Valid N (listwise)	13		

Table 4-1 Means and standard deviations of the correlation analysis between variables for the current study

4.2. Dependant variable: participants' summary map scores

Before analysis could take place, the summary map score of each participant needed to be determined. As explained in Chapter 3, the SMART system (Butler, Butler & Schutte, 2022) was used to score the summary maps. In order to ensure accurate and fair scores, an independent marker (who is highly experienced in using the SMART system) was asked to score the summary maps as well. The results of the two markers (i.e., the researcher and the

independent marker) have been included in Table 4-2. It is evident from the high inter-marker reliability that the scores are accurate and fair. According to Meadows and Billington (2005:14), “inter-marker reliability refers to the variation in the marks assigned to an examination script by different markers”. The lower the variation, the higher inter-marker reliability is believed to be. Because of the high inter-marker reliability, the original scores allocated by the researcher/main marker was used for analysis.

Main marker		Independent marker	
Participant	**%**	**Participant**	**%**
P2	11	P2	14
P4	18	P4	17
P5	50	P5	49
P8	11	P8	12
P9	16	P9	17
P10	58	P10	57
P11	50	P11	49
P12	36	P12	38
P13	51	P13	47
P14	26	P14	24
P15	0	P15	0
P16	49	P16	49
P17	59	P17	59

Table 4-2 Marks awarded for summary map by the researcher and independent marker

The final summary map scores are presented with regard to the scores on the different levels of ideas that participants achieved on the SMART system. A final score is also provided. The scores are presented in Table 4-3:

Summary map scores								
Participant	**Level 1**	**%**	**Level 2**	**%**	**Level 3**	**%**	**Total score /76**	**Total %**
P2	4	27	0	0	4	12	8	11
P4	0	0	0	0	14	42	14	18
P5	15	100	11	39	12	36	38	50
P8	3	20	0	0	5	15	8	11
P9	8	53	0	0	4	12	12	16
P10	15	100	15	54	14	42	44	58
P11	3	20	15	54	20	61	38	50
P12	8	53	7	25	12	36	27	36
P13	15	100	9	32	15	45	39	51
P14	8	53	12	43	0	0	20	26
P15	0	0	0	0	0	0	0	0
P16	8	53	10	36	19	58	37	49
P17	15	100	11	39	19	58	45	59
Averages	8	52	7	25	11	32	25	33

Table 4-3 Summary map scores

The mean score for the summary map is *M=33.4*. This score is lower than the 3-year average of 43% reported in Chapter 1. The lower average score could be attributed to a number of factors including, but not limited to, the impact of online teaching and COVID-19. During the year in which data collection took place, the COVID-19 pandemic necessitated that the teaching and learning of AL be conducted via the online format. Some researchers believe that the digital divide experienced in South African universities would lead to a drop in the academic performance of students, especially for first-year students. Mbodila (2020) argues that many first-year students come from under resourced schools and have little or no exposure to information technology like computers in the teaching and learning environment. Although this factor may have had an influence on the students' mapping performance, it is rather speculative, since there was no such significant drop in the overall

pass rates of ALDE111 students during the previous three years. The pass rates over the past 3 years (2019-2021) only deviated by 6 % or less.

The average mark obtained for the summary map, however, does not impact on the goal of the study, which is to investigate the process of summary mapping, but reiterates the problem in question (that despite teaching and instruction most students are not able to construct appropriate summary maps).

4.3. Sub-question 1 - Comprehension test scores

In order to also ensure an accurate and fair comprehension test score for participants, an independent marker evaluated all the tests, after which the marks awarded by the researcher were compared to those of the independent marker. As can be seen in Table 4-4, the inter-marker reliability is once again high. Therefore, scores allocated by the researcher/main marker for the comprehension test were considered to be fair and accurate.

Comprehension test scores			
Researcher		**Independent marker**	
Participant	**Mark /26**	**Participant**	**Mark /26**
P2	15.5	P2	17.5
P4	11	P4	10.5
P5	14.5	P5	14.5
P8	11	P8	12.5
P9	15	P9	16
P10	18	P10	18
P11	13	P11	12
P12	15.5	P12	14.5
P13	18	P13	18
P14	13	P14	13
P15	14.5	P15	14
P16	15	P16	16
P17	16	P17	17

Table 4-4 Marks awarded for comprehension test by the researcher and independent marker

In order to investigate different components of the test, the comprehension test scores were categorised into five relevant categories taking the Cadime *et al*. (2013) categorisation as a point of departure (as discussed in Section 3.4.2). A complete list of categories included in the comprehension test, as well as the specific items categorised under each and totals out of 26, is included in Table 4-5:

Category	Question item	Total /26
Basic vocabulary	Section 1 – Questions 1a, 1b, 2a and 3	4
Complex vocabulary	Section 1 – Questions 2b and 4	4
Literal comprehension (LC)	Section 2 – Questions 1, 2, 4 and 5	6
Inferential comprehension (IC)	Section 2 – Questions 3, 6, 7 and 8	9
Reorganisation (R)	Section 2 – Question 9	3

Table 4-5 Categorisation of comprehension questions

The total scores and percentages for all categories, as well as total scores for the complete comprehension test as awarded by the researcher/main marker, are presented in Table 4-6:

Comprehension test data											
Participant	**Basic vocabulary**	**%**	**Complex vocabulary**	**%**	**Literal comprehension**	**%**	**Inferential comprehension**	**%**	**Reorganisation**	**%**	**Total %**
P2	3	75	2	50	5	83	3	33	2.5	83	60
P4	2	50	3.5	87.5	2	33	2	22	1.5	50	42
P5	2	50	4	100	3	50	3	33	2.5	83	56
P8	1	25	2	50	5	83	1.5	17	1.5	50	42
P9	3	75	3	75	4	67	3	33	2	67	58
P10	3	75	2	50	6	100	5	56	2	67	69
P11	3	75	2	50	3	50	3	33	2	67	50

P12	2	50	2	50	6	100	5	56	0.5	17	60
P13	3	75	4	100	6	100	3	33	2	67	69
P14	2	50	2	50	4	67	2	22	3	100	50
P15	2	50	1	25	5	83	4.5	50	2	67	56
P16	3	75	2	50	4	67	4	44	2	67	58
P17	3	75	2	50	6	100	3	33	2	67	62
Averages	2	62	2	61	5	76	3	36	2	65	56

Table 4-6 Comprehension test scores per category

The average total comprehension score for the group of participants is *M=56.2%,* with only two participants scoring under 50%. This average indicates that the majority of the group understood the text well enough to at least answer half of the questions correctly. Although this average score would be considered a passing score by academic institutions and is better than the average scores for the summary mapping and selection scores, it is low if one considers the level of understanding needed to summarise a text adequately. Scholars (Enright *et al*., 2000; Grabe & Stoller, 2019) explicitly state that one needs to demonstrate reading ability beyond general comprehension at university because readers are expected to read for learning purposes, integrate information and critically engage with texts, abilities that can be considered cognitively challenging. This lower score seems to be in line with other research on reading level at university. De-la-Peña and Luque-Rojas (2021:2) state that:

> Livingston *et al*. (2015) found that first-year students present limited reading strategies and difficulties in understanding written texts. In another study, Ntereke and Ramoroka (2017) also conducted research on reading proficiency demonstrated by 1st year students in terms of comprehension. They found that only 14.2% passed the proficiency test well while 34.3% performed below the level expected at tertiary level.

In order to answer sub-question a (How do students' comprehension levels of tests relate to their production of a summary map?) a correlation analysis was performed between comprehension and summary map scores. In terms of comprehension, a practically significant correlation can be seen between *Total comprehension* and *Summary map total score* (*r = 0.539; p-value = 0,057)* for this study*.* Upon deeper investigation, a practically significant correlation is evident between specifically *Basic vocabulary questions* and *Summary map total score (r = 0.492; p-value = 0,087),* and a practically visible correlation is evident between *Complex vocabulary questions* and *Summary map total score. (r = 0.302; p-value = 0.316).* In comparison, the effect sizes between the two comprehension subsections (*Literal*

comprehension questions and *Inferential comprehension questions*) and *Summary map total score,* are smaller *(r = 0.272; p-value = 0.369)* and *(r = 0.251; p-value = 0.407)* respectively. It is thus evident that participants' level of vocabulary knowledge influences their ability to produce appropriate summary maps for this particular sample. Figure 4-1 shows the summary map scores in relation to total comprehension scores.

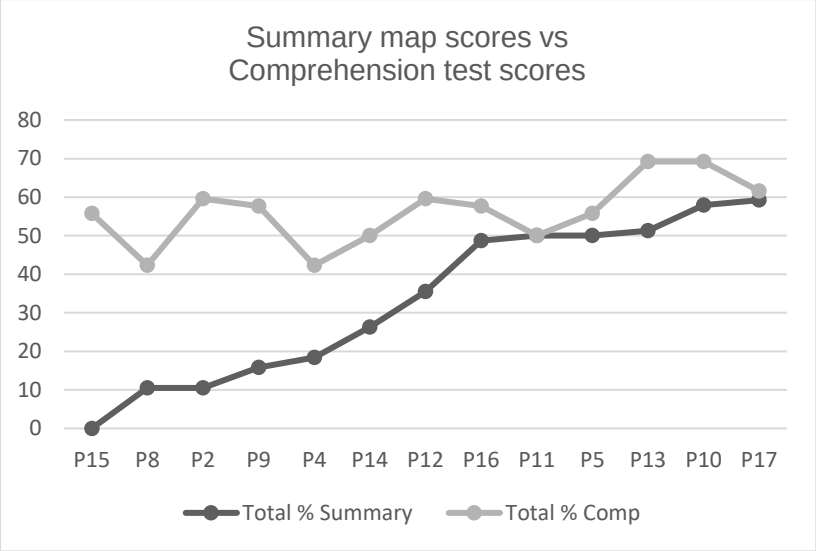


Figure 4-1 Summary map score vs Comprehension test scores

Although a correlation is indicated in the statistical data as discussed above, the graph in Figure 4-1 shows no discernible. Participants who scored below 40% for the summary map phase of the experiment had more erratic comprehension test scores, whereas the this was not the case with participants scoring more than 50%. This may indicate that the level of comprehension and, in particular, the level of vocabulary may be good predictors of high scoring summary maps. The correlation analyses show that a low level of comprehension can have an impact on summary mapping abilities for this study. Although some participants did pass the comprehension test but clearly could not draw an appropriate summary map, the overall low score in the comprehension test still indicates a challenge with regard to reading comprehension for participants in this study. This finding is significant because reading comprehension is the first step in the summary mapping process. Without ample reading comprehension, none of the subsequent tasks in the process can be completed adequately. If this challenge is not addressed satisfactorily, students may not be able to master summary mapping skills sufficiently, regardless of how summary mapping abilities are taught in an intervention.

4.4. Sub-question 2 - Selection of relevant information

Information selection was evaluated by awarding 1 mark for each chunk of selected information relevant to the summary map memorandum for each level indicated on the summary map. A demonstration of how the marking of this phase of the experiment was completed follows in Figures 4-2 and 4-3.

Birds

Light is a powerful force, and on many species it acts as a magnet. This process is being studied by researchers Travis Longcore and Catherine Rich, co-founders of the Los Angeles-based Urban Wildlands Group. The effect of light is so powerful that scientists speak of seabirds being "captured" by searchlights on land circling and (circling in the thousands until they drop). Birds are also apt to collide with brightly lit tall buildings because they migrate at night, immature birds on their first journey suffer the most.

Some birds like nightingales sing at unnatural hours in the presence of artificial light. Scientists have determined that long artificial days—and artificially short nights—induce early breeding in these birds. And because a longer day allows for longer feeding, it can also (affect migration schedules). One population of swans, wintering in England put on fat more rapidly than usual, priming them to begin (migration early). The problem, of course, is that migration, like most other aspects of bird behaviour, is a precisely timed biological behaviour. Leaving early may (mean arriving too soon for nesting conditions to be right.)

Nocturnal mammals

Insects have the tendency to cluster around streetlights, and feeding at those insect clusters is now ingrained in the lives of many bat species. In Sweden the Horseshoe bat began to vanish after streetlights were installed, because those areas were suddenly filled with day -feeding Pipistrelle bats. Other nocturnal mammals, including (desert rodents, possums, and badgers) forage more cautiously under the permanent “full moon” of light pollution (because they've become easier targets for predators.)

Reptiles

Nesting sea turtles, which show a natural predisposition for dark beaches, find fewer and fewer of them to nest on. Frogs and toads living near brightly lit highways also suffer because nocturnal light levels are a million times brighter than normal, throwing nearly every aspect of their behaviour out of joint.

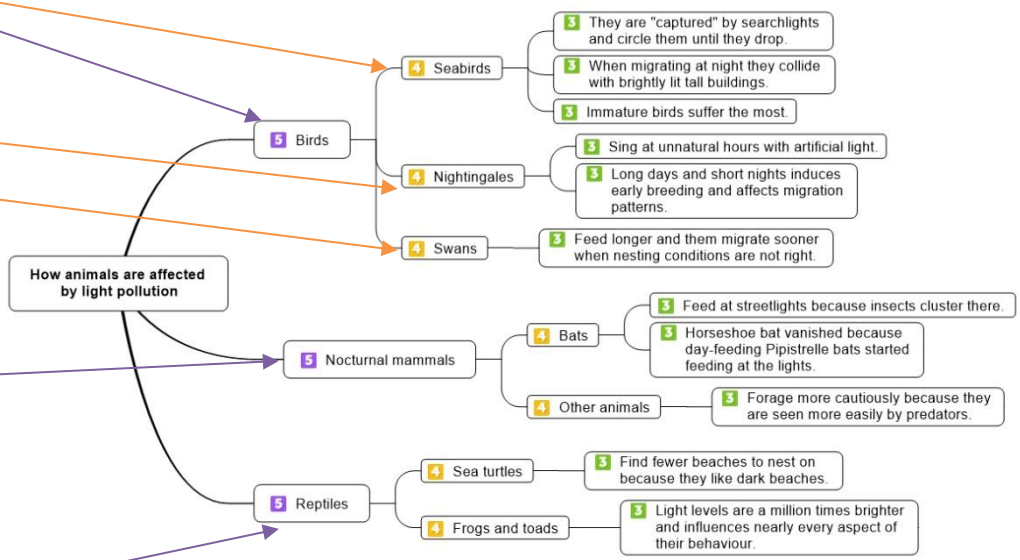


Figure 4-2 Demonstration of selection assessment - memorandum

Birds

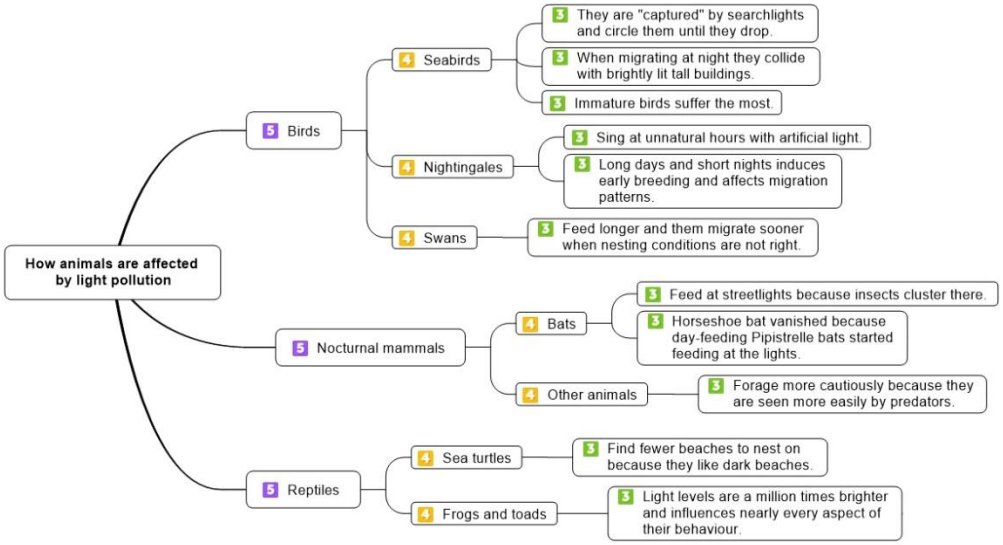
1. Light is a powerful force, and on many species it acts as a magnet. This process is being studied by researchers Travis Longcore and Catherine Rich, co-founders of the Los Angeles-based Urban Wildlands Group. The effect of light is so powerful that scientists speak of seabirds being "captured" by searchlights on land circling and circling in the thousands until they drop. Birds are also apt to collide with brightly lit tall buildings because they migrate at night, immature birds on their first journey suffer the most.
2. Some birds like nightingales sing at unnatural hours in the presence of artificial light. Scientists have determined that long artificial days—and artificially short nights—induce early breeding in these birds. And because a longer day allows for longer feeding, it can also affect migration schedules. One population of swans, wintering in England put on fat more rapidly than usual, priming them to begin migration early. The problem, of course, is that migration, like most other aspects of bird behaviour, is a precisely timed biological behaviour. Leaving early may mean arriving too soon for nesting conditions to be right.

Nocturnal mammals

3. Insects have the tendency to cluster around streetlights, and feeding at those insect clusters is now ingrained in the lives of many bat species. In Sweden the Horseshoe bat began to vanish after streetlights were installed, because those areas were suddenly filled with day -feeding Pipistrelle bats. Other nocturnal mammals, including desert rodents, possums, and badgers forage more cautiously under the permanent “full moon” of light pollution because they've become easier targets for predators.

Reptiles

4. Nesting sea turtles, which show a natural predisposition for dark beaches, find fewer and fewer of them to nest on. Frogs and toads living near brightly lit highways also suffer because nocturnal light levels are a million times brighter than normal, throwing nearly every aspect of their behaviour out of joint.



Example of marking P17

Level 1: 0/3 = 0%

Level 2: 4/7 = 71%

Level 3: 8/11= 73%

Figure 4-3 Demonstration of selection marking - participant example

As is indicated in Figures 4-2 and 4-3, participants could score a maximum of 3 marks on Level 1 as there are 3 chunks of relevant information on Level 1. Similarly, participants could score a maximum of 7 marks for Level 2 and a maximum of 11 marks for Level 3. A maximum of 21 marks could therefore be obtained for the selection of relevant information. This mark was then converted to a percentage mark. The total scores and percentages are presented in Table 4-7:

Selection data scores							
	Level1	**%**	**Level2**	**%**	**Level3**	**%**	**Total %**
P2	0	0	1	14	3	27	19
P4	0	0	1	14	6	55	33
P5	3	100	4	57	7	64	67
P8	0	0	1	14	1	9	10
P9	0	0	1	14	2	18	14
P10	0	0	5	71	8	73	62
P11	0	0	1	14	9	82	48
P12	0	0	0	0	7	64	33
P13	3	100	0	0	6	55	43
P14	0	0	2	29	9	82	52
P15	0	0	5	71	6	55	52
P16	0	0	2	29	6	55	38
P17	0	0	5	71	8	73	62

Table 4-7 Selection data scores

In order to answer sub-question b, a correlation analysis was performed on selection scores and summary map scores. A practically significant correlation can be seen between *Total selection score* and *Summary map score (r = 0.682; p-value = 0.022).* More specifically, a practically significant correlation can be seen between *percentage of 3rd level information selected* and *Summary map score (r = 0.645; p-value = 0.017).* No visible correlation could be reported on other levels. The line graph (Figure 4-4) clearly indicates an emerging pattern when total scores are compared.

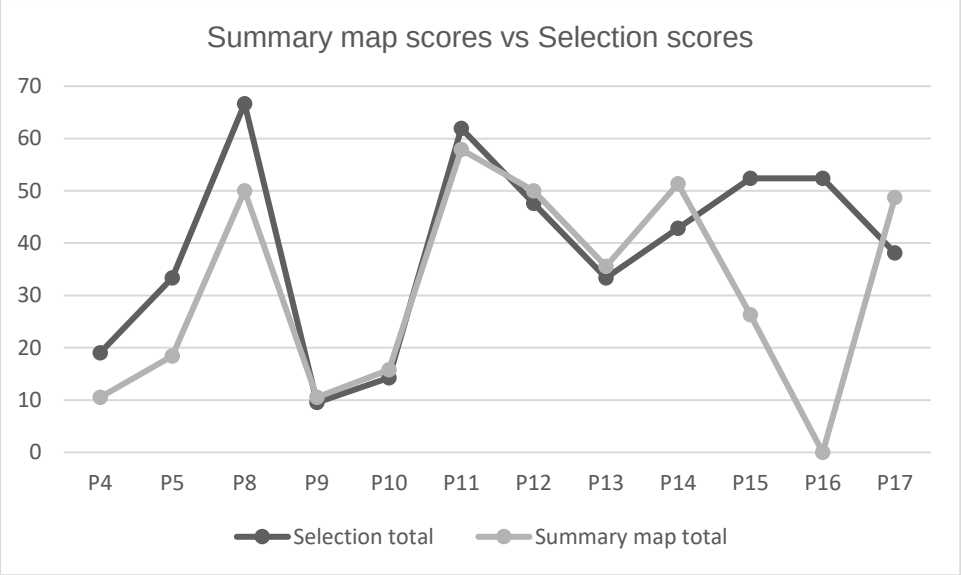


Figure 4-4 Summary map score vs Selection scores

The correlation between percentage of selected information and summary map score indicates that the selection of relevant information in the text and specifically detailed information (typically more detailed than would be considered 1st and 2nd level information), seems to be an integral step in the process of summary map drawing for this study. Not being able to successfully complete this step (not being able to identify important information), in other words, not being able to differentiate between essential and non-essential information, seems to be a potential challenge for participants.

As stated in Section 1.1, one of the unique characteristics of summary mapping when compared to other mapping techniques is that a summary map is in essence a summary of a text. Even though the final output will be different from that of a written summary, the initial step of reading will be similar for both summary mapping and summary writing. For this reason, it is considered closely related to summary writing. Taylor (1984) mentions that summary writing skills are notoriously difficult to develop for all students but especially for second and foreign language students because it requires the ability to identify the meaningful propositions in a text and to restate them in a succinct and coherent manner. Moreover, some propositions are more important than others, so students are asked to identify important and less important/unimportant ideas (Taylor, 1984). This notion seems to ring true for participants in this study as well. It is evident that participants were not able to determine adequately what the most important information in the text was and this could have been influenced by a lack of deeper level comprehension.

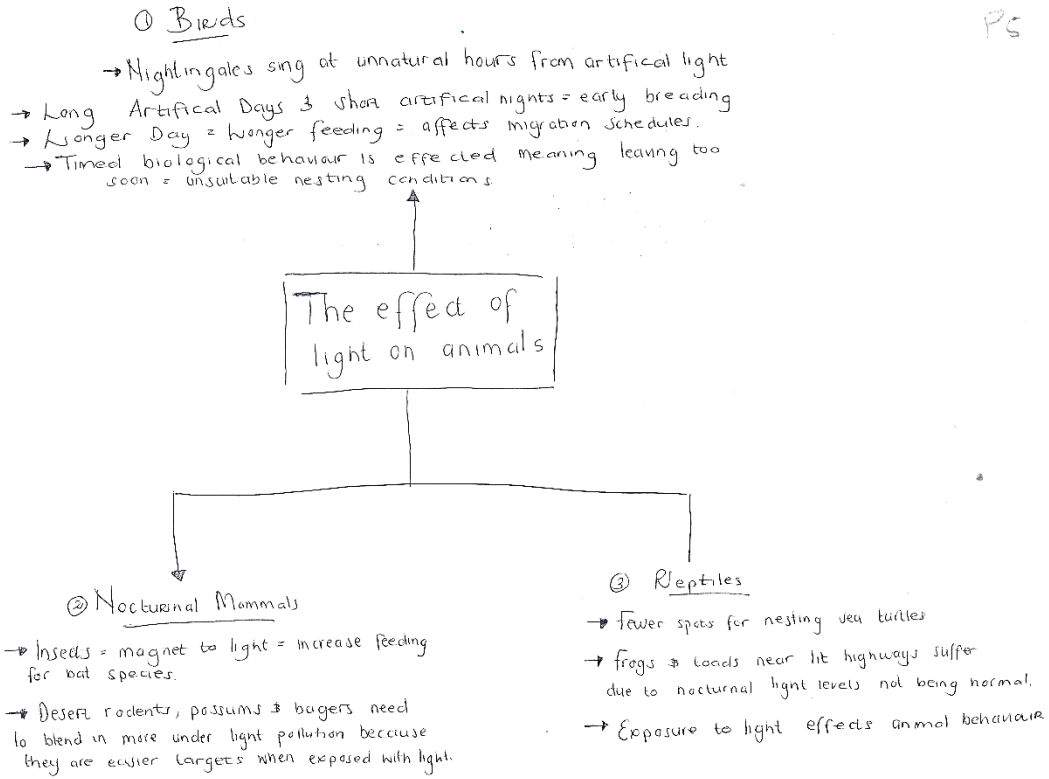
4.5. Sub-question 3 – Organising information (ability to present information diagrammatically)

As mentioned earlier, in order to find possible difficulties participants may encounter when drawing summary maps, the different steps involved in mapping was investigated in isolation. The final step in the process, the categorisation of information and actual representation of the map is addressed in the third sub-question. Categorisation of information is less straight forward to measure since the SMART scoring system was designed to score both content and structure as they are equally relevant to mapping ability. However, when only the structure of the maps is taken into consideration, the following observations are made: All participants started in the centre of the page with the central theme and branched out from there. Of the 13 participants, only 5 participants categorised the information into two or more levels of information in their maps. Four of these participants were overall high scorers. This is very relevant as it correlates with the finding stated in the previous section about selection of information, namely that participants in this study experience difficulty with identifying higher level organising ideas in the used text. They seem to be better at identifying detailed information, but the higher order categorisation ability is lacking. This observation is not unique, since studies that focus on higher education like Barletta *et al*. (2005) and Yáñez Botello (2013) indicate that, with reference to reading comprehension, students read at a basic level that does not surpass literal understanding. They are often not able to make inferences and have trouble recognising the macrostructure of a text. This observation echoes the identified challenge participants seemed to face in the current study. Recognition of macrostructure of the text and, in this case, the subsequent categorisation of the information contained therein is problematic.

It is furthermore worthwhile to point out that despite similar scores for summary mapping by P05 and P11 (both content and categorisation being taken into account), P05 demonstrated a superior ability to organise information into a logical structure. See Figure 4-5 for comparison.

Participant 5

Participant 11



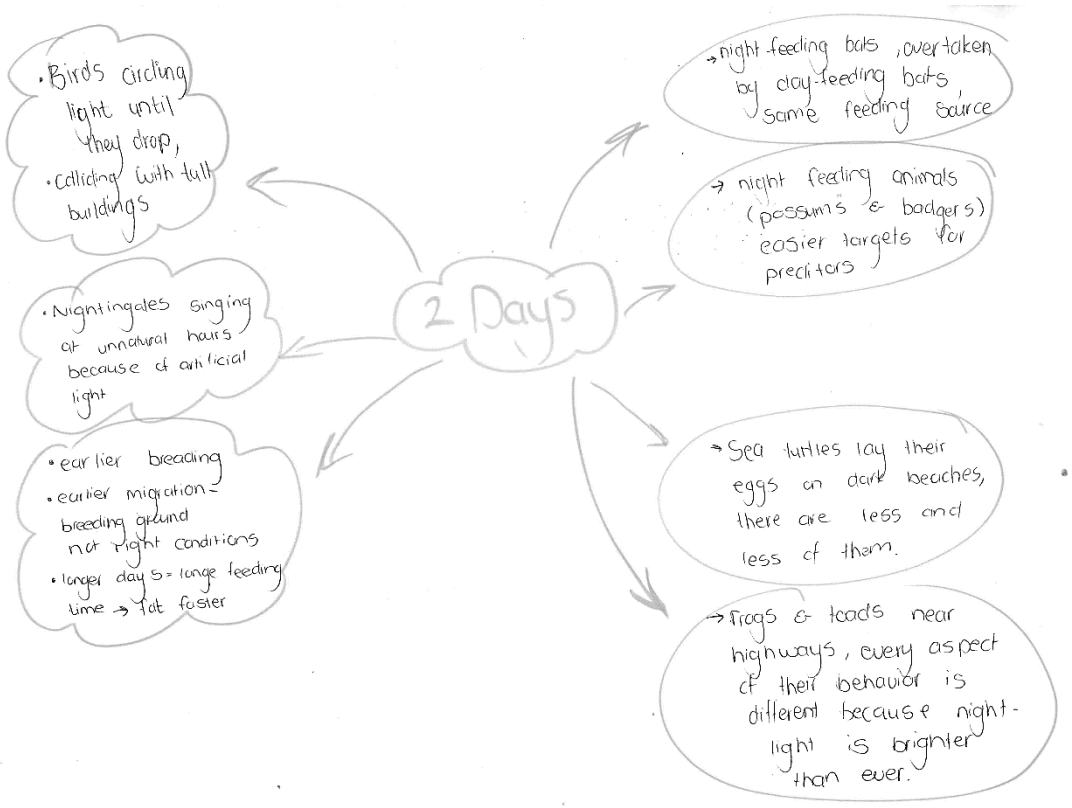


Figure 4-5 Summary maps completed by Participants 5 and 11

This corresponds to what Dogusoy-Taylan and Cagiltay (2014) observed in their study in terms of cross-linking. They state that the higher quality maps produced by their expert participants were due to increased understanding of organisational strategies used to display knowledge effectively. They furthermore observed that novices did not seem to have a strategy or embrace a plan before starting the act of mapping but rather "tended to write information as it came to mind in a stream of consciousness manner" (Dogusoy-Taylan and Cagiltay, 2014:90). A comparison of participants' map structures in the current study leads the researcher to believe that participants with higher summary mapping scores had a more holistic, bigger picture approach to the task similar to what Dogusoy-Taylan and Cagiltay (2014) observed in their study. The high scoring participants in the current study seem to have started the act of mapping with a clear idea of where they were going, indicating that they may very well have had a plan before they started. This inference can be made by considering the way the participants used the available space (the A3 page) to produce the summary map. The higher scorers showed a more balanced use of the page. They spread out the information and drew the diagram in such a way that if filled the page. Without considering the content, the diagrams of these participants seem more organised.

These observations indicate that the ability of participants of this study to categorise information logically strongly influences their capacity to draw a logically structured summary map that can ultimately be used for study purposes. Organisational strategies that influence logical representation therefore seem to be an area of difficulty for participants.

As one exception to the observed pattern, P12 differentiated between 2 or more levels of information but did it so illogically that the categorisation of information does not make sense. This participant scored a total of 36% for the summary map. The summary map completed by participant 12 has been included as Figure 4-6.

Figure 4-6 Summary map completed by Participant 12

It is clear that the information presented in the summary map is not structured in any logical way. The almost random placement of words like “Birds” and “wintering” does not convey these ideas in a meaningful or logical way.

In Figure 4-7 the selection scores discussed in Section 4.4 are compared to the effective categorisation of information in the summary map as discussed above. For the multi-level summary map data, a score of 1 indicates that the participant used two or more levels, a score of 0 indicates that only one level was used and a score of 0.5 shows the participant that used more than two levels but did so illogically.

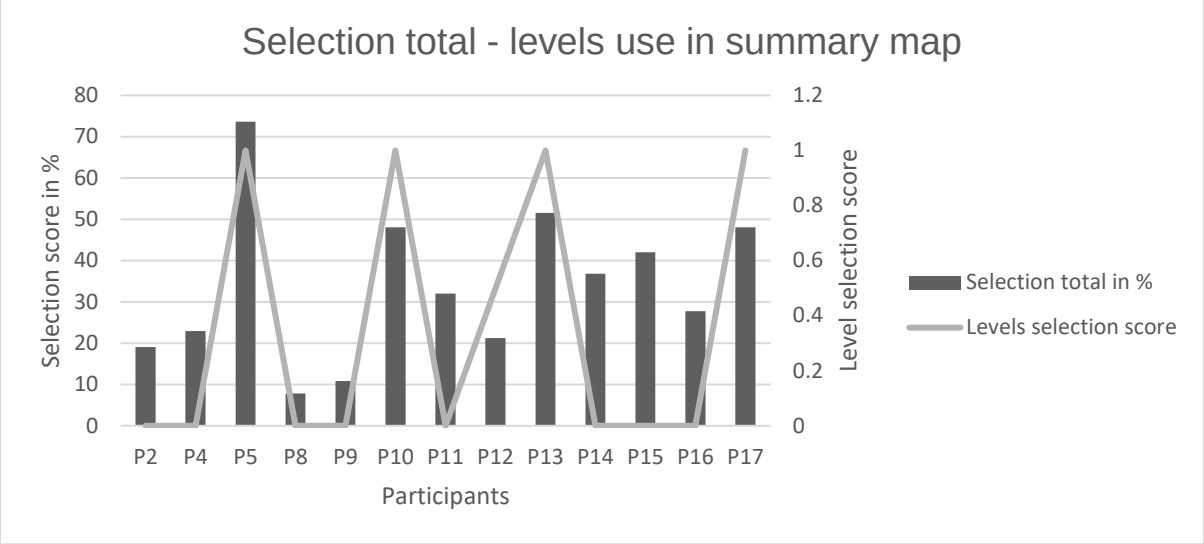


Figure 4-7 Selection totals and levels used in summary map

The chart clearly indicates that there is a relationship between selection scores and the number of levels distinguished in the summary map. In other words, the higher the selection total, the more levels of information were distinguished by participants. This suggests that for the current study, the problem may not necessarily lie with presentation ability *per se*, or not only with that ability, but rather with the ability to fully understand the text and being able to identify the most important information.

As already stated, research about summary mapping very seldomly affords us the opportunity to investigate the process of mapping and only allows for investigation of the product or the completed map. For this study, however, it was possible to scrutinise the process of each participant by making use of a combination of collected data sets. The analysis of eye-tracking measures as well as qualitative analysis of video data collected during the experiment will be used to form a holistic view of the mapping process of each participant.

4.6. The mapping process: general eye-tracking measures

For this study, emerging patterns with regard to the mapping process could be studied by making use of a combination of eye-tracking data and test scores obtained during the experiment. In their study, Dogusoy-Taylan and Cagiltay (2014) utilised three eye-tracking parameters in order to explore the cognitive process of participants during map development. These parameters included fixation count, visit duration and average fixation duration. For the current study, relevant AOIs needed to be determined in order to calculate visit and fixation data. The identified AOIs as well as what they comprise of are included in Table 4-8. The AOI

labels were chosen to represent either a part of the text (the AOIs labelled with a “T”) or a part of the map (the AOIs labelled with a “M”).

AOI Label	What the AOI comprises of
T1	Text paragraph 1
T2	Text paragraph 2
T3	Text paragraph 3
T4	Text paragraph 4
MID	Central main idea of summary map
M1	Concept box in summary map 1
M2	Concept box in summary map 2
M3	Concept box in summary map 3
M4	Concept box in summary map 4
M5	Concept box in summary map 5
M6	Concept box in summary map 6
M7	Concept box in summary map 7

Table 4-8 Selected AOIs and what they comprise of

Figure 4-8 illustrates how the AOIs were set up in the software. The different coloured boxes drawn on the screen represent the different AOIs. The label of each AOI is displayed in the middle of the coloured box. Because the participants could move their heads freely (and thereby move the camera that records what the participant is looking at), the AOIs would not necessarily remain in the same place in the recorded video - the AOI therefore had to be dynamic (adjusted as the participant moved).

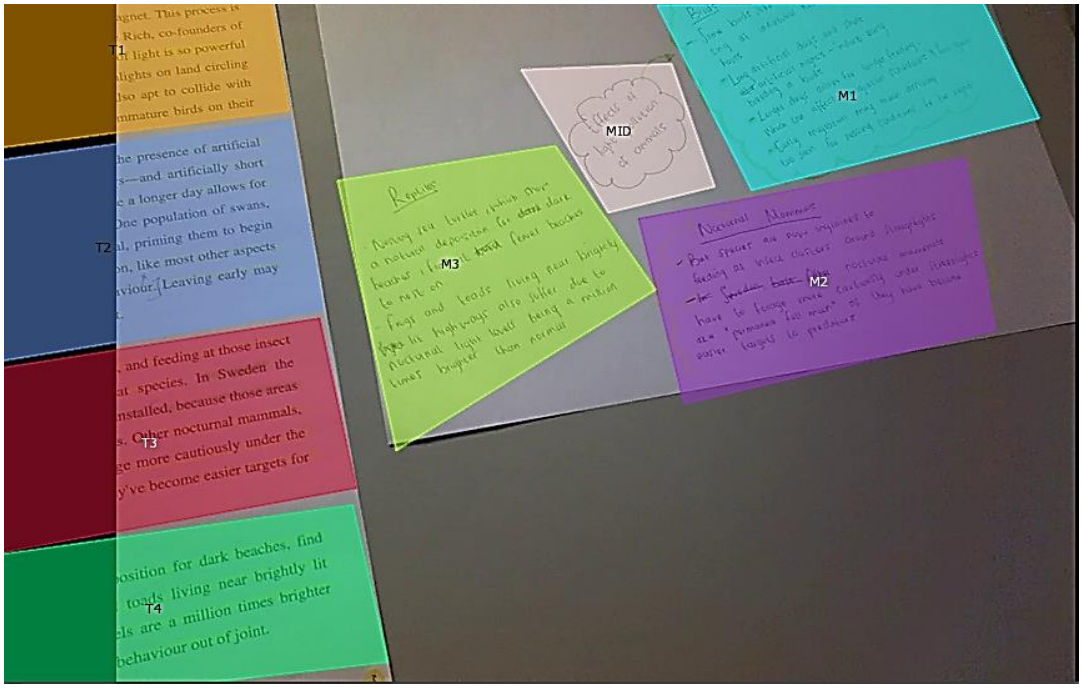


Figure 4-8 Example of AOI selection in the software

In order to determine a more appropriate process of summary mapping that leads to a better structured and more complete summary map, a comparative analysis was done between three groups of participants. The following groups were identified for comparison based on summary map scores:

- Group 1 – High scoring participants;
- Group 2 – Average scoring participants; and
- Group 3 – Low scoring participants.

The scores obtained in the summary map task as well as demonstrated categorisation ability were used in order to identify the three groups of participants, as is shown in Table 4-9:

Group 1 – High scorers	Score in %	Group 2 – Average scorers	Score in %	Group 3 – Low scorers	Score in %
P05	50	P11	50	P15	0
P13	51.3	P16	48.5	P08	10.5
P10	57.8	P14	26.3	P02	10.5
P17	59	P12	35	P09	15.7
		P04	18.4		

Table 4-9 Grouping of participants for comparative analysis

For each group the highlighted participants are considered outliers for different reasons. These reasons will be discussed under each group individually in the sections pertaining to each group. P05 and P11 obtained the same score for their summary maps due to P05 excluding some important information. It is, however, evident from observation that P05 organised information in a much more logical and hierarchical manner (see Figure 4-5 earlier in the chapter for comparison). P11 was therefore placed in the average group whereas P05 is considered a high scorer based on superior organisational ability.

4.6.1. Fixation count

The first eye-tracking measurement that was compared across the three groups is the fixation count in the text and in the summary map respectively for the different groups. Table 4-10 and Figure 4-9 represent the results.

	Group1 High Scorers				Group 2 Average Scorers					Group 3 Low Scorers			
Fixation count - Summary map	1113	1240	2353	481	299	548	1034	321	474	388	362	239	358
Fixation count - Text	1794	1946	3740	2253	2513	1639	2566	2020	1054	388	2250	1054	823

Table 4-10 Comparison of fixation count for summary map and text respectively by group

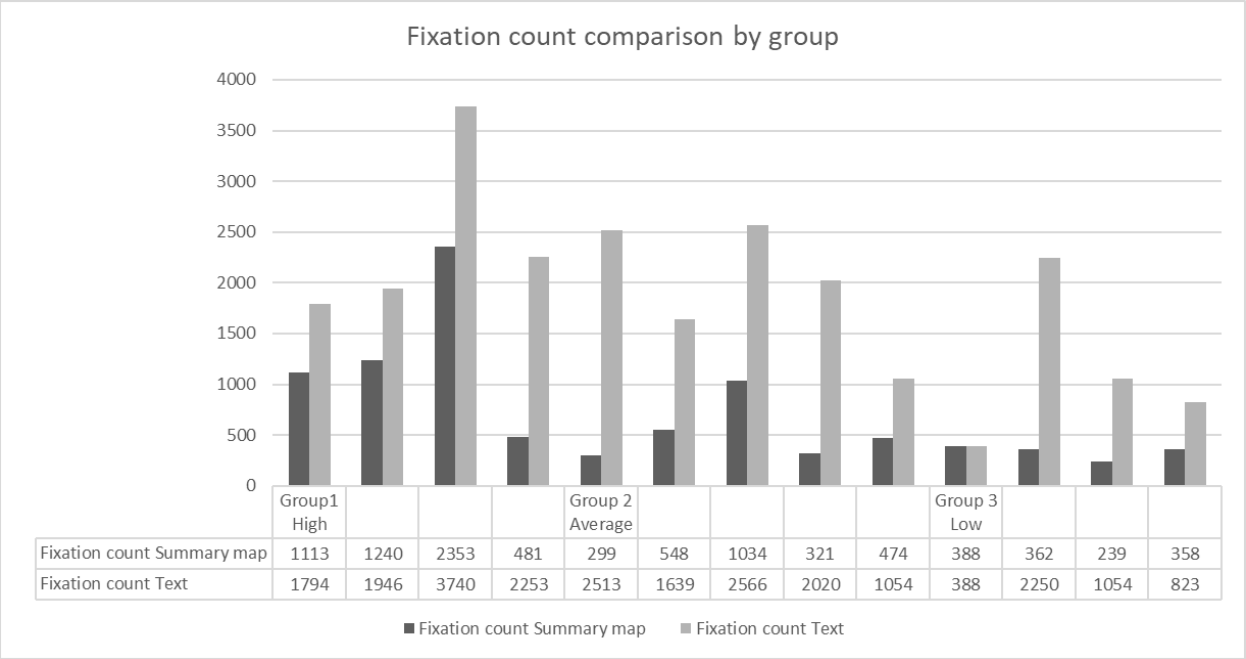


Figure 4-9 Fixation count comparison by group

These results show that the number of fixations differed significantly, not only among summary map and text but also among the groups. A difference in fixation count between the summary map and the text is expected because the text is denser in terms of word count than the summary map. It therefore makes sense that the participants would have more fixations on the text than on the summary map. What is interesting, however, is the differences between groups. The graph below is a representation of the average fixation counts per group. It contains the same information as Figure 4-9, but shows the averages in the groups more clearly.

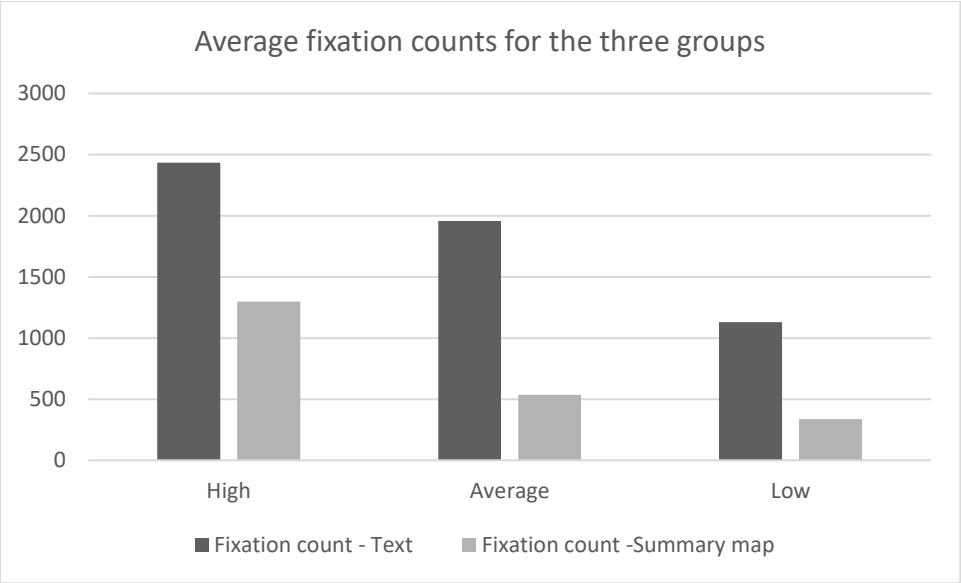


Figure 4-10 Fixation count comparison by group

For the high scorers, fixation count between map and text was more or less proportional and a definite pattern can be seen when referring to Figure 4-9. For Group 2 (the average scorers) the fixation count was much higher on the text than on the summary map. This could indicate a difficulty in processing the text. These participants fixated on the text almost as much as the high scoring group but did not focus on the maps as much and produced summary maps of poorer quality. The low scoring group (Group 3) fixated on the summary map almost as much as the average group, but the text fixation was lower. Average scorers in this study clearly realised that the information they needed was contained in the text but could not manage to extract it in a meaningful way to complete the summary map. The lower scorers focused on the maps in a similar way to average scorers but did not produce maps of similar quality and they did not move back to the text as often to attempt to find the information where it was located.

4.6.2. Average fixation duration

Average fixation duration was the next eye-tracking measurement that was compared for the three groups. Average fixation duration refers to the total duration of all fixations divided by number of fixations in a trial. According to Negi and Mitra (2020:12), “fixation duration can be a useful metric to trace the learning process”. Again, the results are presented by group for the text and the summary map. For this study, these averages were determined for each group and compared. The results for average fixation duration are presented in Table 4-11 and Figure 4-10 below.

	Overall average Group 1 High	Overall average Group 2 Average	Overall average Group 3 Low
Average Fixation Duration for summary maps [ms]	574.3	560.9	514.7
Average Fixation Duration for Text [ms]	233.1	241.3	218.7

Table 4-11 Comparison of average fixation duration for summary map and text respectively for each group

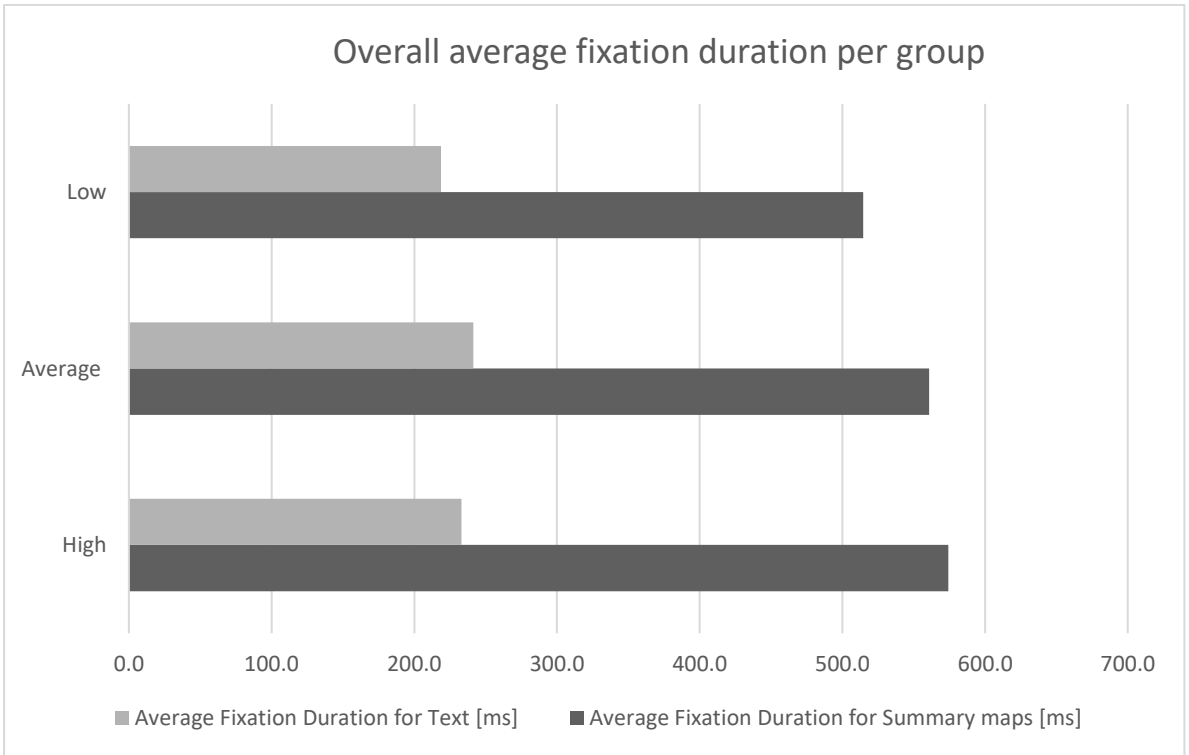


Figure 4-10 Overall average fixation duration for summary map and text respectively for each group

The particularly long fixation duration averages visible for summary mapping is expected since participants would have been writing into their maps during many of these fixations, resulting in a much higher average. The differences between the groups are not significant. The low scoring group had a slightly lower fixation duration average for the summary map than the other two groups that differed even less. In general, research about fixation duration points out that very high fixation duration could be a sign of perceived difficulty or confusion related to a task (Negi & Mitra, 2020). In the current study, little difference is observed and although the low scoring group did have the lowest average fixation duration average, the difference is not significant.

4.6.3. Dwell time/ visit duration

The final eye-tracking parameter that will be discussed is dwell time or visit duration. Again, this was compared by group for both summary maps and texts. Dwell time/visit duration refers to the time spent within an AOI (see Table 3-5 for comparison between eye tracking measures). It starts the moment the AOI is fixated and ends the moment the last fixation on the AOI ends. In other words, it accounts for the sum of durations from all fixations and saccades that took place in the AOI. The dwell time/visit duration results for this study are presented in Table 4-12 and Figure 4-11.

	Group1 High Scorers				Group 2 Average Scorers					Group 3 Low Scorers			
Dwell Time Summary map [ms]	191611.0	191611.0	191611.0	191611.0	50434.5	50434.5	50434.5	50434.5	50434.5	22352.7	44473.1	27723.1	57994.0
Dwell Time Text [ms]	149937.7	149937.7	149937.7	149937.7	111732.2	111732.2	111732.2	111732.2	111732.2	63922.8	47189.9	142568.6	124422.3

Table 4-12 Comparison of dwell time/visit duration for summary map and text respectively for each group

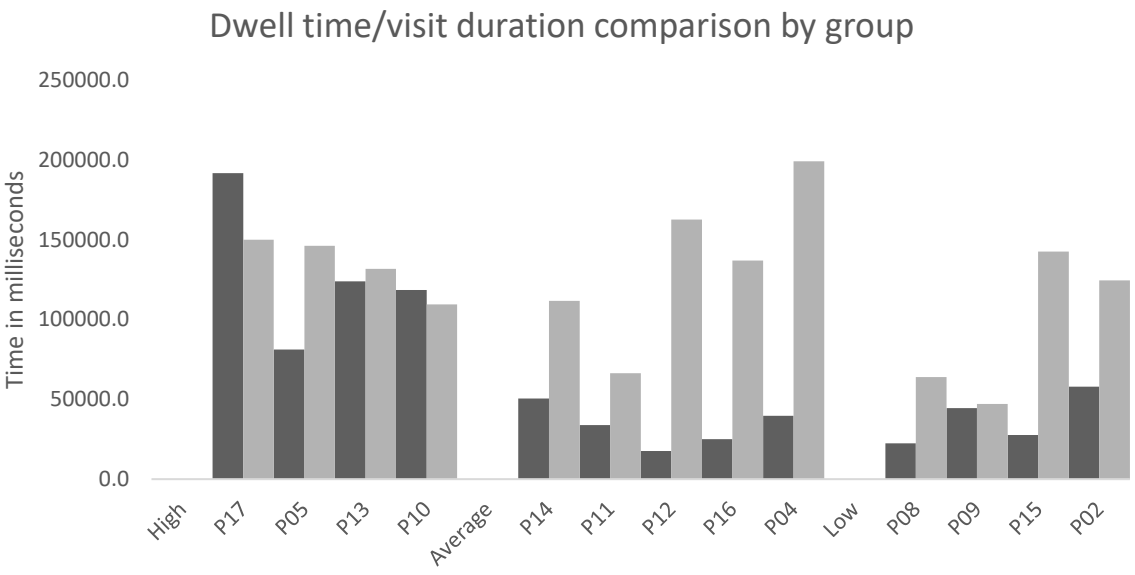


Figure 4-11 Dwell time/visit duration for summary map and text respectively for each group

The results show that the dwell time on summary maps for Group 1 is much higher than for the other two groups. This indicates, in other words, that higher scorers spent more time overall in the AOIs of the map. Groups 2 and 3 spent much more time in the AOIs of the text compared to Group 1. Figure 4-11 below represents the average dwell time per group to ease the comparison.

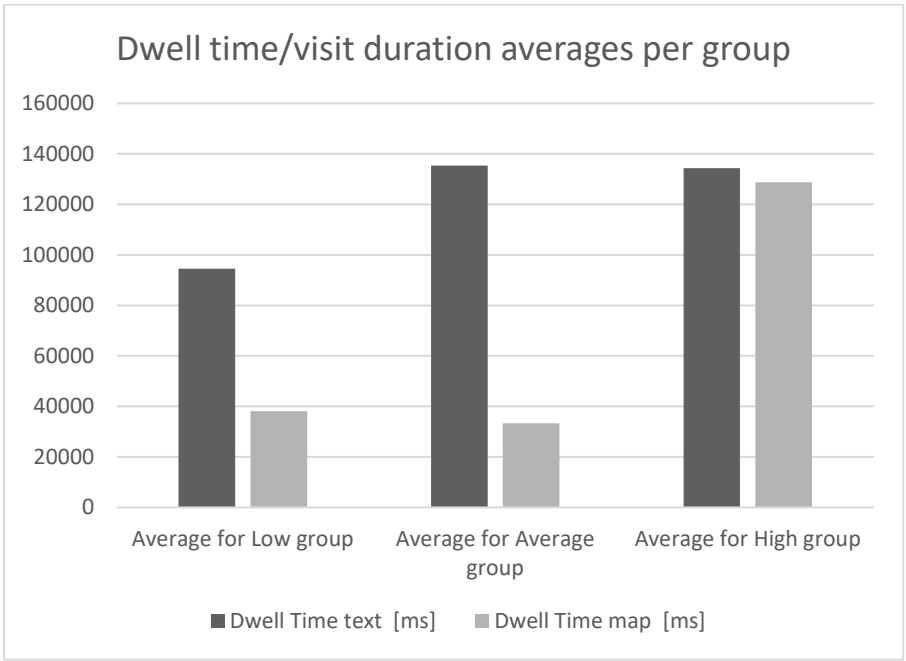


Figure 4-12 Average Dwell time/visit duration for summary map and text per group

This supports the findings discussed comprehensively later in the chapter that refer to the processes followed by the three groups when reading and developing summary maps. These

findings show that high scorers mostly read the text once. They did not reread the text much thereafter (during the mapping part of the task), whereas average and low scorers referred back to the text more often. That could explain the longer dwell times on the maps seen in the high scoring group (Group 1).

Eye-tracking data can be extracted and interpreted in many ways, depending on the specific context and aims of the research. If these results are analysed in isolation, they may leave room for misinterpretation. For the current study, however, these results are considered to be one part of a series of results that, when combined, should provide a more holistic interpretation of the findings. A more qualitative data analysis will therefore be discussed in the following section.

4.7. The mapping process: Observed acts

Dogusoy-Taylan and Cagiltay (2014) furthermore identified what they call “frequently observed acts” and compared the above-mentioned eye-tracking parameters (fixation count, average fixation duration, and dwell time/gaze time) for the observed acts. For the current study the observed acts can be defined as listed in Table 4-13:

Observed acts	Definition
Reasoning	Instances where participants fixate for longer than 500ms on any area that was not identified as an area of interest.
Comprehensive reading	Engaging optimally with the text, reading for full understanding.
Rereading	Reading a section of text that has been read critically before.
Constructing concept boxes	Drawing a bounding box for a concept.
Writing into concept boxes	Writing content into a concept box or area that is considered a concept box.
Writing notes	Writing notes in the text.
Referring and writing into concept boxes	Writing while constantly referring back to the text. Constantly jumping between text and concept box.
Checking	Running the eyes quickly over certain sections.
Fixing mistakes	Revising or erasing and rewriting concepts.

Linking	Drawing linking arrows or lines between concepts or boxes.
Selecting information	Underlining or highlighting important words or sections of texts.
Selecting while reading	Underlining or highlighting important words or sections of text while reading the text, switching frequently between the two.

Table 4-13 Frequently observed acts and definitions as defined for the current study

In the following section only the observed act of reasoning will be discussed since eye-tracking measures were used to analyse this act. The other observed acts will be discussed in section 4.7.2 where the process of summary mapping is investigated in detail using a more qualitative approach.

4.7.1. Reasoning

For the act of reasoning, eye-tracking metrics and statistical observations were used for analysis. Dogusoy-Taylan and Cagiltay (2014:86) define reasoning as: "A thinking process that usually continues into another act, like constructing a new concept, writing about a concept or relationship, constructing a cross link, or adding/deleting something; easily observed during eye tracking". For this study, reasoning was not considered to be easily observable, therefore eye-tracking parameters were used to analyse the act of reasoning by isolating the fixations that lasted longer than 500ms and fell outside the identified areas of interest, in other words, that did not form part of either the paragraphs of text or the content boxes in the summary map. This specific measure was used because fixations longer than 500ms can be indicative of especially language processing and information processing (Glöckner *et al*. 2011, Rayner, 1998). Furthermore, only fixations that fell outside the defined AOIs were used, as fixations falling within the different AOIs could be defined differently (reading/checking/writing). A typical example of such a fixation is shown in the screenshot in Figure 4-13. The screenshot was taken from the SMI BeGaze software and shows a fixation (the circle or dot) of a certain size. The larger the circle, the longer the fixation. In Figure 4-13 the dot numbered 1373 above the board is the referred to fixation. The size of the fixation becomes bigger, the longer the fixation lasts. It is clear that this fixation falls outside of the general areas of interest (i.e., the text and summary map) and is long enough to be indicative of processing. After ensuring that these instances could indeed be defined as reasoning (instances where fixations were longer than 500ms, fell outside the set AOIs and were not part of an irrelevant act like picking up a pencil) by reviewing the video footage, an average fixation duration for reasoning could be determined.

Figure 4-13 Long fixation falling outside of the set AOIs

An average fixation duration for the act of reasoning could therefore be identified and compared to the summary map scores. The comparison is illustrated in Figure 4-14 and Table 4-14:

Participant	Summary map score Total %	Average fixation duration (ms)
P15	0	1300
P2	10.53	1210
P8	10.53	880
P9	15.79	980
P4	18.42	1210
P14	26.32	1050
P12	35.53	1490
P16	48.68	1590
P11	50	790
P5	50	1020
P13	51.32	900
P10	57.89	1050
P17	59.21	1100

Table 4-14 Average fixation duration vs summary map scores

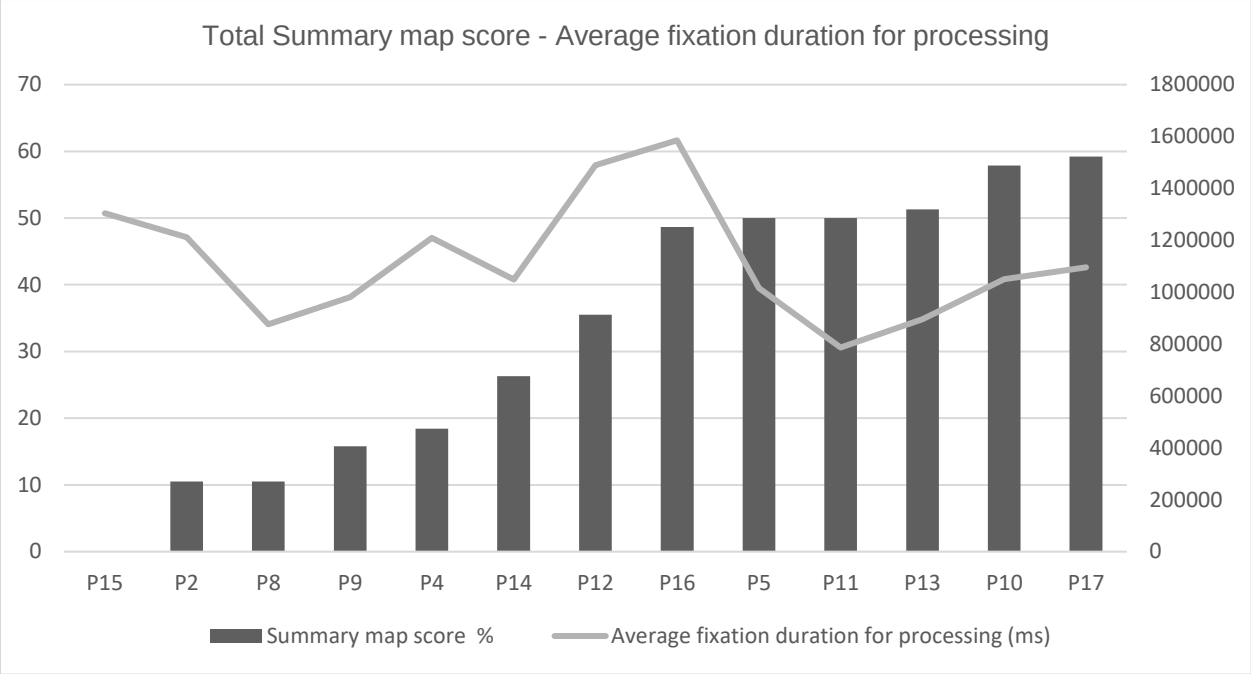


Figure 4-14 Average fixation duration for reasoning vs Summary map score

When analysed statistically, a very slight negative correlation can be seen between *Average fixation duration* for reasoning and *Summary map score (r = -0.18; p-value = 0.552).* When these values in Figure 4-13 are considered, the observed trend seems to be a general increase in average fixation duration for the participants scoring 50% or lower for the summary map. Conversely a sharp decline and overall lower average fixation duration can be seen for participants scoring higher than 50% for summary maps. For this study, it seems as though participants who passed the summary map task spent less time reasoning than students who did not. This may indicate difficulty with the task at hand, as Holmqvist (2011:382) indicates: "A longer fixation duration is often associated with a deeper and more effortful cognitive processing". In other words, students who clearly struggled with the summary map spent more time processing and reasoning about the information at hand. Contrary to this, though, Dogusoy-Taylan and Cagiltay (2014:86) found in their study that for reasoning, experts' fixation periods were fairly longer than that of novices. Their conclusion in this regard is that experts could be considered slower thinkers because their main focus is on understanding a problem instead of trying to solve it. However, none of the participants in the current study can be considered experts, even though the students have undergone training in summary mapping. They do not have the same amount of experience that expert participants in the Dogusoy-Taylan and Cagiltay (2014) study had. Schau and Mattern (1997) state that it is cognitively demanding for a student to create a map. Therefore, based on the summary map scores, it would be fair to conclude that, the longer average fixation times for reasoning seem

to be attributed to more intense cognitive processing rather than superior ability for the current study.

4.7.2. The sequence of observed acts – Qualitative analysis

In the Dogusoy-Taylan and Cagiltay (2014) study, observed acts were analysed by measuring the frequency of acts performed during four stages of summary mapping. In their study: “Four periods were identified while considering progress as a basis for analysis. While determining these four periods of CM development (beginning, early-mid, late-mid, and final), the researchers set a percentage of constructed concepts as the basis for analysis instead of length of time, since the periods were extremely different based on the individual” (Dogusoy-Taylan & Cagiltay, 2014:85). A schematic representation of the periods has been included in Figure 4-15.

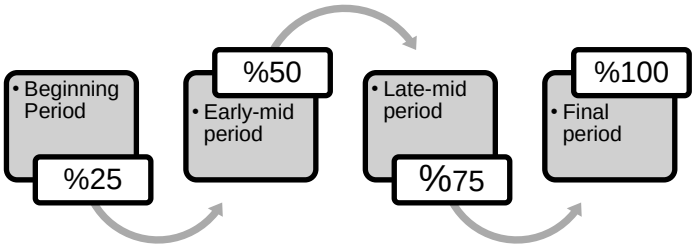


Figure 4-15 Four periods of progress analysis as used by Dogusoy-Taylan and Cagiltay (2014:85)

For the current study, the frequently observed acts (other than reasoning) were analysed by coding each video using ATLAS.ti as explained in Section 3.6. Thereafter sequence diagrams could be drawn for each participant illustrating the sequence of acts performed.

The processes followed by the three groups of participants (high scorers, average scorers and low scorers) to draw an appropriate summary map were analysed by considering two representations of the data. Firstly it was determined how often (counting instances of codes) the groups engaged in different acts. This provided an overall view of the acts and the number of times the participants engaged in these acts over the three groups, but it did not show individual processes in sequence. Secondly the sequence diagrams that portrayed the entire process were investigating which gave an individual account of each participant. Specific attention was given to analysing the two parts of the task separately – firstly reading the text and selecting relevant information, and secondly drawing the summary map.

Figure 4-16 below shows the holistic view of the experiment by indicating the frequency of observed acts per group.

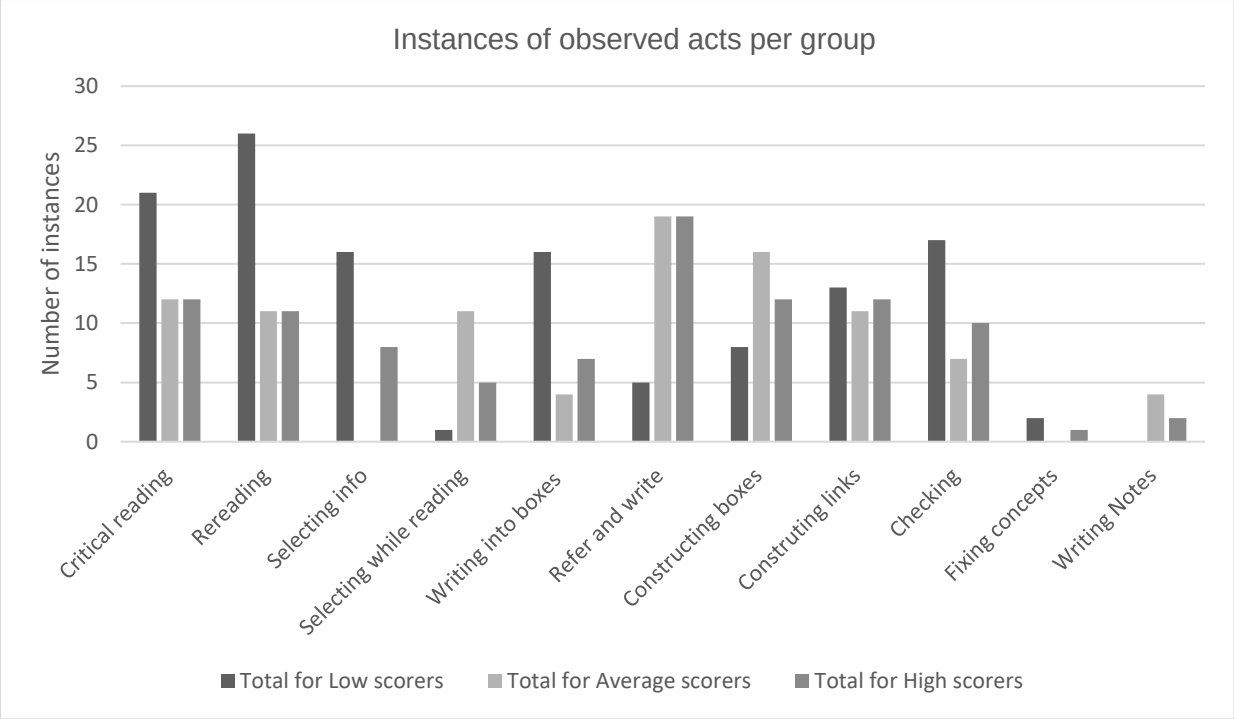


Figure 4-16 Observed acts per group

The most observable difference between the groups visible in this holistic analysis of the number of instances is the high number of reading instances (both comprehensive and rereading) of the low scoring group (Group 3) as compared to the other two groups (Groups 1 and 2). This finding seems to be contradicting the eye tracking data that indicated a higher text fixation count for the higher scoring group (Group 1), but this is not necessarily the case. The qualitative data speaks to the process followed whereas the eye tracking data counts fixations in areas regardless of the specific actions that they performed or the sequence of the acts. In other words, even though the high scoring group had the highest number of fixations on the text this could simply point to how engaged they were with the text and is compared to the fixation counts of the other groups. Actions such as “text selection” and “selecting while reading” would also manifest as text fixations but does not speak to the action being performed at that point. If would therefore be difficult to reconcile the two sets of data in such a way as to compare observed instances of reading and fixation counts within a text.

It is clear that the predominant action performed by the low scoring group was reading. This could indicate difficulty in understanding or analysing the text as they felt the need to perform this action many times. What supports this inference is the high number of instances for checking by the low scoring group as compared to the other groups. It is, therefore, clear that Group 3 participants felt the need to check the text and summary map more often and were not very sure of what they were doing. Furthermore, in terms of writing information into the boxes, it is evident that the low scorers needed to approach the steps in isolation. They reread

the text and then wrote information, after which they returned to rereading again, whereas the average and high scorers could refer to the text and write in one integrated action, indicating that they had internalised the information and did not struggle as much with the text. The same inference can be made when analysing the selection acts. Group 3 (the low scorers) read the text first and then proceeded to select the information whereas Group 2 made use of a different technique where they seemed to read and select simultaneously, switching quickly between these two acts. Group 1 used both “selecting” and “selecting while reading” acts. Furthermore, Group 3 did not write any notes. This again speaks to the superior ability to read in an active manner for comprehension demonstrated by Groups 1 and 2. The summary maps and sequence diagrams of the three groups will be provided and discussed in the following 3 sections.

4.7.2.1. Summary mapping process employed by Group 1 – High scorers

The summary maps of participants 5,10 and 13 are included in Figures 4-17 to 4-19. From a visual analysis of the summary maps, it is evident that the high scorers were, as discussed in Section 4.5, able to categorise the information in a logical and hierarchical manner, clearly differentiating between first and further levels of information. This is observable by looking at the three animal categories (birds, reptiles and nocturnal mammals) that are clearly differentiated in each summary map, as well as the further inclusion of relevant summarised information spreading out from this first level categorisation.

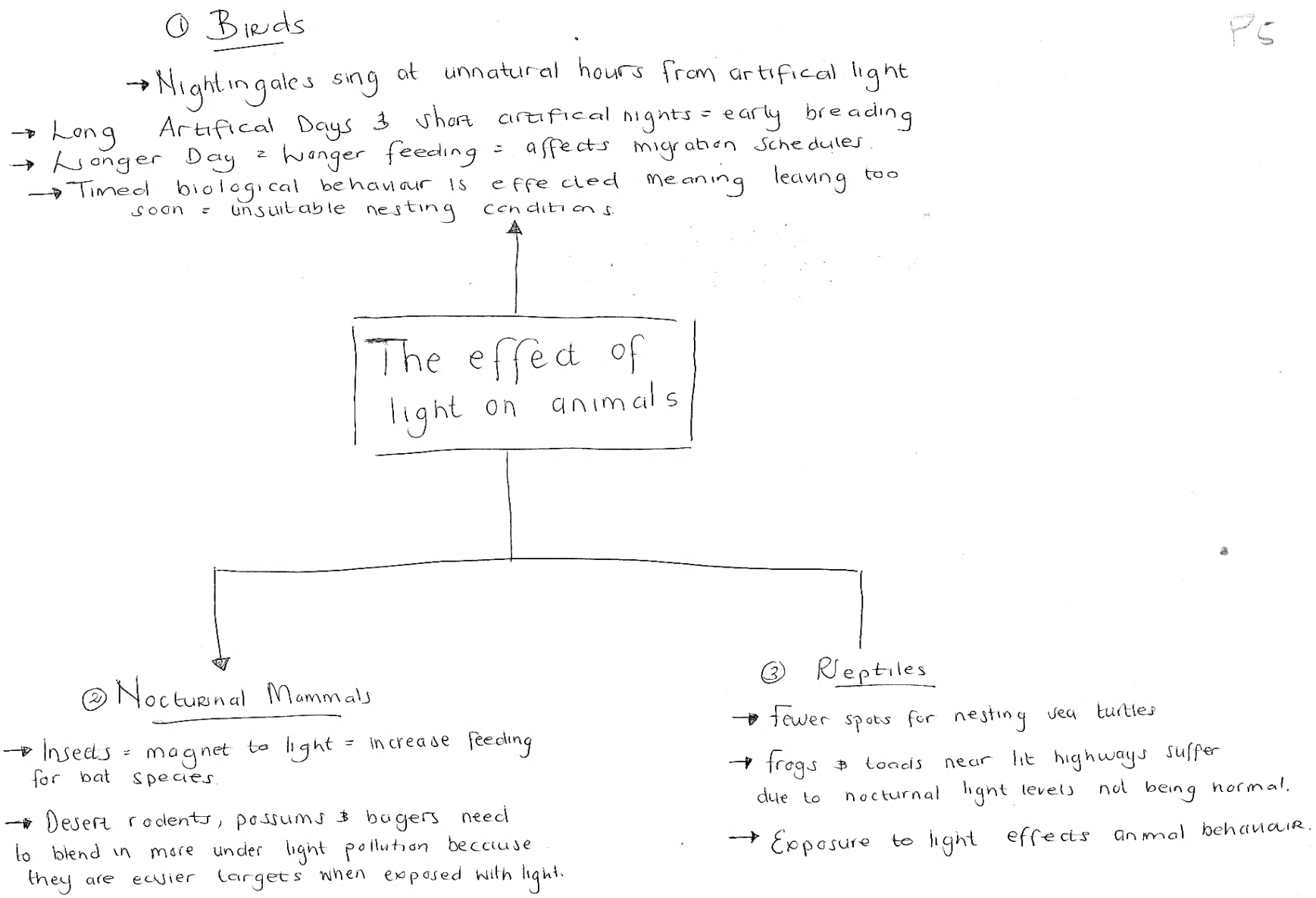


Figure 4-17 Participant 5 Summary map

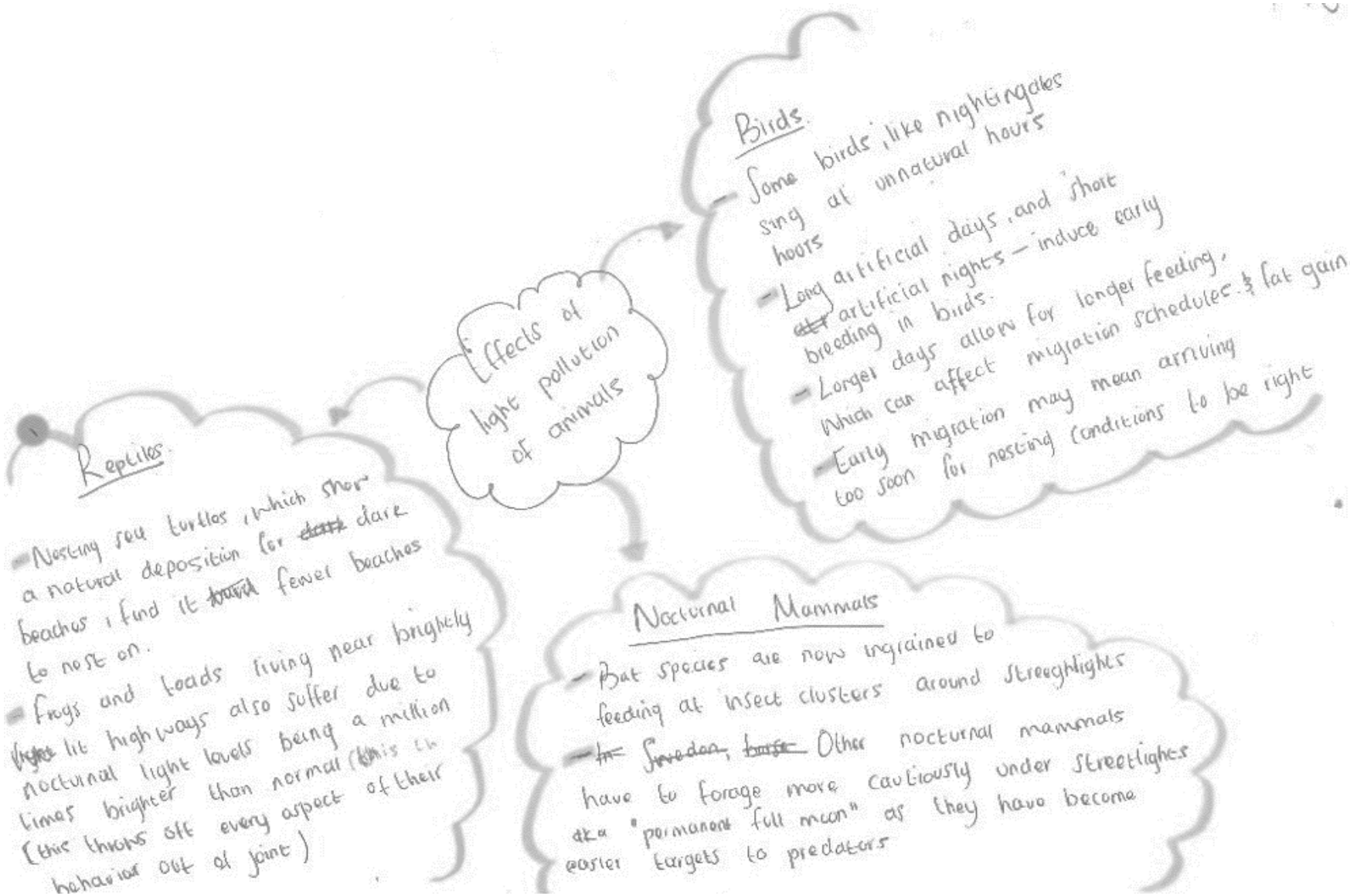


Figure 4-18 Participant 10 Summary map

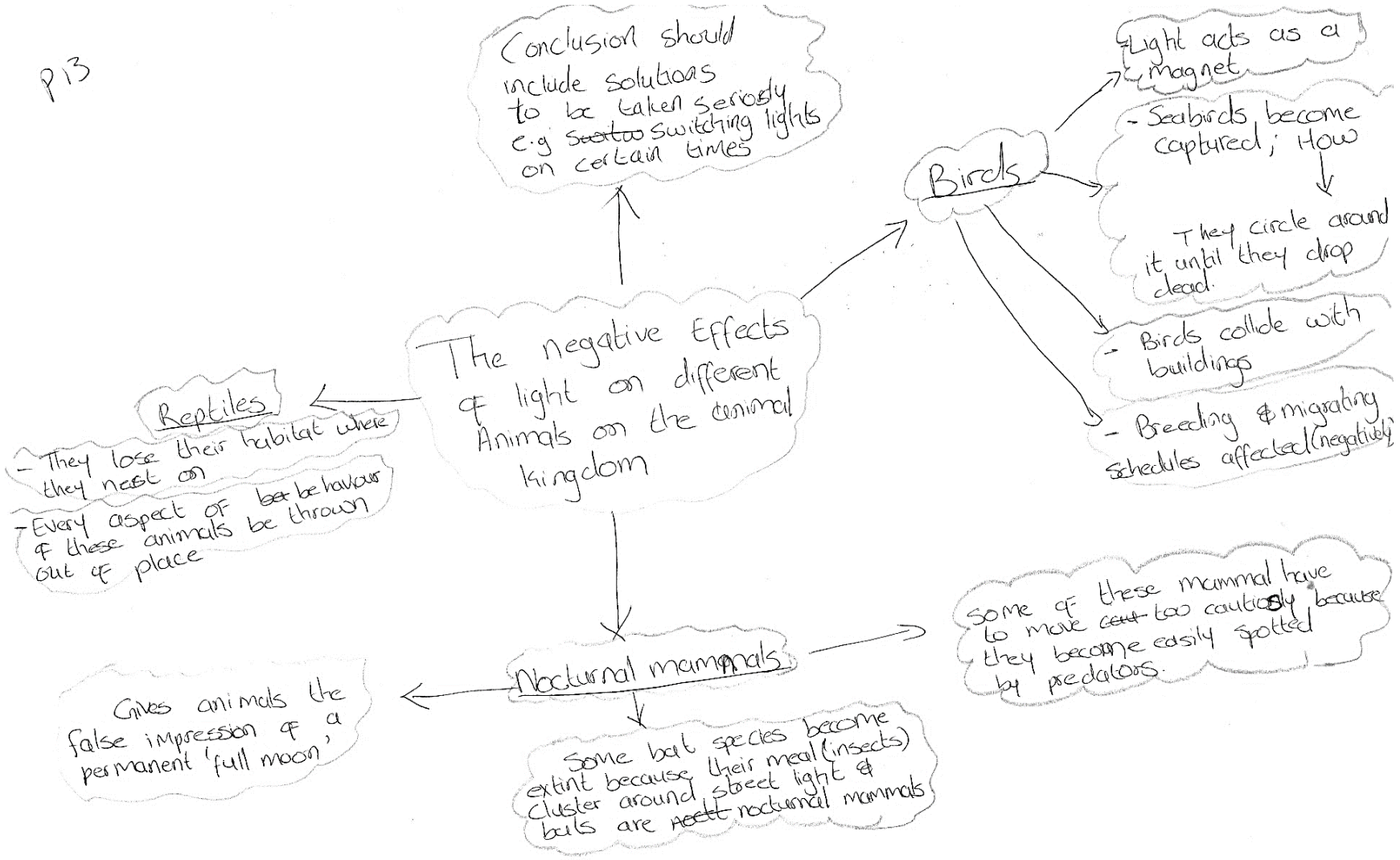


Figure 4-19 - 13 Summary map

The sequence diagrams of participants 5,10 and 13 are included as Figures 4-20 to 4-22 and illustrate how participants moved between frequently observed acts that are indicated in the “columns” at the top of each diagram. Each step they took is indicated by a number and arrow pointing to the next act.

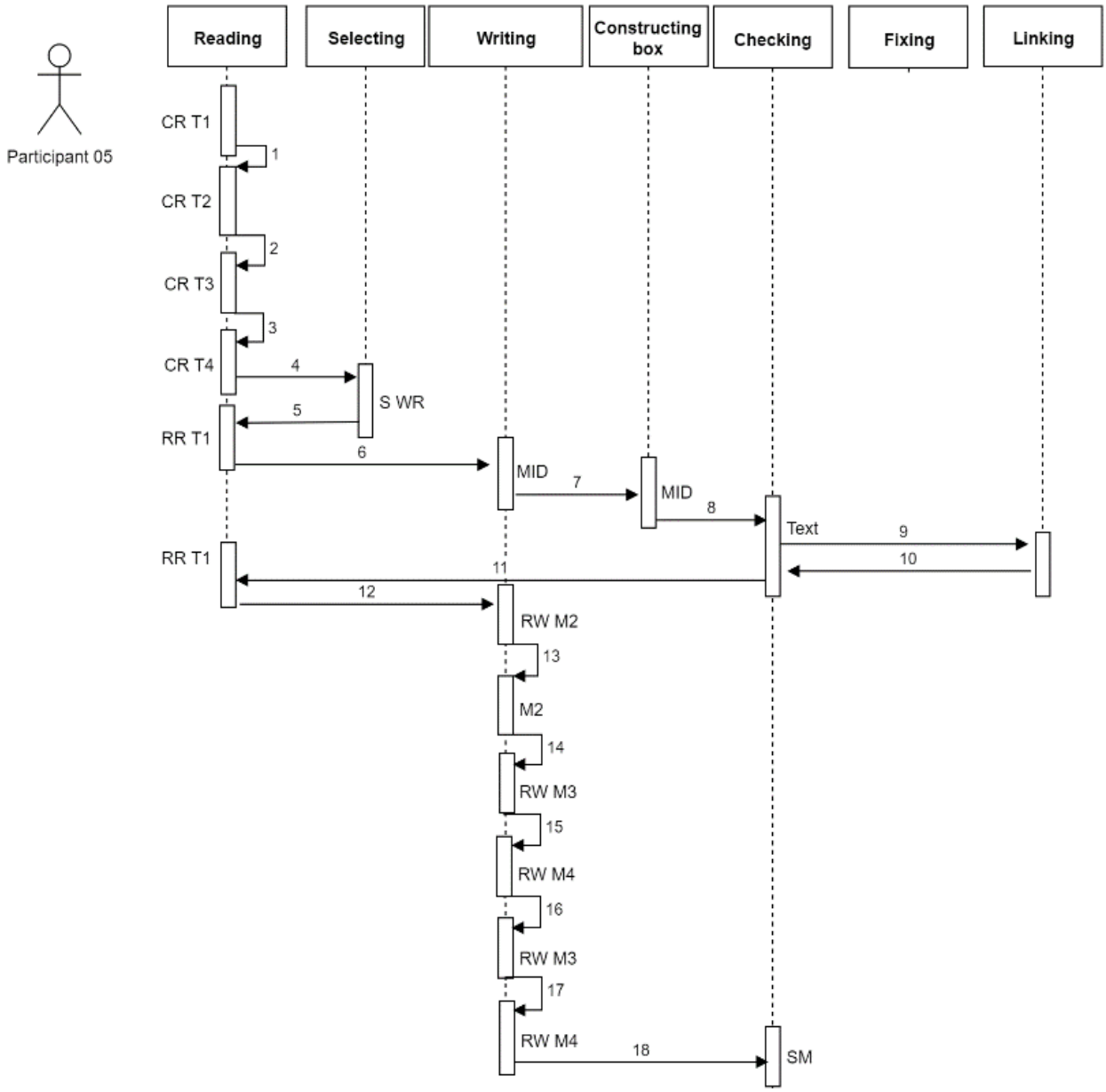


Figure 4-20 Participant 5 Sequence diagram

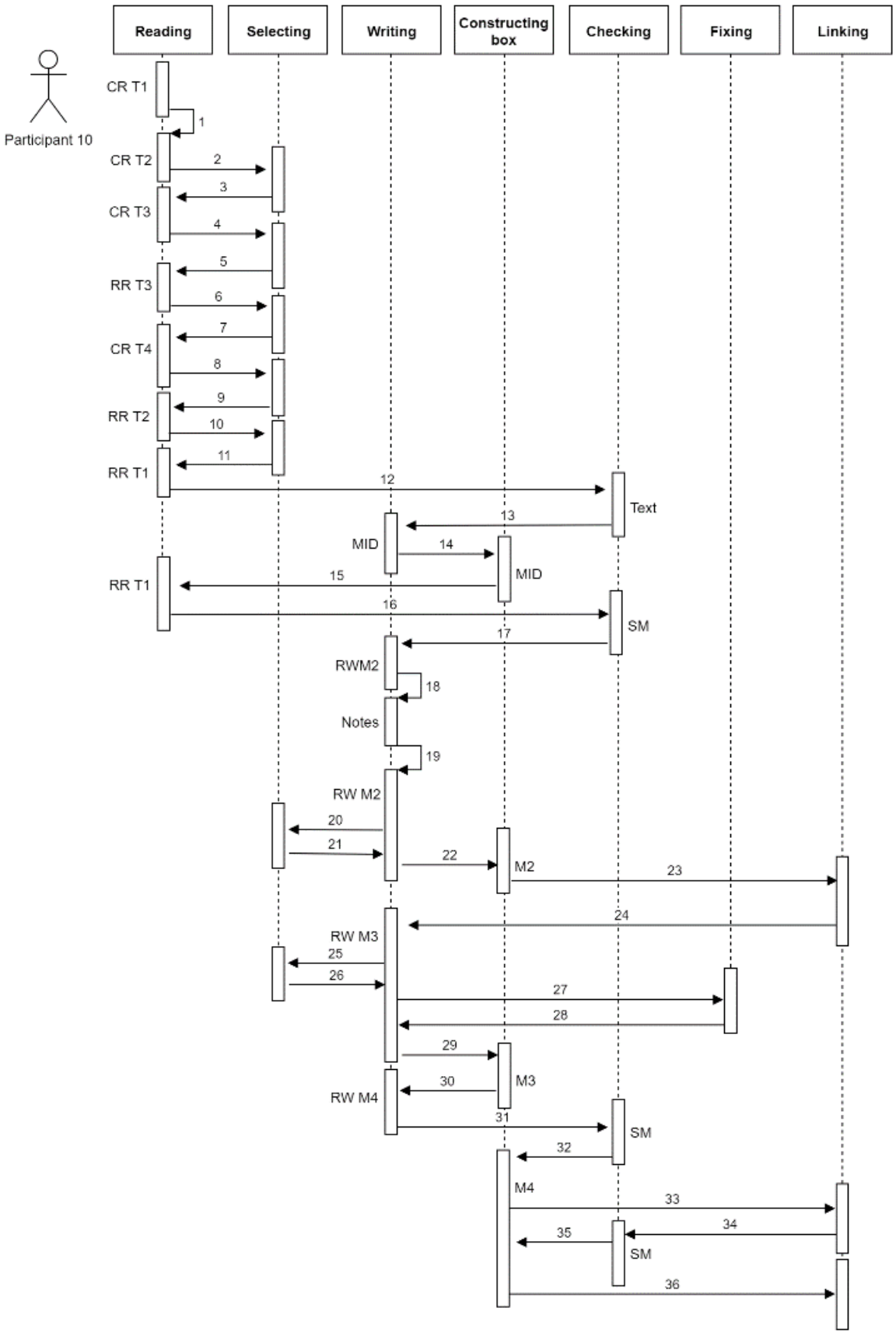


Figure 4-21 Participant 10 Sequence diagram

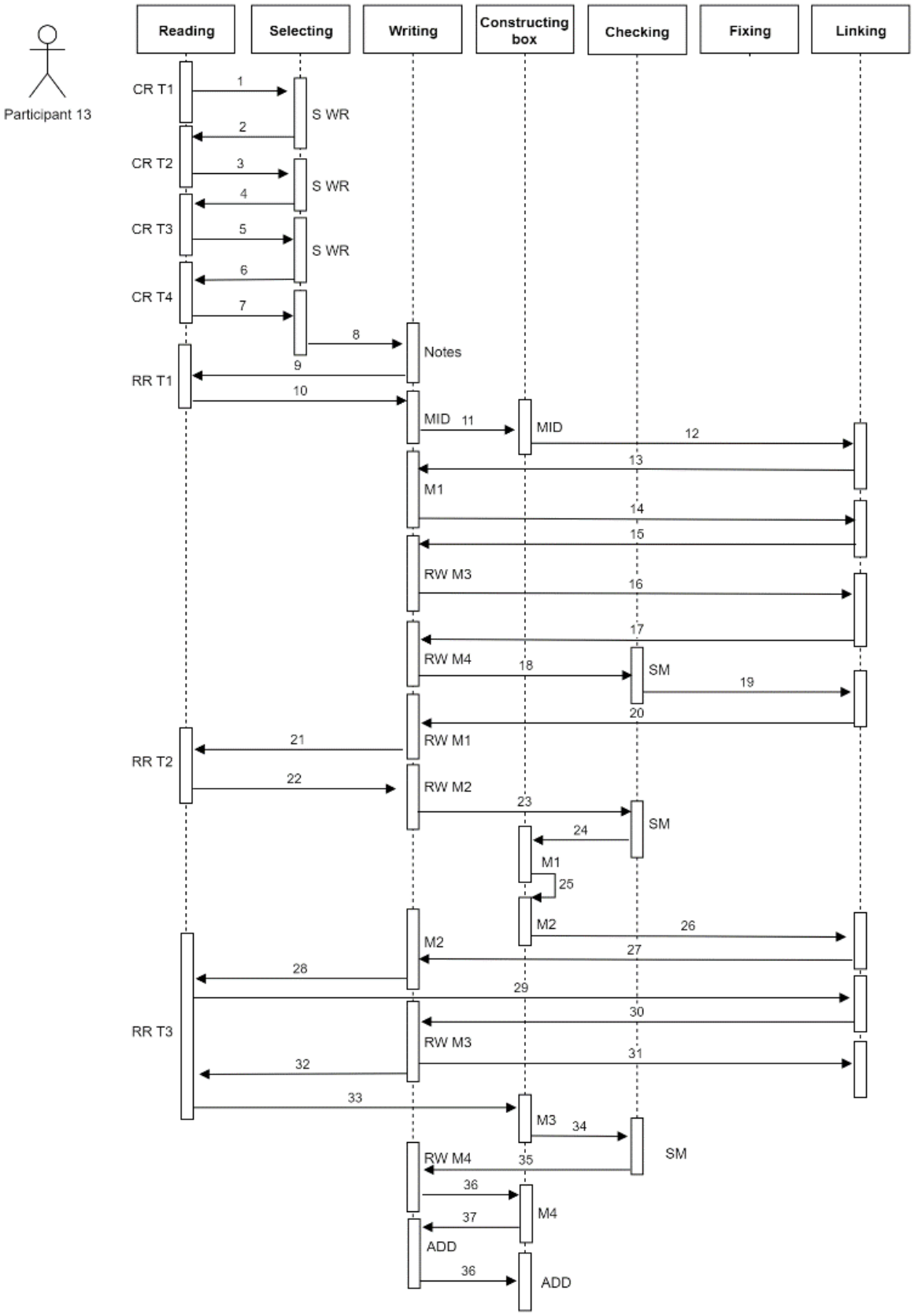


Figure 4-22 Participant 13 Sequence diagram

In terms of the processes followed by participants in Group 1, there are two relevant observations that can be made. Firstly, P05, P13 and P10 performed fewer initial critical reading actions as is evident from the few reading instances in the reading column of the sequence diagrams for the first part of the task (reading the text and marking the relevant information). After the initial comprehensive reading of the text there is little rereading, and selection seems to take place simultaneously. It can thus be deduced that higher scoring participants found it easier to critically read the text and did so faster and at a deeper level that lower scoring participants.

The second observation is that during the second part of the task, when participants started drawing maps, the higher scoring participants did not need to reread sections of the text. They used a “refer and write” technique to populate their maps which means their eyes moved swiftly between the text and the map, showing they are checking (but not attentively reading) information and writing into the map. During this act writing is the main activity and not reading – they referred back to the text when writing but did not need to reread the text. The screenshot indicated in Figure 4-23, shows a typical example of how this act took place. There is rapid movement between the text and the map with longer fixations on the map while the participant is writing. The screenshot was taken from the SMI BeGaze software and shows fixations (the circles or dots) in varying sizes. Again, the larger the circle, the longer the fixation. These fixations are connected by lines representing the scan path of the participant’s eyes as they moved between the text and the summary map.

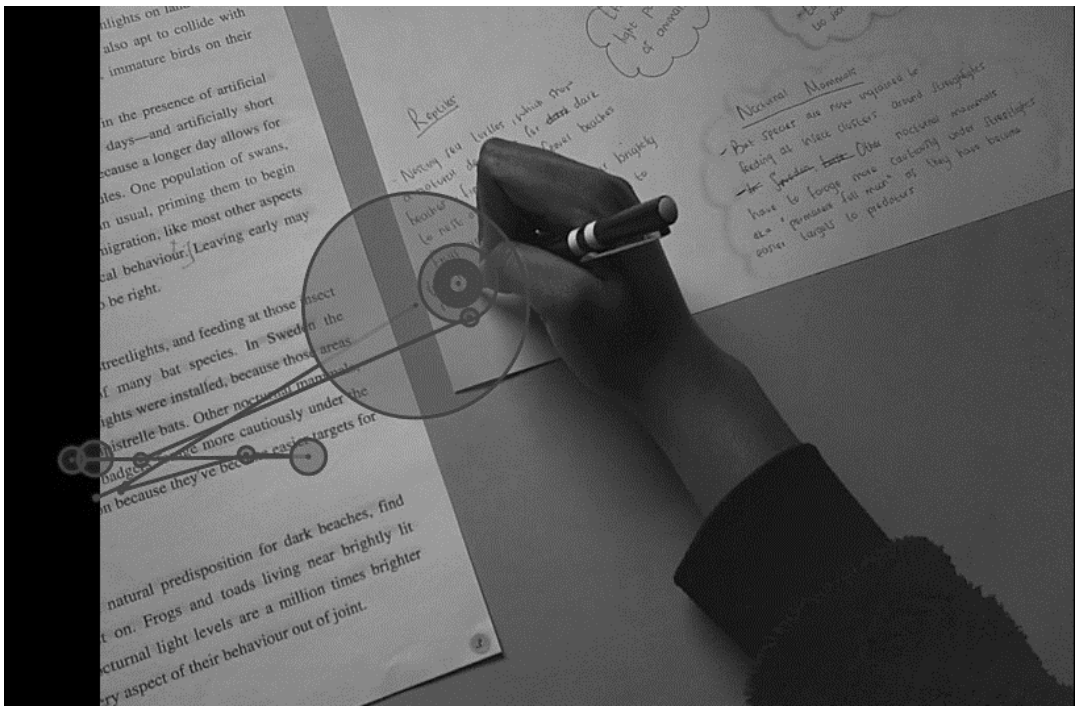


Figure 4-23 Screenshot demonstrating the "refer and write" technique

P17 is considered an outlier in this group due to the deviation from this pattern. The summary map and sequence diagram of this participant is included as Figures 4-24 and 4-25. This participant frequently reread the text. An explanation for this deviation is that this participant did not summarise the information optimally and included more details than what would normally be considered an optimal summary. Therefore, the constant returning to the text can be attributed to attempting to copy detailed information rather than attempting to internalise or understand the text and to then write a summarised version of the key ideas in the text.

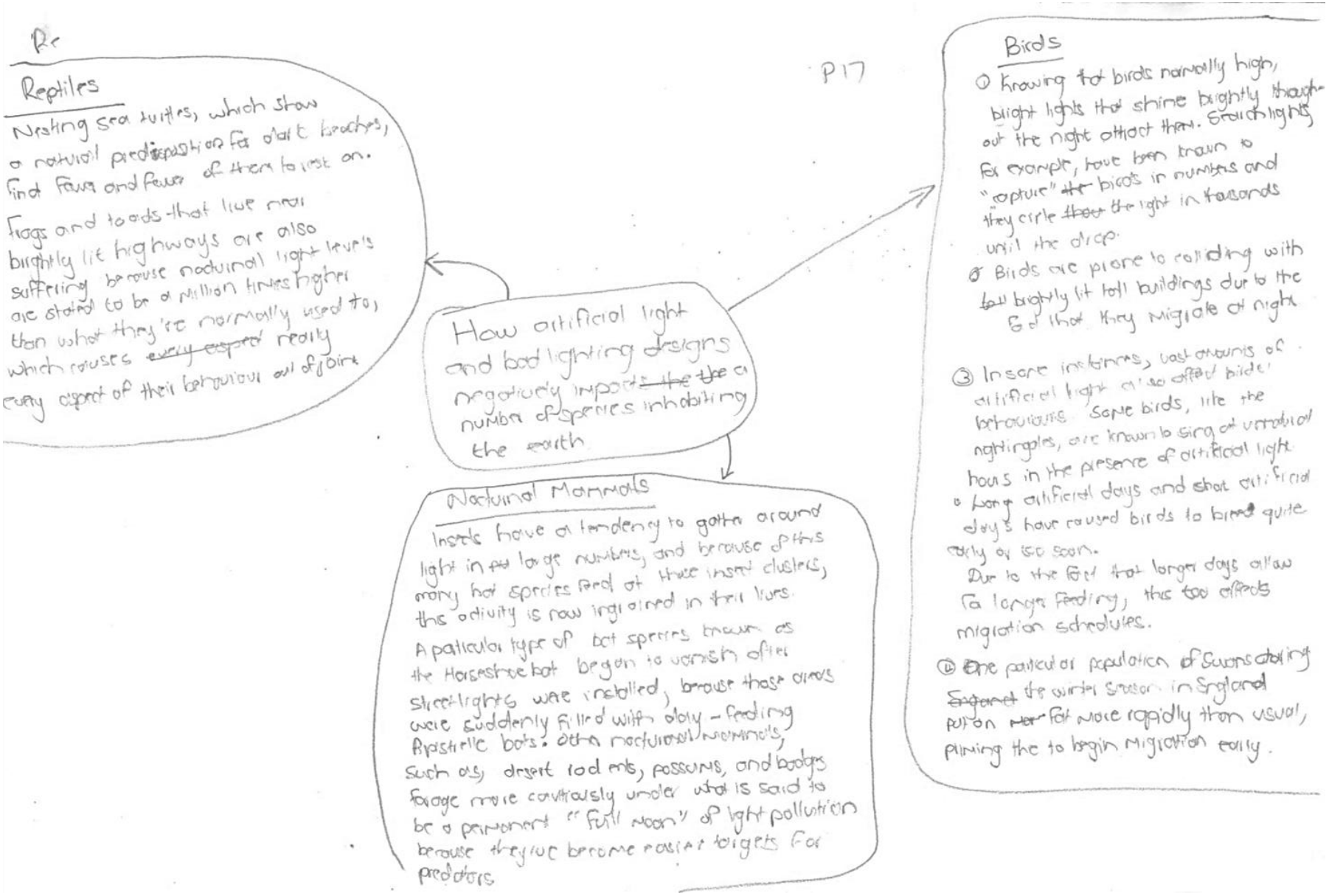


Figure 4-24 Participant 17 Summary map

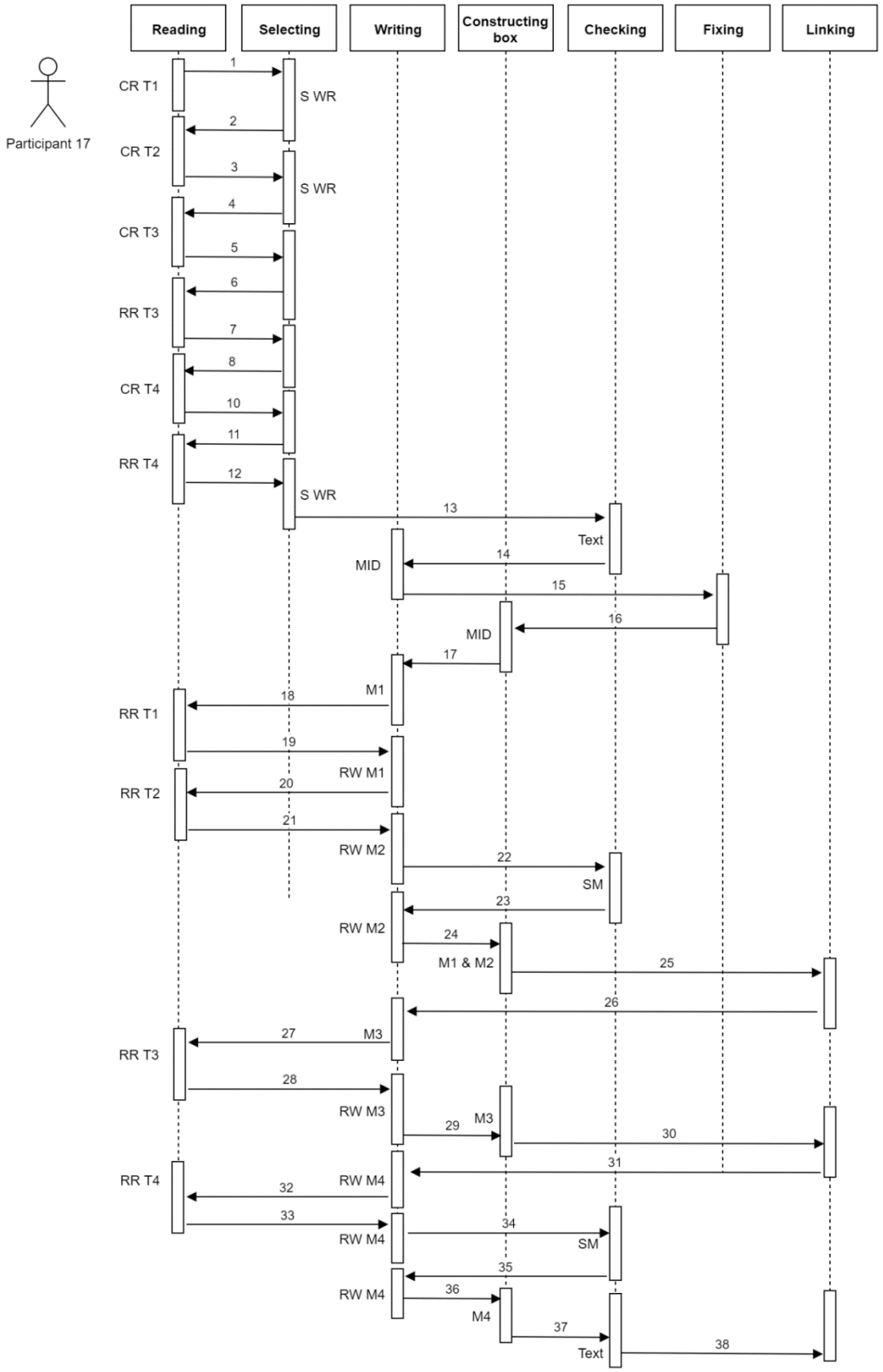


Figure 4-25 Participant 17 Sequence diagram

4.7.2.2. Summary mapping process employed by Group 2 – Average scorers

In the analysis, average scorers (Group 2) included more information in the summary maps than what could be seen with low scorers, but they still lacked the more effective hierarchical categorisation seen with higher scorers. The summary maps for the average scorers are included in Figures 4-26 to 4-28.

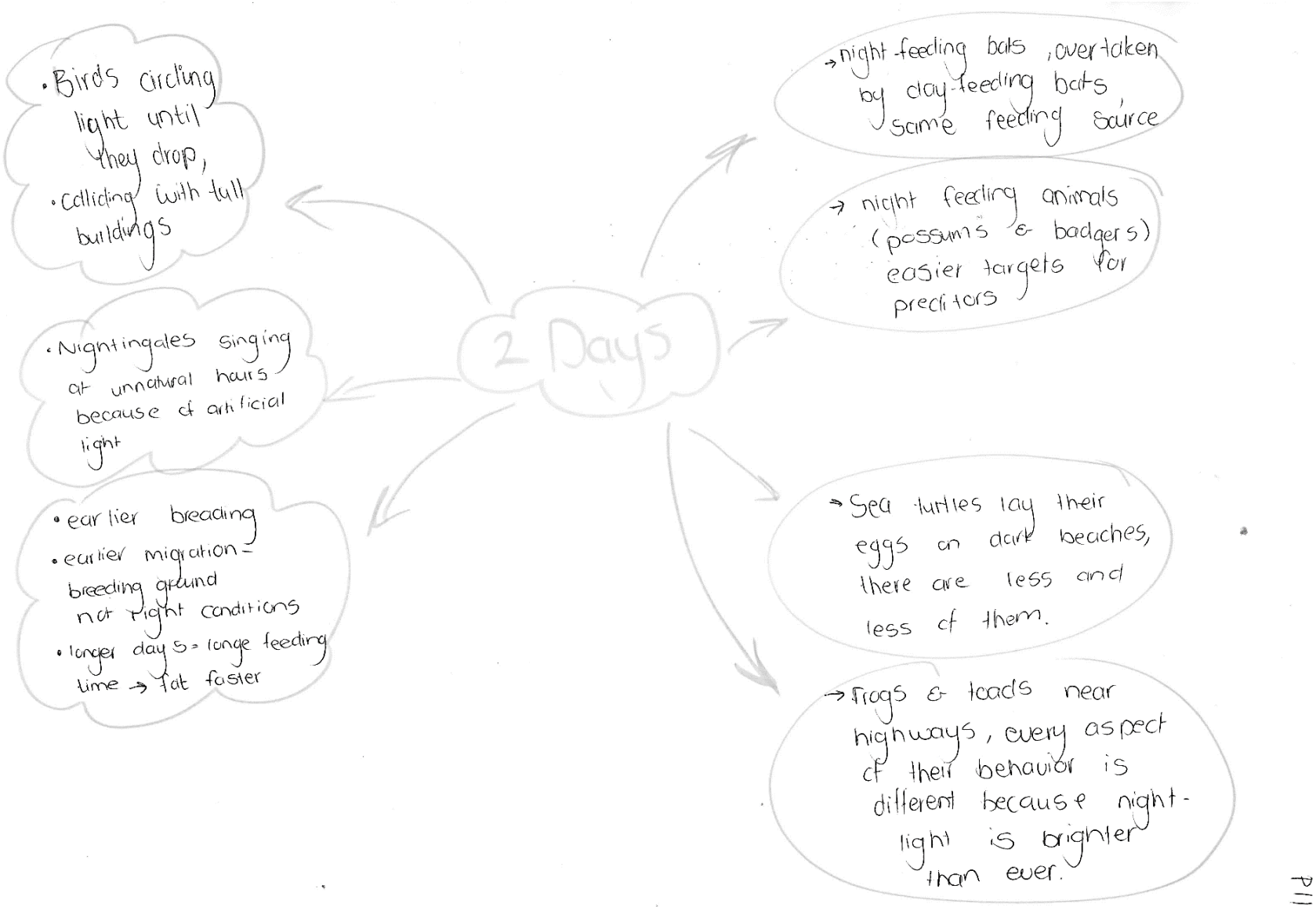


Figure 4-26 Participant 11 Summary map

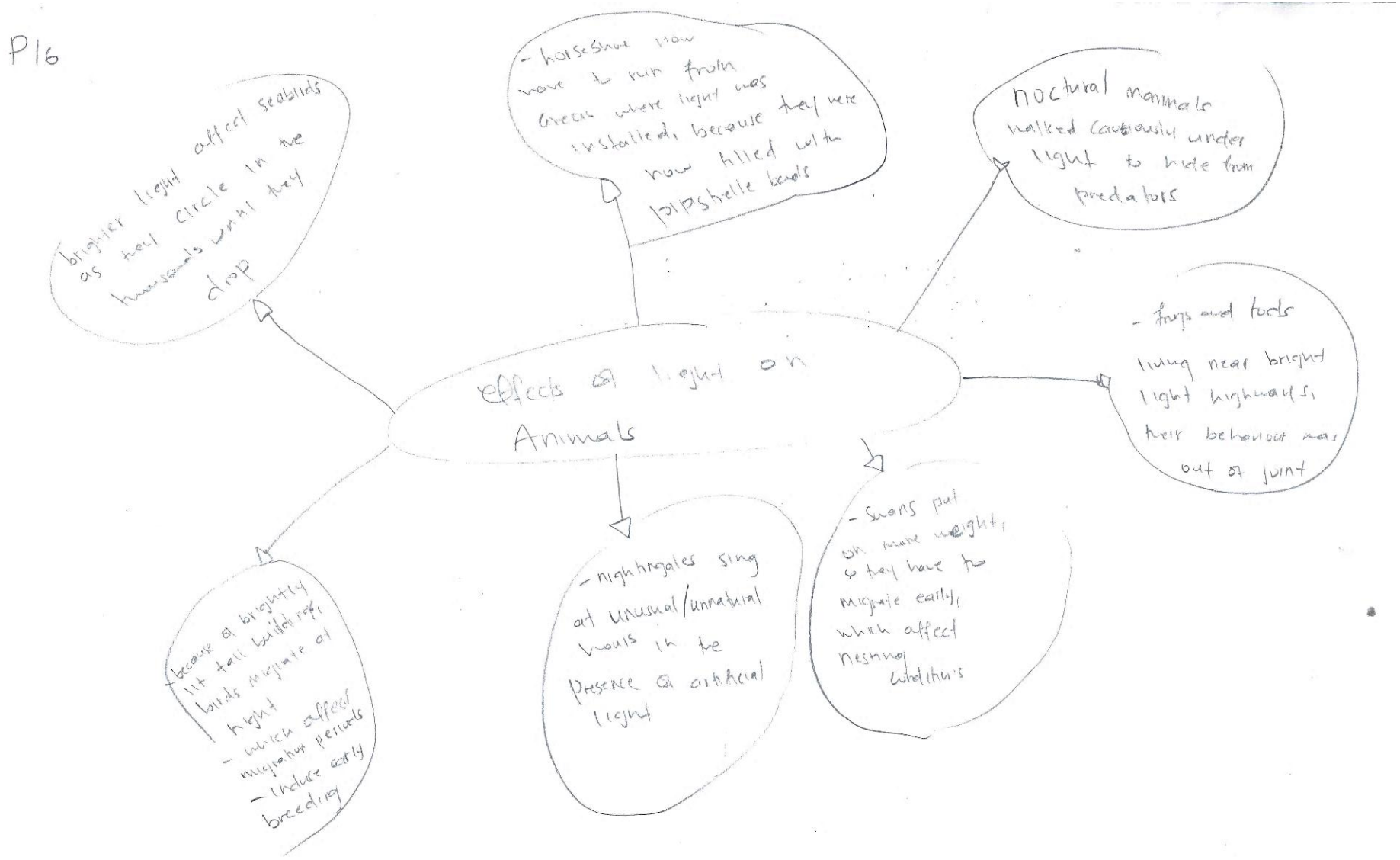


Figure 4-27 Participant 16 Summary map

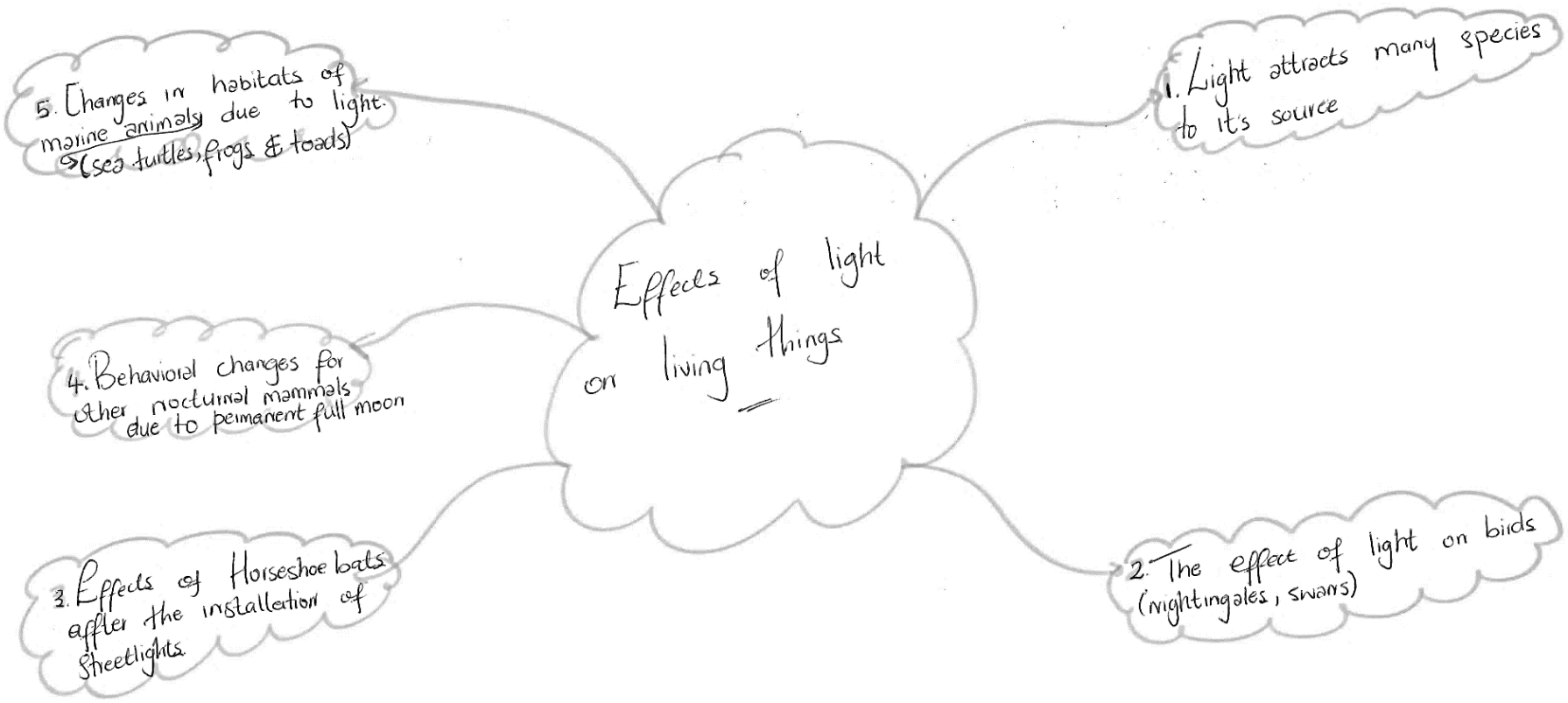


Figure 4-28 Participant 14 Summary map

During the initial part of the task the average scorers engaged with the text in a similar way to the high scorers, with participants reading the text only once and then moving on to mapping. Participants also seem to have followed a similar strategy for selecting information as the high scoring group, making use of the “selecting while reading” technique.

However, it is very interesting to note that for the mapping part of the task the average scorers reacted more like the low scorers in that they often reread sections of the text. This is especially noteworthy because it appears as if they were initially able to engage with the text easily, but they had difficulty to reproduce the information into a coherent and logical diagram without rereading. This could indicate that, although they felt that they had a firm grasp on comprehension of the text and differentiating between levels of information in the text, they did not internalise the text in such a way that they could reproduce it in the summary map without rereading some sections. This is in line with the earlier observation indicating that the categorisation ability of summary mapping could be a challenge for students. The sequence diagrams for average scorers have been included as Figures 4-29 to 4-31.

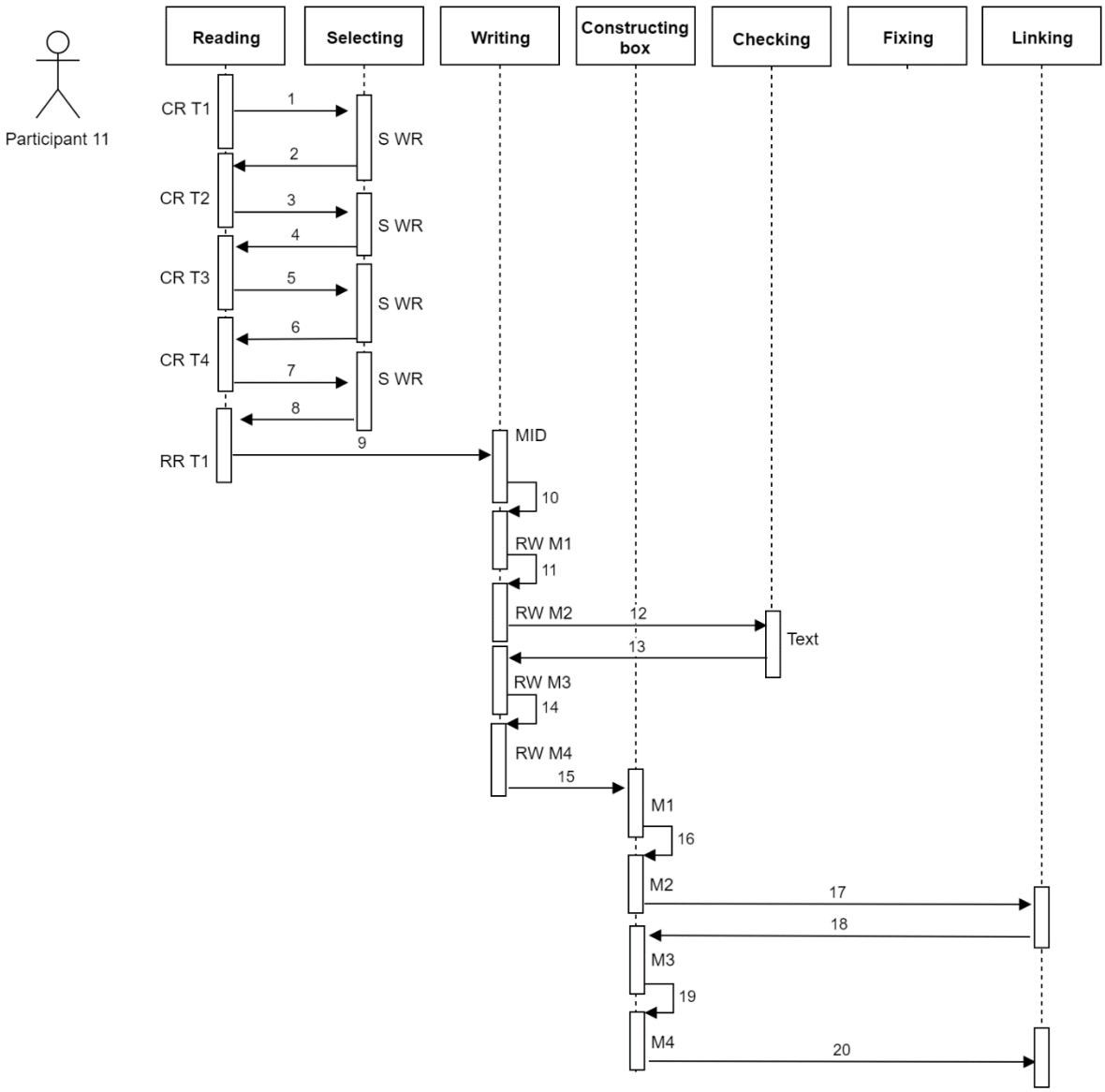


Figure 4-29 Participant 11 Sequence diagram

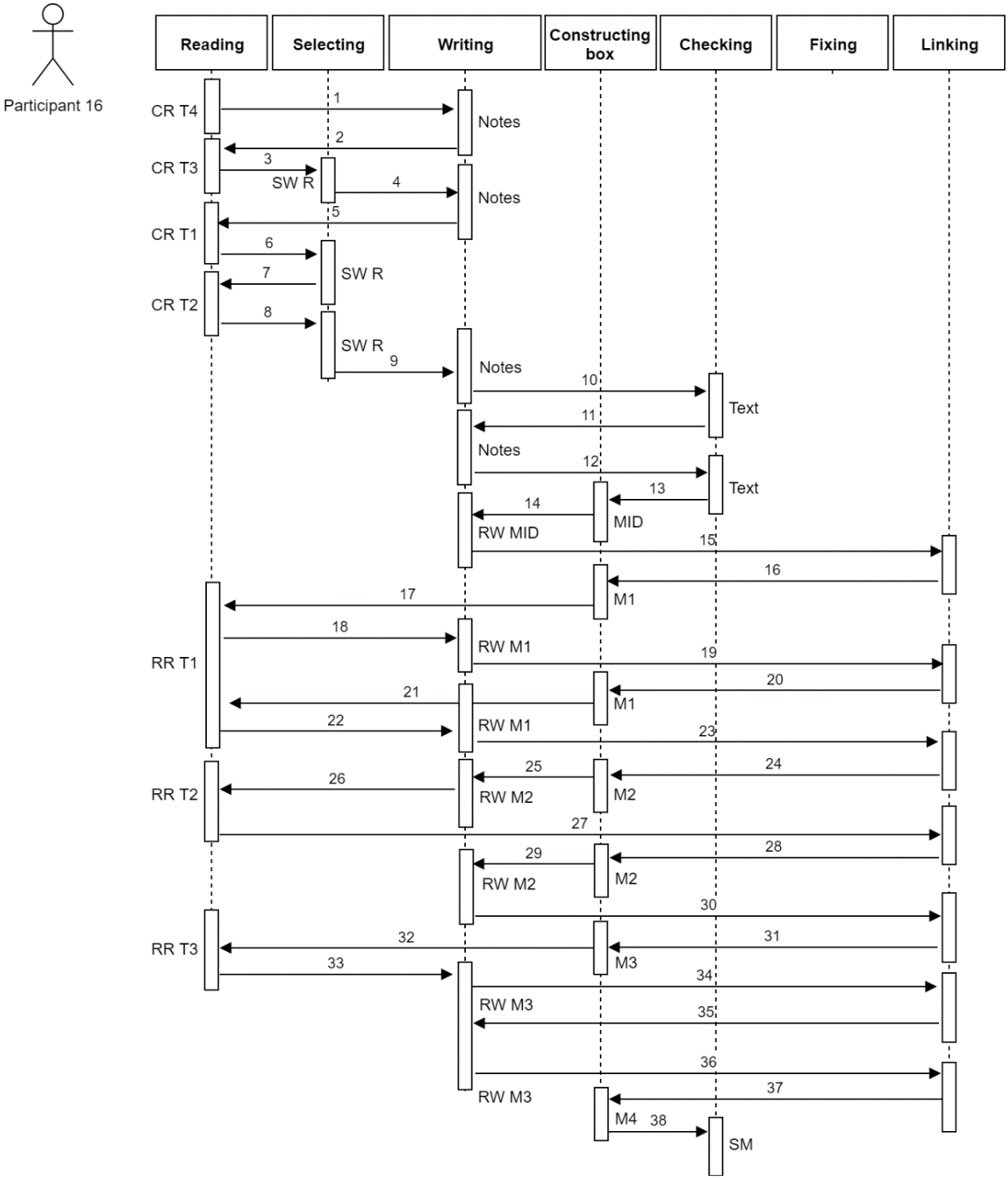


Figure 4-30 Participant 16 Sequence diagram

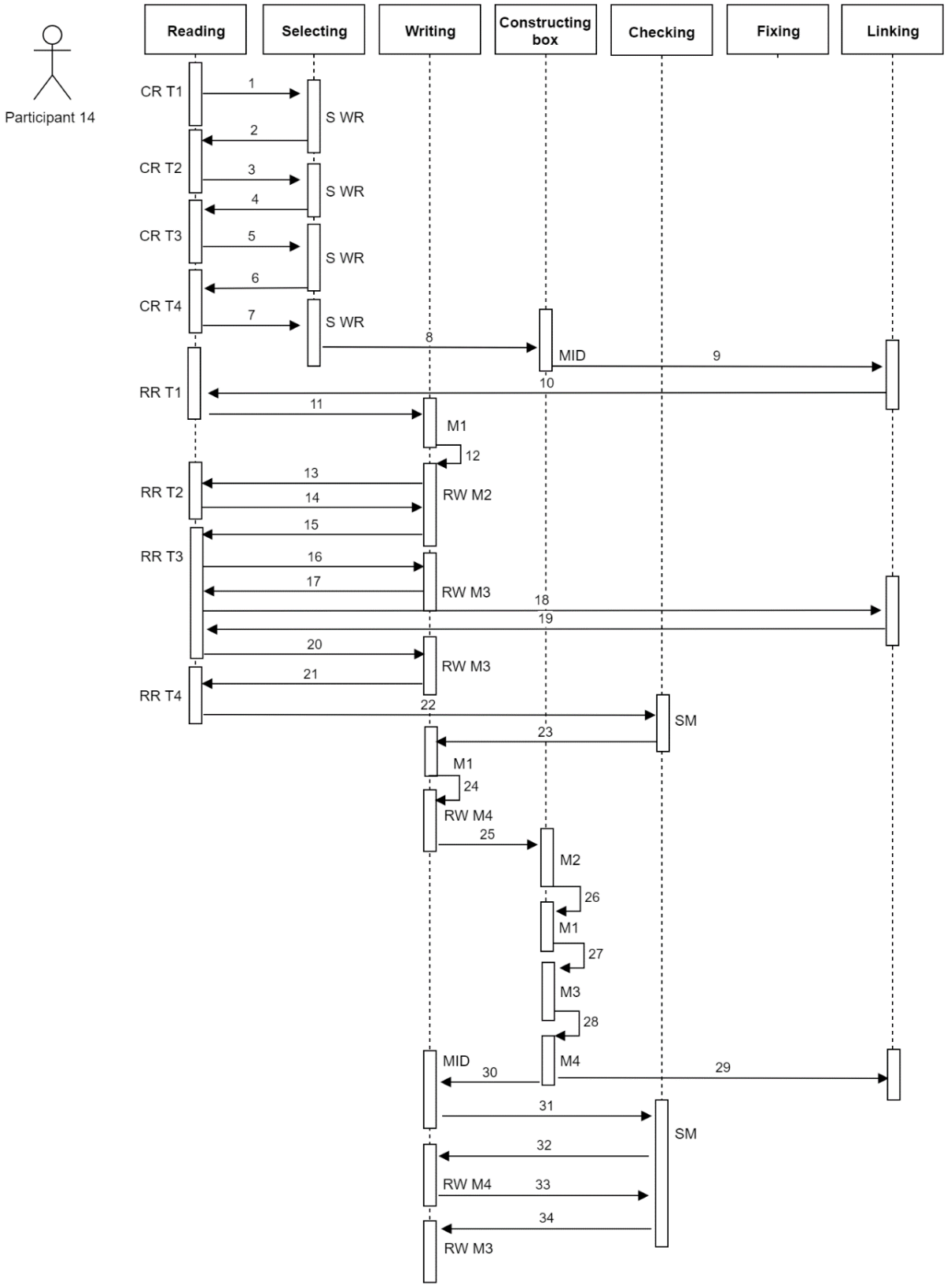


Figure 4-31 Participant 14 Sequence diagram

Participants 4 and 12 are considered outliers in this group. Participant 12 followed a similar approach to the group in terms of initial reading and selecting and also does a fair bit of rereading during the mapping part of the task, but then very often checks the summary map. A possible reason for this is the participant's illogical structuring of the summary map. It seems as if the participant struggled to make sense of the structure or tried to determine where to put information in the map. Due to this illogically structured map and the constant checking, this participant is considered an outlier. Even though this participant is an outlier in terms of the observed process, the participant clearly also experiences categorisation of information as a challenge. Although this summary map has already been included in the chapter, it is included here again as Figure 4-32 for ease of reference.

Figure 4-32 Participant 12 Summary map

Participant 4 deviated significantly from the rest of the group. The approach followed resembles that of low scorers in that the participant reread the text initially and also reread the text many times after mapping was started. This could be attributed to the fact that the summary submitted by the participant did not resemble a summary map diagram at all - it is a bulleted list of main ideas from the text. This summary was, however, marked and taken into consideration as it is a typical response that lecturers often see when teaching ALDE111. Furthermore, the format used by the participant could explain the heavy reliance on the text because a bullet point summary would typically include more information written in a more comprehensive way when compared to summary map content. The summary that participant 4 completed is included in Figure 4-33. A sequence diagram could not be drawn for the participant since the participant did not perform the acts illustrated by the diagram.

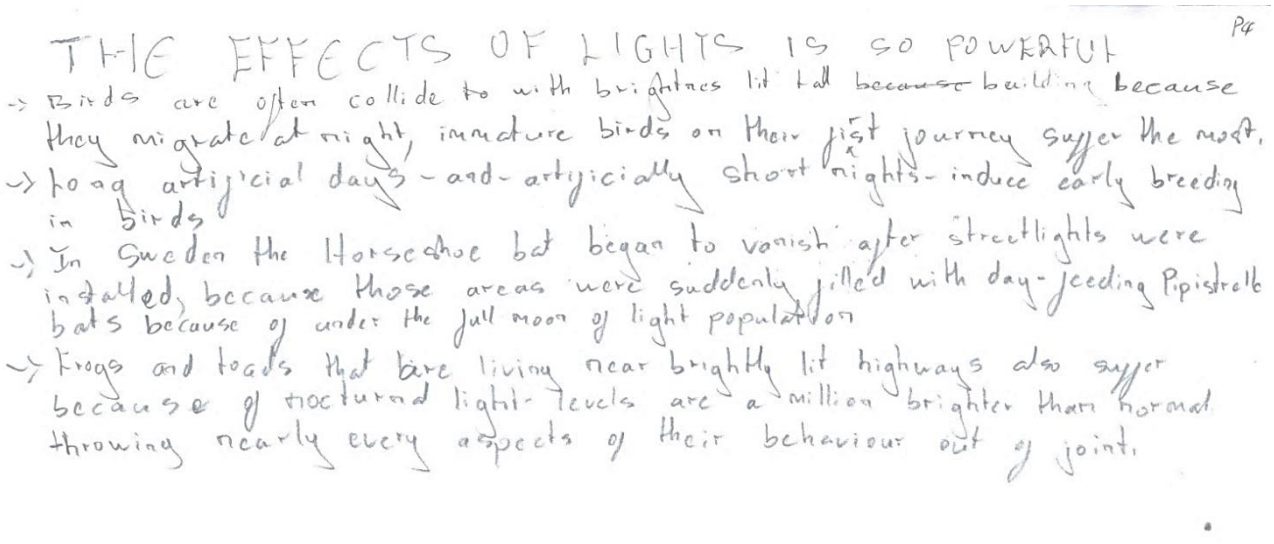


Figure 4-33 Participant 4 Summary

The sequence diagrams discussed above have provided valuable information in terms of the processes followed by participants when completing a summary map. In general, the processes followed support the statistical correlations between comprehension and summary map scores that indicate deep level comprehension as a challenge for participants. This can be seen in the way different groups of participants approached the reading part of the task.

4.7.2.3. Summary mapping process employed by Group 3 – Low scorers

In the summary maps of the lower scorers the lack of hierarchical structure and content is obvious. Not only did they include very little information in the maps, but the information is included on the same level. This is similar to what Dogusoy-Taylan and Cagiltay (2014) observed from their novice participants. They indicate that novices had poor map quality and stated that this may be due to a lack of initial strategy (Dogusoy-Taylan and Cagiltay, 2014:90). The summary maps of low scorers are included in Figures 4-34 to 4-36.

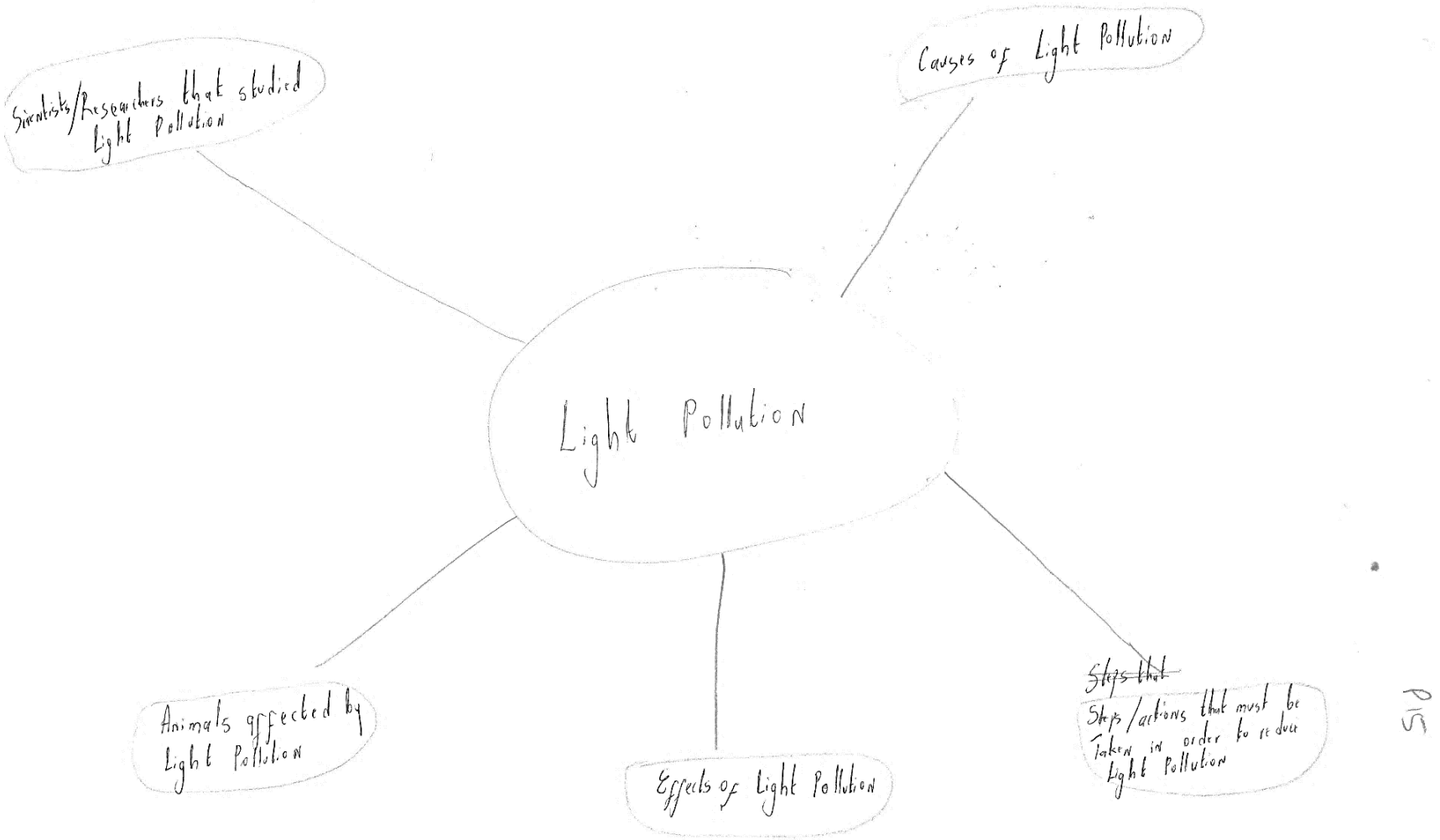


Figure 4-34 Participant 15 Summary map

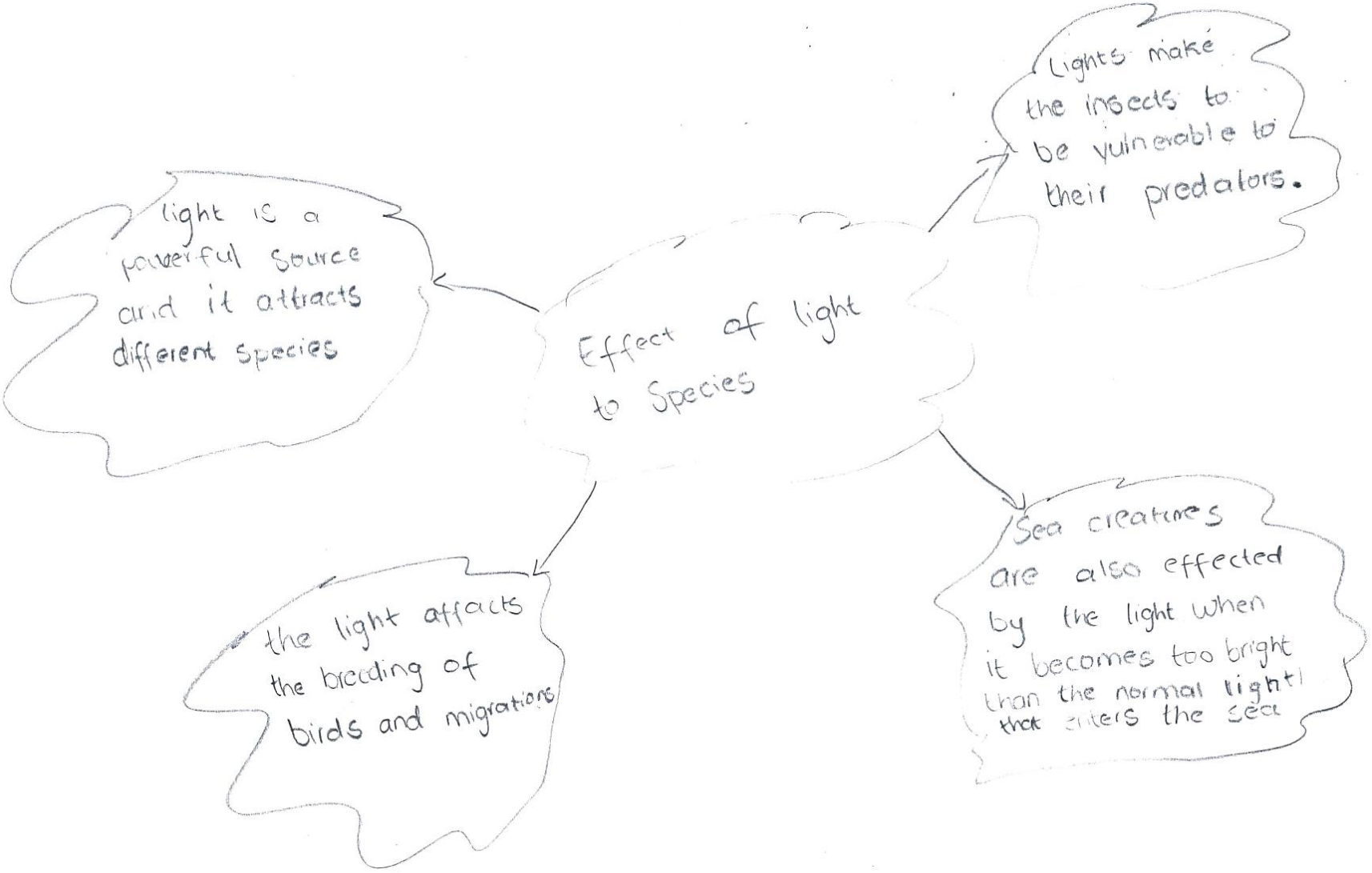


Figure 4-35 Participant 2 Summary map

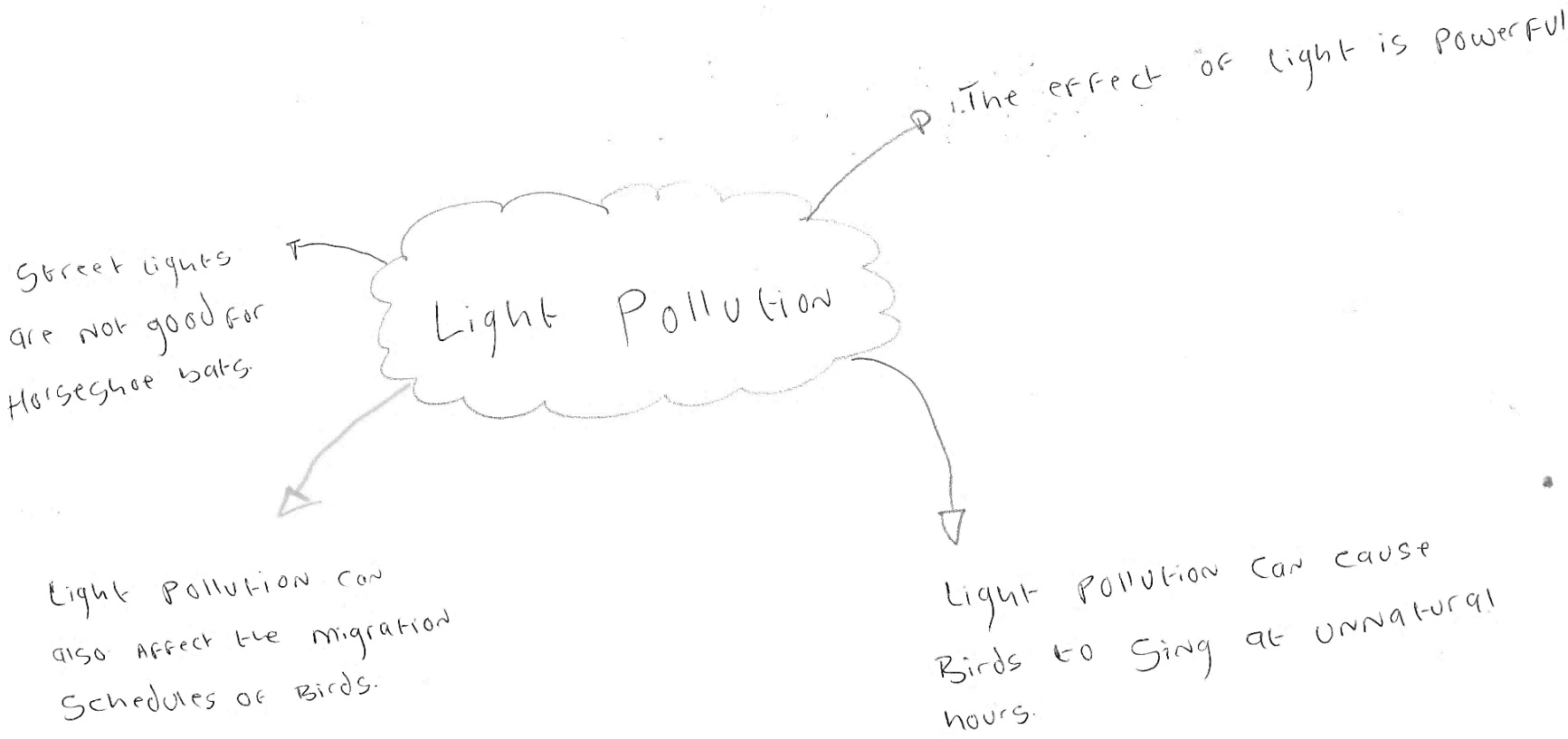


Figure 4-36 Participant 8 Summary map

From the sequence diagrams of the low scoring participants, it is evident that for the first part of the task, two of the three participants had to reread the text entirely before they could start mapping. The other participant read the text only once. Selection of information mostly seemed to take place in isolation with all the participants switching between reading and selecting information. In comparison, the high scoring group seemed to be able to read and select in a more simultaneous and integrated fashion and used a “select while reading” technique.

For the second part of the task, the participants reread the text much more often in comparison to the higher scorers and based on the little information included in their summary maps, this reliance on the text cannot be attributed to copying information. The sequence diagrams for low scorers have been included as Figures 4-37 to 4-39.

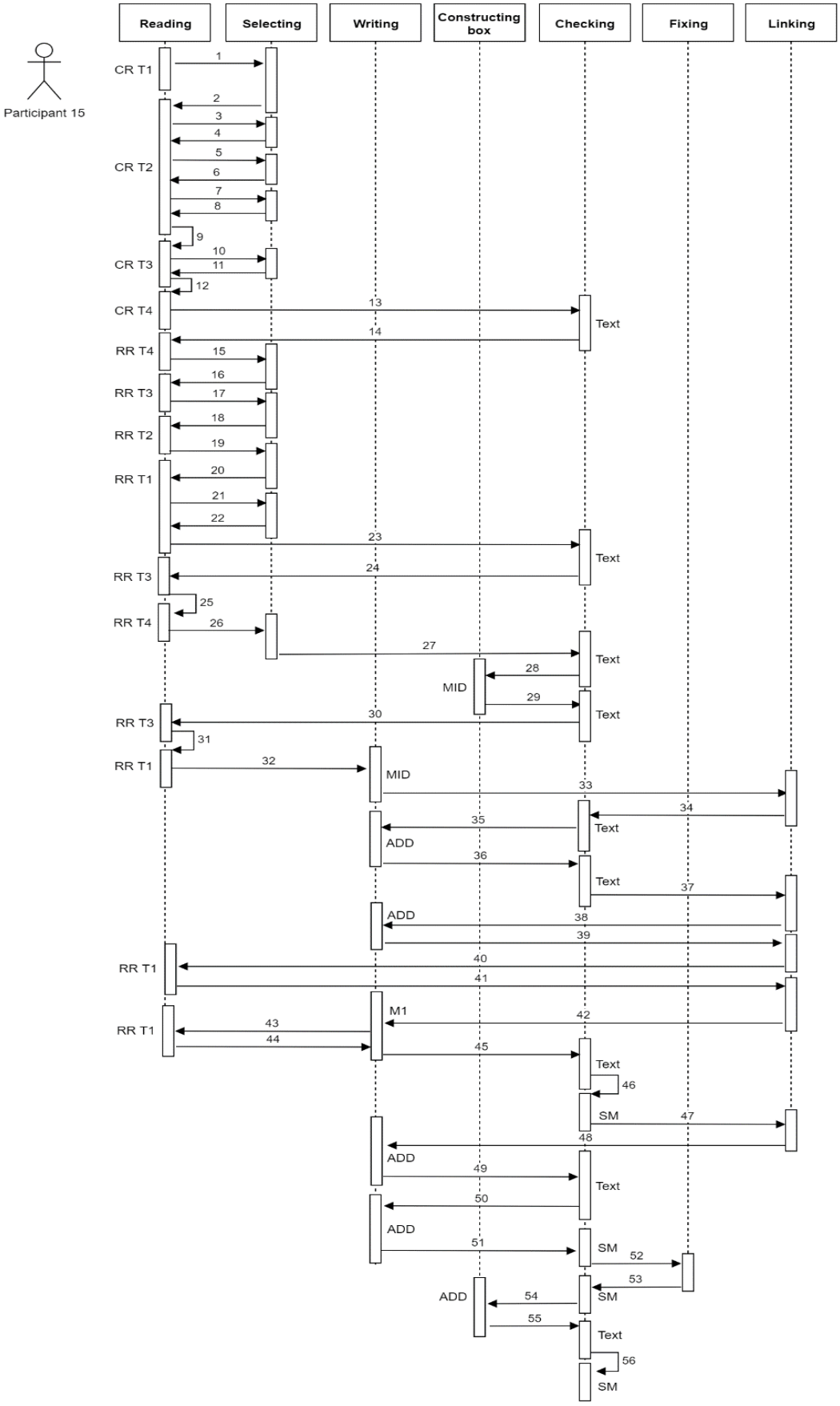


Figure 4-37 Participant 15 Sequence diagram

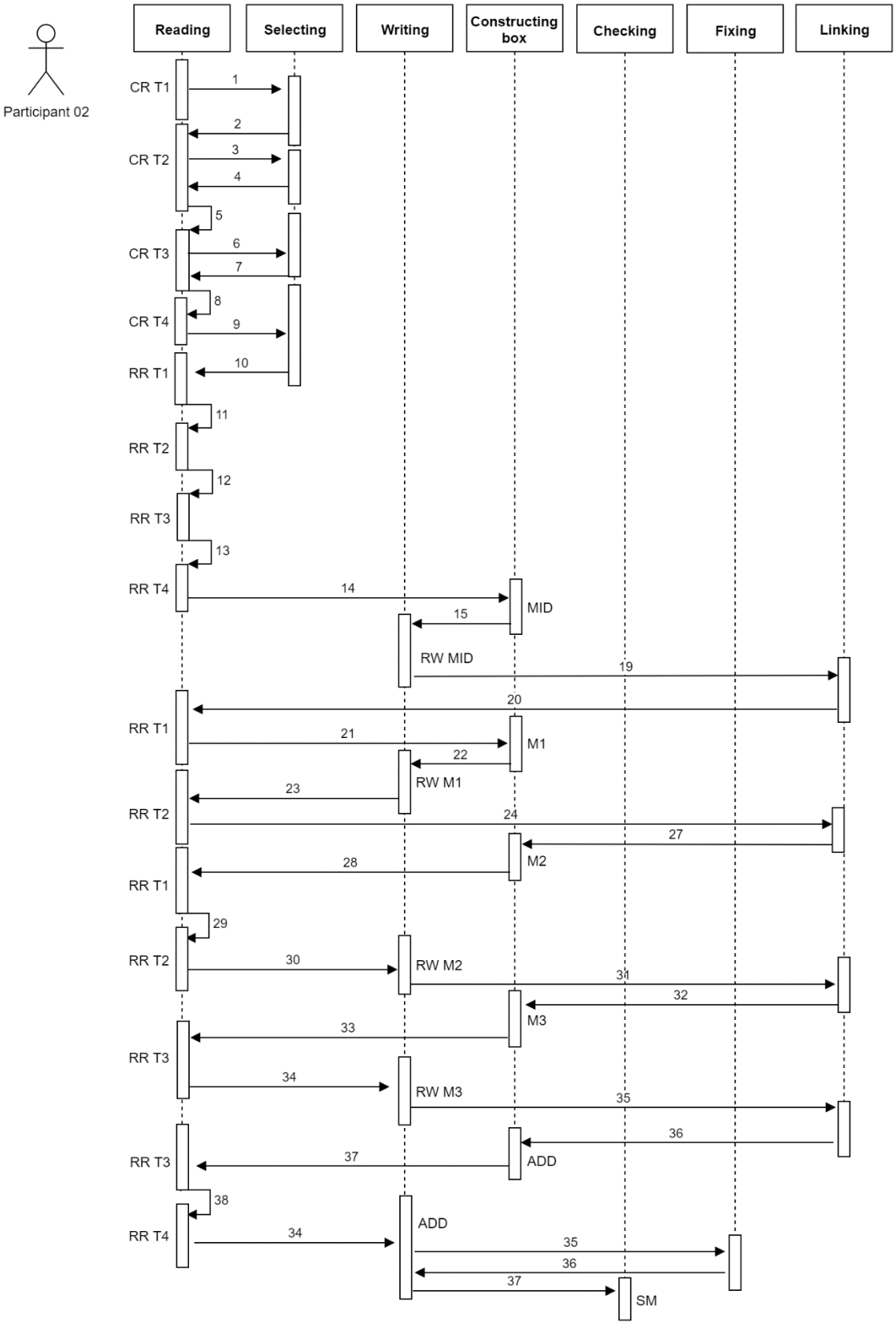


Figure 4-38 Participant 2 Sequence diagram

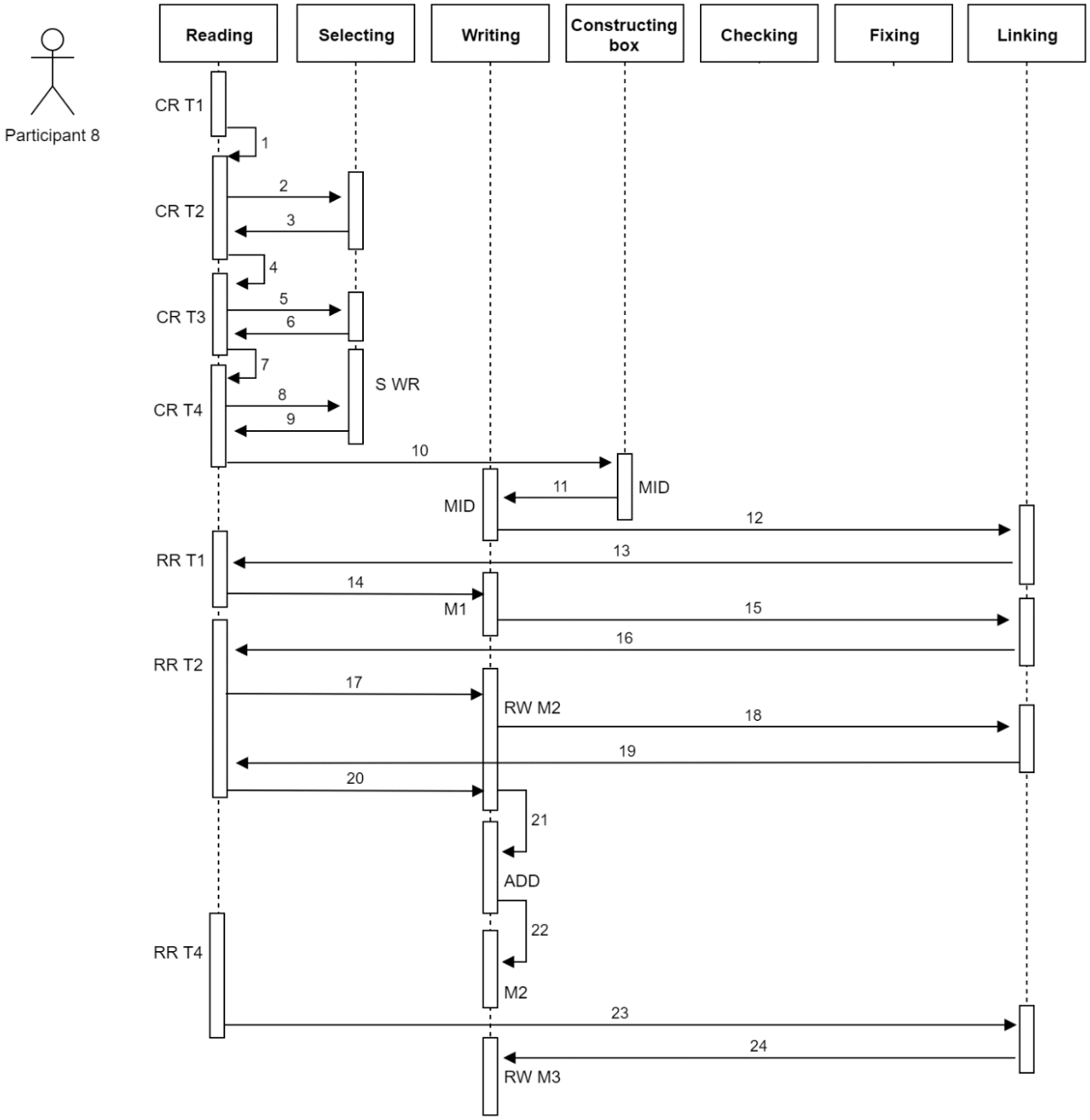


Figure 4-39 Participant 8 Sequence diagram

Overall, it seems that the lower scoring group struggled to comprehend the text and needed to constantly reread it in order to attempt to take out the most relevant parts. As reported in Section 4.3 with regard to comprehension test data overall, the participants demonstrated understanding for only about 50% of the text. The act of rereading could, therefore, be attributed to participants struggling to gain an adequate deeper understanding of the text that is required for appropriate summary mapping. It seems as if participants found it difficult to

engage with the text when they needed to use it for summary mapping, which essentially means they struggled to differentiate between essential and non-essential information and with the categorisation thereof.

Participant 9 is considered an outlier in that this participant deviated from the observed pattern and did not reread the text at all after mapping was started. This could be attributed to the fact that there was abnormally little information included in the summary map. It could be that the participant only wrote into the summary map what he/she could remember from the initial reading and did not deem it necessary to continue fleshing out the map. Another explanation could be that the participant was not fully engaged with the activity of summary map writing at all. The summary map and sequence diagram of participant 9 has been included as Figures 4-40 and 4-41.

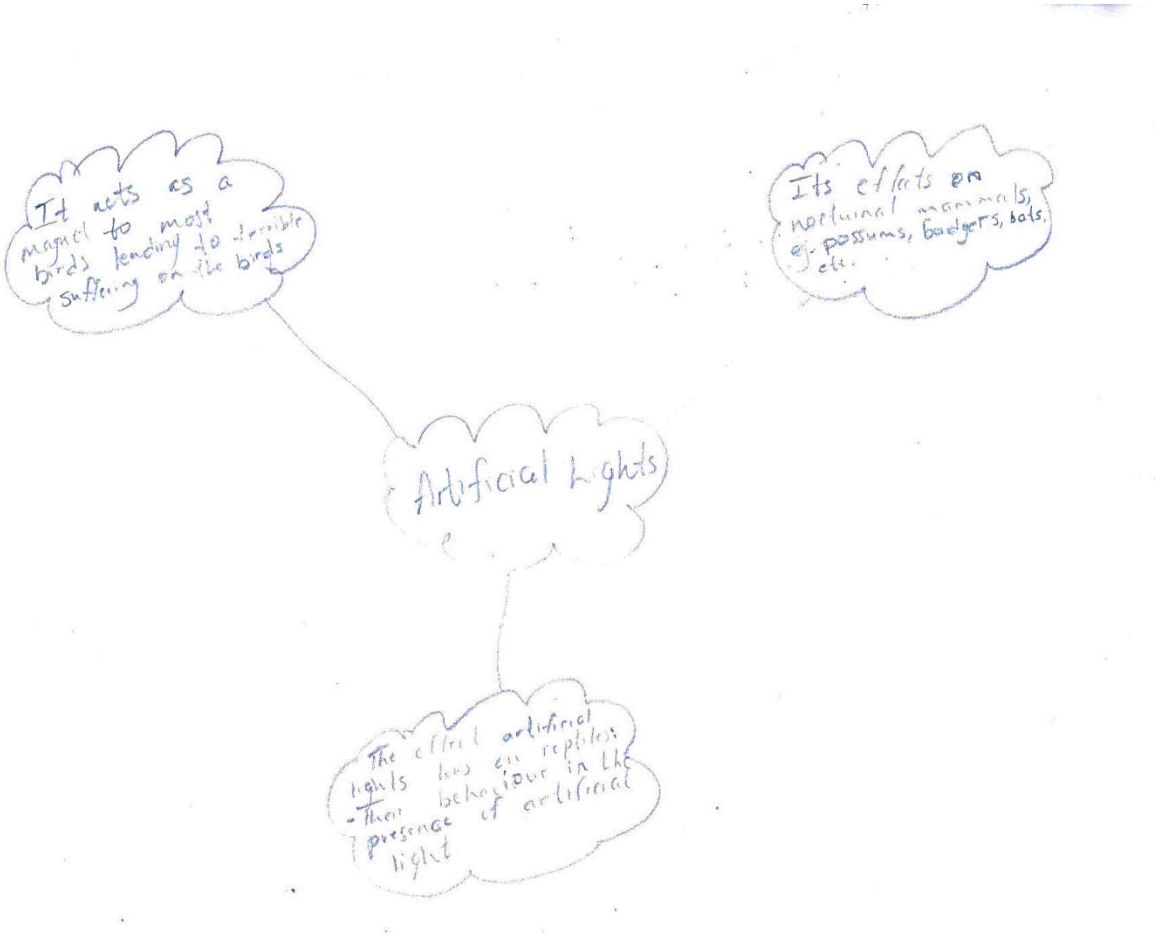


Figure 4-40 Participant 9 Summary map

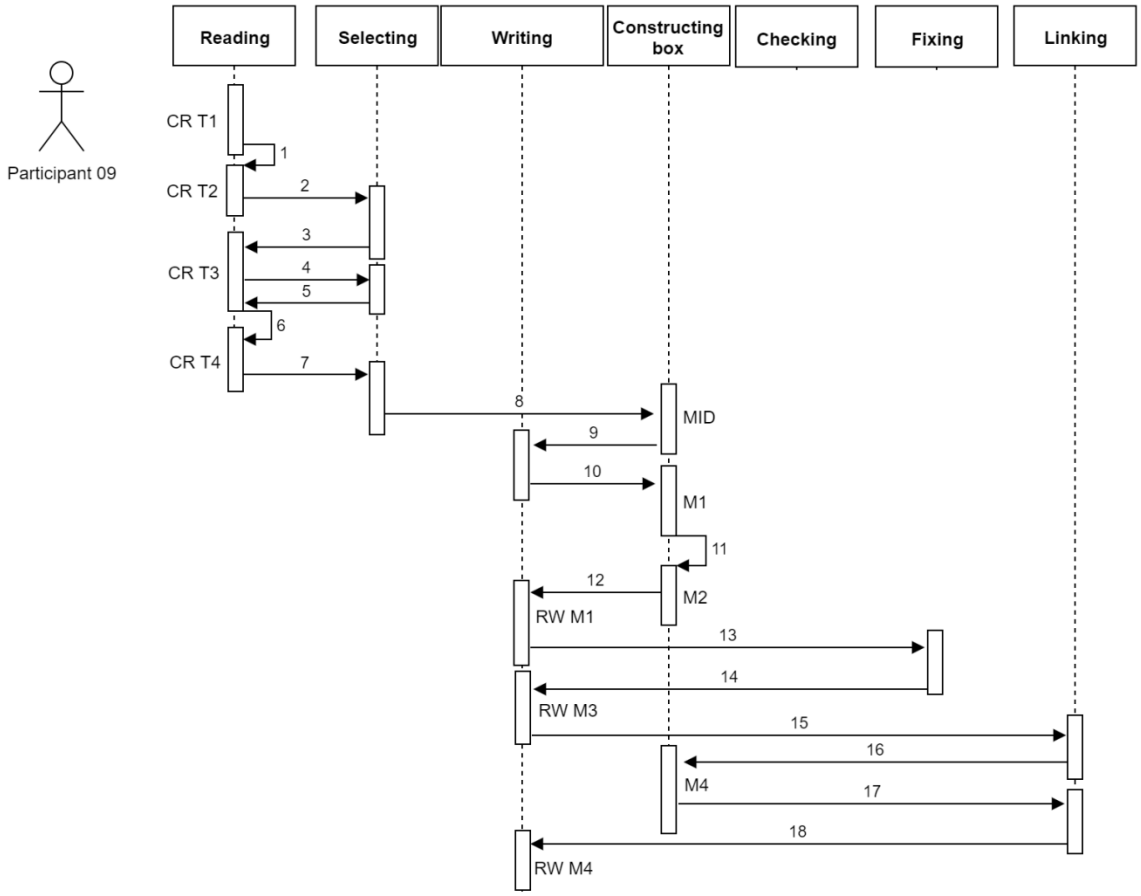


Figure 4-41 Participant 9 Sequence diagram

The amount of rereading that occurred during the mapping task coupled with the lowest scorer (P15) constantly rechecking both the text and summary map could be indicative of the participants struggling to fully understand the text at a deeper level. As already mentioned, a deeper level understanding of the text is required for differentiating between essential and non-essential information and subsequently categorising it. This is also in line with what Dogusoy-Taylan and Cagiltay (2014) observed in terms of checking – they indicated a higher frequency of checking for novices in all stages of mapping. Although all participants in the current study could demonstrate comprehension of about 50% of the text, lower scorers seem to grapple with a deeper understanding and analysis of the text, as well as differentiating between different levels of information in the text. They could furthermore not rely on their understanding/internalising of the text when they started populating their maps with information and could therefore not apply a “refer and write” technique like that observed for high scorers.

4.8. The sequence of observed acts – Transition matrixes

The sequence of movement of the eyes between different AOIs were recorded in the form of transition matrices. In a transition matrix, “the AOIs are listed in columns and rows and the number in each cell indicates how many times gaze has shifted from one AOI to another” (Holmqvist *et al*., 2011:193). According to Kurzhals and Weiskopf (2015:41), “the analysis of transitions between areas of interest (AOIs) in eye-tracking data provides insight into visual reading strategies followed.” It can, in other words, show the sequence in which participants’ eyes moved between AOIs as well as the frequency of these movements.

For the current study these transition matrices were combined into the comparative analysis groupings of participants in order to compare the processes followed by each group as an additional method of process analysis. The identified AOIs as well as what they comprise of are included again in Table 4-15 for ease of reference.

AOI Label	What they comprise of
T1	Text paragraph 1
T2	Text paragraph 2
T3	Text paragraph 3
T4	Text paragraph 4
MID	Central main idea of summary map
M1	Concept box in summary map 1
M2	Concept box in summary map 2
M3	Concept box in summary map 3
M4	Concept box in summary map 4
M5	Concept box in summary map 5
M6	Concept box in summary map 6
M7	Concept box in summary map 7

Table 4-15 Selected AOIs and what they comprise of

The matrices included in Tables 4-16 to 4-18 show each AOI in both the first row and the first column of the table and the number indicated in the cross-linked cell represents the number of times the participant moved between the AOIs. In Tables 4-16, 4-17 and 4-18, transitions frequencies of 10 and above are high-lighted in order to illustrate between which AOIs the most movement took place.

Combined transition matrix for Group 1 - High scorers									
	M4	M3	M2	M1	MID	T4	T3	T2	T1
M4	0	0	2	0	4	0	0	0	0
M3	1	0	9	1	10	9	19	1	1
M2	1	14	0	9	9	1	38	3	5
M1	0	1	8	0	7	0	0	23	11
MID	3	9	8	10	0	0	2	0	2
T4	0	8	3	0	1	0	32	1	1
T3	0	8	36	0	1	46	0	23	2
T2	0	1	6	9	4	0	35	0	33
T1	0	3	5	8	6	0	0	21	0

Table 4-16 Combined transition matrix for group 1

Combined transition matrix for Group 2 - Average scorers												
	M7	M6	M5	M4	M3	M2	M1	MID	T4	T3	T2	T1
M7	0	2	0	0	0	0	0	1	2	0	0	0
M6	3	0	0	0	0	0	0	0	0	1	0	0
M5	0	1	0	15	0	0	1	4	0	3	2	2
M4	0	0	16	0	3	1	0	3	0	4	4	1
M3	0	0	0	9	0	4	1	2	1	5	13	0
M2	0	0	0	0	5	0	3	4	0	1	9	2
M1	0	0	1	0	0	1	0	1	0	0	3	7
MID	0	0	5	3	5	0	0	0	0	0	1	3
T4	1	1	0	2	1	0	0	0	0	22	12	16
T3	0	0	1	2	7	2	0	2	24	0	29	0
T2	0	0	1	1	7	10	0	1	16	33	0	40
T1	0	0	2	1	1	5	7	0	11	3	41	0

Table 4-17 Combined transition matrix for group 2

Combined transition matrix for Group 3 - Low scorers										
	M5	M4	M3	M2	M1	MID	T4	T3	T2	T1
M5	0	0	0	0	0	0	0	0	0	0
M4	0	0	2	1	0	5	1	3	1	0
M3	0	0	0	0	1	6	0	0	2	2
M2	0	0	1	0	5	5	1	0	2	2
M1	0	0	0	2	0	5	0	0	1	4
MID	0	7	3	4	1	0	0	1	1	2
T4	0	0	0	0	1	0	0	17	20	1
T3	0	2	0	0	0	1	23	0	5	0
T2	0	1	1	3	0	1	23	9	0	36
T1	0	1	0	0	2	0	0	1	41	0

Table 4-18 Combined transition matrix for group 3

If the highlighted cells in the above tables are considered, differences between the groups are apparent. Transitions in Group 1 are spread across the matrix in a more balanced way. The most transitions still took place between AOIs in the text (the lower right corner of the matrix representing transitions between text AOIs), but a high number of transitions also took place between the text and the summary map, seen in highlighted blocks elsewhere in the matrix. For Group 2 there are fewer highlighted blocks outside of the lower right corner, showing again that transitions were concentrated between the text AOIs but there are two instances outside this area. For Group 3 the highlighted blocks are only concentrated in the text AOI area. The specific number of transitions taking place are not necessarily important but noting the AOIs between which a higher number of movements are taking place is interesting as it confirms findings presented earlier in the chapter. If these matrices are presented in the form of chord diagrams that visually represent how each group moved between identified areas of interest, these differences between the groups can also be seen. In the cord diagrams frequencies are depicted visually with the broader bands between AOIs (indicated on the outer ring) displaying the higher frequencies. The cord diagrams of the three groups are depicted in Figures 4-42 to 4-44.

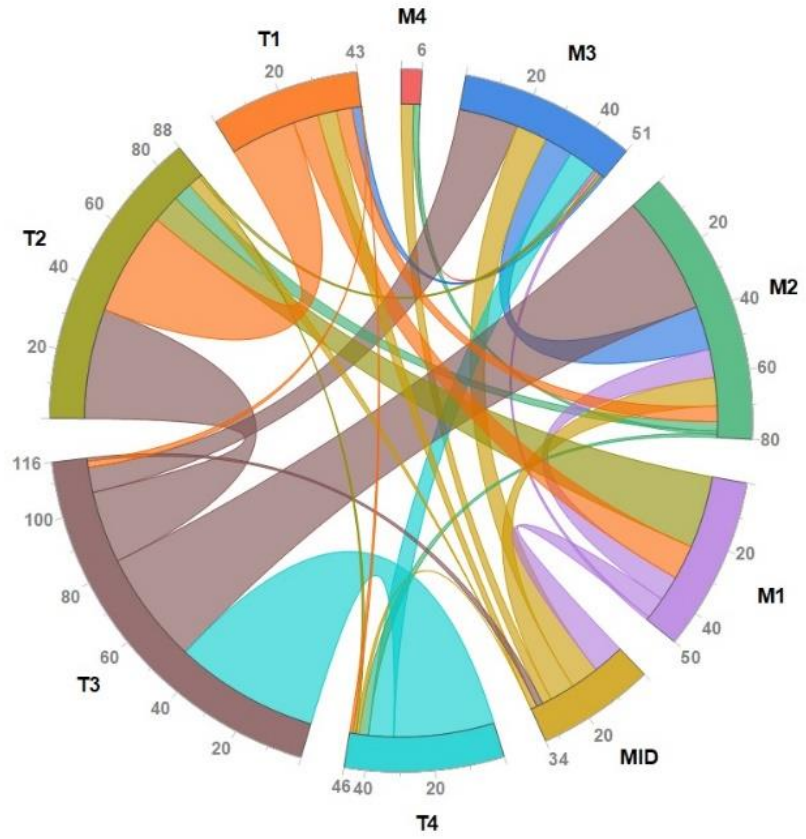


Figure 4-42 Transitions Group 1 High scorers

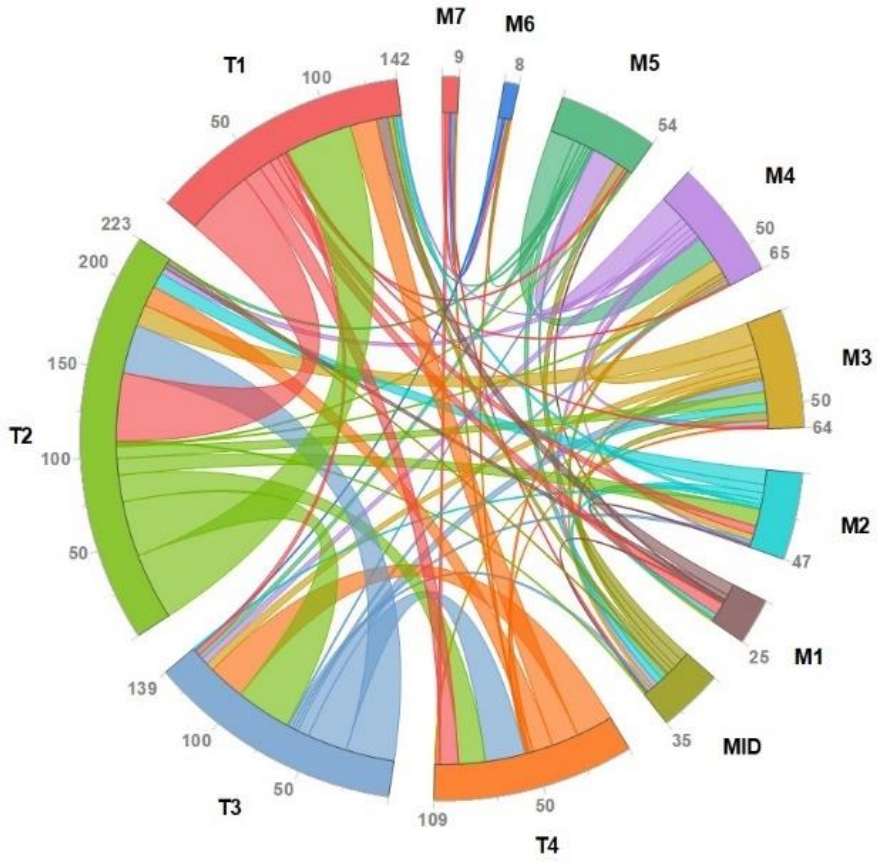


Figure 4-43 Transitions Group 2 Average scorers

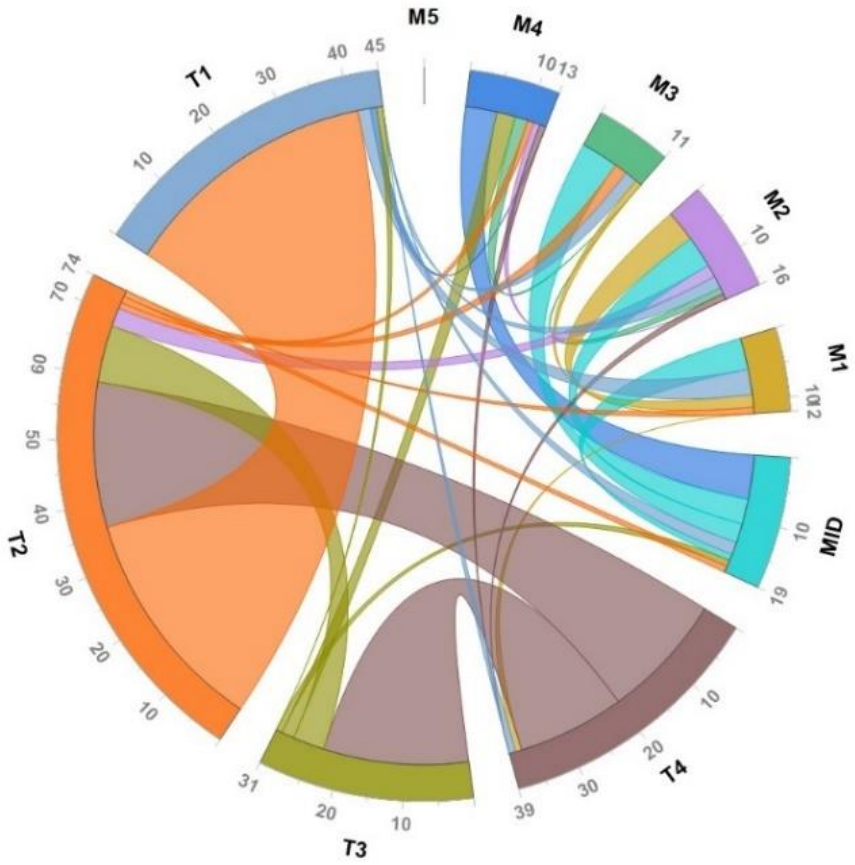


Figure 4-44 Transitions Group 3 Low scorers

What can be discerned from this comparison reiterates previous findings. Low scorers navigate between sections of text for longer periods of time compared to the other two groups. This can be seen in the broad bands running between text AOIs in Figure 4-44. In Figure 4-43 broader bands can also be observed among the text AOIs but they are not as evident and there are many other transitions taking place as well. High scorers seem to have a more balanced distribution between all the AOIs. This can be seen in the relatively even breath of the outer rings in Figure 4-42. What is very interesting is the high density of transitions seen in the average group. If the cord diagrams for the three groups are compared this can be seen in the high number of thin lines running between segments on the outer rings of the diagram representing the different AOIs. This could be attributed to average scorers including more additional information in their maps, as can be seen in the higher number of indicated AOIs, or to a tendency to reread information in texts as was already discussed. These diagrams do not indicate any other findings that have not already been discussed, they merely represent the information in a visual way, allowing the reader to see different processes instantly.

4.9. Summary of key findings

The key findings related to the components of the summary mapping task (reading, selecting information and mapping) that were illuminated by the analysis of the data are firstly, that there

seems to be a lack in the overall level of text comprehension among participants. The fact that an average score of 56% was obtained for the comprehension test indicates that participants could only demonstrate that they understood about half of the information in the text for this study. Furthermore, even high scoring participants could only manage an average score of 38.9% for the inferential comprehension questions in the test (which is very similar to the average scores of the other 2 groups). These results indicate that comprehension (at the required level to complete a summary map) could be a major challenge for students.

Secondly, the correlation between specific knowledge of vocabulary items and summary mapping is also a prominent finding. Inadequate vocabulary knowledge hindered the participants in their map development and could also hamper their ability to express ideas in their own words. Although it would be sufficient for students to populate summary maps with key words from the text, they are encouraged to use their own words in order to further facilitate internalisation of the information and to ensure that this tool can be used optimally as a study tool.

Thirdly, the correlation between the amount of selected information and the obtained summary map scores indicates that the ability to differentiate between essential and non-essential information is a critical step in the mapping process. Participants who failed to do so also scored low in the summary map as a whole. Identifying essential information is a cognitively challenging task which is also closely related, in the first place, to an optimal level of understanding of what one reads. Considering that the analysis of the act of reasoning also indicated that the lower scorers found the task more challenging, it seems fair to assume that comprehending the text to such an extent that one is able to determine the most essential information from a text is a major challenge for such participants. Subsequently, inadequate levels of text comprehension would also have a major impact on the ability to make judgements about the selection and categorisation of information at different levels of importance, a difficulty that is confirmed in the fourth major finding below.

With regard to the fourth prominent finding, lower scorers in particular struggled with the act of categorisation, either failing to categorise the information at all or categorising the information illogically. From the analysis it is evident that lower scoring participants struggle especially with organising higher level ideas, in other words, information on Level 1 and Level 2 in a summary map. Although this challenge can once again be attributed to participants' inability to attain a deep level understanding of the text, it would not be wise to assume that this is the only possible explanation for this difficulty. This can be said based on observations of participants P05 and P11 in particular as discussed in Section 4.6. These participants achieved similar scores in the summary map and they scored within 6% of each other in the

comprehension assessment, but one participant displayed superior categorising abilities. This observation shows that inadequate comprehension may not the only attributing factor influencing categorising ability and that it could be just as challenging for students with an ample level of comprehension.

The findings related to the observed process of mapping indicate that low scorers seemed to spend more time on the act of reasoning than the other groups as already mentioned, indicating once more that they found the task more challenging than the other groups. Furthermore, low scorers seemed to struggle to fully understand and internalise the text despite it not being their first encounter with the text (having read it before in an earlier phase of the experiment when they completed the comprehension test). This was seen in the way these participants needed to reread the text during the summary mapping process. High scorers generally did not need to reread the text as often and managed to perform certain acts like selection of information and reading the text simultaneously. The process that average scorers followed was similar to high scorers during the part of the task that involved reading and selecting information but they mimicked the process of lower scorers for the part of the task that involved the drawing of the summary map. This could indicate that even though they initially felt content with their understanding of the text and moved on to the mapping task, they in fact needed to reread the text often during the mapping process in order to confirm that they understood the text correctly.

A summarised table indicating challenges experienced by the groups of participants in the current study is included in Table 4-19 for easy reference.

	Low Scorers	Average Scorers	High Scorers
Sufficient vocabulary knowledge	X	X	
Deep level understanding of the text	X	X	X
Identifying essential information	X	X	
Categorising information and completing summary maps	X	X	

Table 4-19 Challenges experienced by participants in the current study

In order to address the identified difficulties experienced by participants, teaching strategies for summary mapping would need to focus on the four abilities included in Table 4-19 if students are to master summary mapping abilities. From this table, it is evident that there are challenges in every section or part of the summary mapping task but not for all the groups. What is however important to remember is that although a comparison is drawn between the groups for the purposes of the study even the group considered high scoring did not fair well in terms of overall academic standards. The overall averages per group are included in Table 4-20.

	Overall average	High scoring group	Average scoring group	Low scoring group
Average summary map scores	33.4	54.6	35.8	9.2
Average selection scores	34.0	55.3	23.9	19.9
Average comprehension test scores	56.2	63.9	51.9	53.8

Table 4-20 Challenges experienced by participants in the current study

This table clearly illustrated that the overall averages for all the parts of the experiments are low in terms of general academic standards even though the comparison in Table 4-19 indicated that for this particular sample the high scorers did not find vocabulary, identification of essential information and categorisation particularly challenging they could still benefit from techniques aimed at improving these skills.

4.10. Conclusion

One of the most prominent findings in the data analysis indicates that a major challenge for participants is the deep level comprehension of the text. This is especially significant because without a deep level of comprehension, the subsequent steps in the process of summary mapping will become more difficult, as is also borne out in the data analysis. This can be seen in the way low scoring participants struggled to identify essential information in the text and to categorise the information into a logical structure. This means that essentially every step in the process of summary mapping, to some extent presented a challenge for the participants,

arguably because they were only partially able to show competency in the first step in the process. The findings in this chapter should not only contribute substantially to improving the teaching of summary mapping skills in the academic literacy intervention at the VC of the NWU, but also have the potential to be used productively in other contexts in tertiary education where similar challenges are experienced. The following chapter presents a proposed teaching model for summary mapping, based on the findings in this chapter. This model will further be applied to the way in which summary mapping is currently being taught at the VC in order to suggest a more optimal teaching strategy for the ability.

CHAPTER 5 A PROPOSED TEACHING MODEL FOR SUMMARY MAPPING

5.1. Introduction

In this chapter, research question 2 stated in Section 1.5 will be answered and recommendations for an optimal teaching model to improve students' ability to complete relevant summary maps will be provided. Addressing the identified challenges will necessitate not only a model for teaching summary mapping specifically, but some of these challenges will need to be addressed in other sections of the academic literacy offering at the VC of the NWU. In the following sections, each of the indicated challenges will be discussed in terms of possible methods that can be applied in a teaching strategy for summary mapping in order to address them adequately.

5.2. Improving vocabulary knowledge

Many of the identified challenges ultimately lie within the realm of reading ability. Grabe and Stoller (2019) have divided an explanation of skilled reading into two parts: lower-level processes and higher-level processes. "The lower-level processes represent the more automatic linguistic processes and are typically viewed as more skills-oriented. The higher-level processes generally represent comprehension processes that make much more use of the reader's background knowledge and inferencing abilities" (Grabe & Stoller, 2019:13). Because both vocabulary and deep level comprehension can be considered challenging for students it is important that an intervention addresses the development of reading ability in terms of both these areas of difficulty. An adequate level of vocabulary knowledge (in other words, word level understanding) speaks to lower-level processes and it is often assumed that students, when entering university, have this level of knowledge. It should, however, be kept in mind that English, as it is used in a tertiary academic context, differs from everyday use of the language. Nguyen (2009:12) explains that one of the major characteristics of academic English is that it is:

> for the most part, a written language. In general, it is confined to the realm of the serious: textbooks, academic or technical works, and most essays at university. Academic English tends to be impersonal and precise, and often uses long, carefully constructed sentences; the formal writer will avoid contractions and abbreviations and will use a more specialized and complex vocabulary than that employed in everyday speech.

This is very different from the spoken English used by even well-educated and fluent users of the language.

The text, in other words, need to stand on its own. The sender is not present to ensure that the message is understood correctly by the receiver. It is, therefore, important for lecturers not to assume that students, even if they are first language users, have adequate academic vocabulary knowledge.

In the context of the NWU, the majority of the students use English as an additional language, with the accompanying challenges it presents. Research by Leibowitz (2004), Paxton (2007) and Leso (2018) mention that students who use English as an additional language have much greater challenges with acquiring academic literacies. A focus on productive teaching strategies for vocabulary acquisition should therefore be considered as a crucial first step in eventually reaching the goal of students being able to construct appropriate summary maps that would enhance their capacity for learning at university.

One such strategy is the acquisition of a broader vocabulary. The correlation found between vocabulary knowledge and summary mapping in the current study is not unique and a broader vocabulary seems to influence summary skills in general. Coullie (2020:45) states that "inevitably success in summarising and paraphrasing will depend on students' command of vocabulary so that they can put others' ideas into suitable alternative words". Although students completing a summary map could make use of key words from the text to populate their maps, the use of their own words is encouraged as it reinforces understanding and internalising of information. To use the tool optimally as a tool for studying will ultimately also require students to use their own words as they may want to flesh out their initial summary maps with additional knowledge as their understanding of their disciplines grow over their years of study.

Kato (2021) also found that the size of participants' vocabulary knowledge measured by Nation's (2007) Vocabulary Size Test "was positively correlated with their English summary performance" (Kako, 2021:77). The Vocabulary Size Test (Nation & Beglar, 2007) measures written receptive vocabulary size. It therefore seems that the broadening of vocabulary does have a positive effect om summarising skills, which is related to summary mapping skills. Folse (2010:139), however, concluded that despite the need for and importance of vocabulary teaching, "it is indeed still neglected by many teachers", as the amount of explicit vocabulary focus in a week of classes he observed was surprisingly low. Taking this into consideration, focusing on improving the vocabulary knowledge of students in an intervention such as ALDE111 may be a valuable contribution to a teaching model for summary mapping.

There are numerous approaches to improving the vocabulary knowledge of students. As part of the current ALDE111 offering, students are taught to deal with unfamiliar vocabulary in three ways: The ALDE111 study guide (Butler, 2019) lists the following strategies for dealing with unknown words in a text by:

- Trying to work out the meaning from the context (making inferences);
- Using the root of the word to work out its meaning; and
- Using a dictionary if the other two strategies do not work. (Butler, 2019:43)

This approach is helpful to students if they are confronted with an unfamiliar word in a text that they are reading, but it does not actively focus on improving the students' vocabulary knowledge. This approach, in other words, does not challenge them to actively work on acquiring new vocabulary or to widen the vocabulary knowledge of the words they do know. It only encourages them to deal with unknown words, in case such words occur in a text. For Fan (2003) vocabulary learning strategies consist of five steps: (1) to come across the word; (2) to establish a visual or auditory image that can be associated with the word; (3) to learn the definition of the word; (4) to make a strong memory link between what the word looks like and what the word means; and (5) to use the word. When one compares this definition to the current strategy for dealing with unfamiliar words in the ALDE111 module, the strategy deals with the first three steps, but memory and retention strategies are not necessarily addressed explicitly. Addressing the final two steps as part of the academic literacy offering has the potential to deepen the vocabulary knowledge of students, which should subsequently not only improve the overall comprehension of texts, but also summary mapping abilities. Students should, therefore, understand better what exactly to summarise as well as have the vocabulary to express ideas in their own words if they choose to do so. This could be achieved by altering the current vocabulary assessments used in ALDE111 to not only include questions on recognition and definition of words, but to also test memorisation and use of the words that are dealt with in the assessments. Furthermore, one could productively address the final two vocabulary deepening steps proposed by Fan (2003) by assessing these in a covert or more integrated way by scaffolding assessments in such a way that it builds on one another. If, for example, the comprehension of a word was assessed in a vocabulary assessment in week 2 of the semester, a subsequent comprehension assessment could be designed to test the memory and use of the same word in a following week, thereby assuring that all 5 steps of the strategy are addressed sufficiently.

To further enhance and broaden students' vocabulary, the use of word lists can be beneficial, especially for second language learners. Folse (2004:2) mention that: "Using simple vocabulary lists can yield better vocabulary retention than relying on lists with more

information, e.g., example sentences". Although this strategy relies on rote learning, a technique that students may not find engaging, it is evident from the literature that it does have positive results in terms of vocabulary learning (Laufer & Shmueli, 1997; Prince, 1995; Hoshino, 2010). What is significant, however, in terms of using word lists to improve vocabulary knowledge, is that in the mentioned studies it is stated that the participants were highly motivated to learn new languages or to apply their new language skills in, for example, a teaching context. This may not be the case in the context of AL at the NWU as students may feel that they are proficient enough in the English language or may underestimate the level of academic English vocabulary knowledge that is needed to succeed at tertiary level. This inference is made based on the results of a recent Beginning University Survey of Student Engagement (BUSSE) report stating that the majority of students who completed the survey feel they are very prepared (highest level of the scale) "to write clearly and effectively" and "speak clearly and effectively" in their academic work at university. Given the high percentage of students that historically show risk in terms of academic literacy ability at the beginning of the first year of study, this is clearly a perception of students who are unfamiliar with the demands of using a language productively for study purposes at university.

A major part of lecturers' success in the endeavour to broaden and deepen the vocabulary knowledge of students will rely on sufficiently motivating them to do so. One way to partially addressed this issue of motivation is to include more modern, on-line approaches for vocabulary acquisition, that may resonate with the current student cohort. In an environment where there is increased pressure on universities to follow a hybrid or more on-line based approach to teaching, several vocabulary-learning applications have emerged (Chen *et al*., 2019). Not only have such applications been proven to be effective for vocabulary acquisition but they have also been shown to motivate students (Zou *et al*., 2018). Furthermore gamification or using game-like applications to improve vocabulary and motivation could also be beneficial. Gamification can be defined as "the application of digital game mechanics to non-game situations to motivate users' behaviors" (Lam *et al*. 2011). Similar blended learning approaches have been found successful.

The improvement of vocabulary knowledge is, however, a continuous activity that should be considered as an ongoing endeavour. It will be important for students to understand that this is not a once-off activity and for them to be motivated enough to continuously attempt to acquire a broader and deeper vocabulary, even when their vocabulary knowledge proves to be sufficient for the tasks provided in academic literacy modules. If this can be achieved, the other recommendations in this chapter will ultimately be more successful.

5.3. Improving deep level comprehension

There seems to be consensus in the literature (as discussed in Section 2.1) that comprehensive reading is one of the most significant skills one should acquire in terms of academic development. Regarding this important reading ability Franzke *et al*. (2005:4) state that "[f]ailure to read with complete and deep comprehension may interfere with the educational progress of many students throughout their school years and for some even into college". In the same article they further mention that:

> All too often readers will adopt a passive stance towards instructional reading, especially when reading expository texts about unfamiliar and conceptually difficult topics … Instructional text may inadvertently reinforce passive reading by over-emphasizing ease of readability. Superficial learning is the result, which leads to poorer than expected performance on tests or in situations that require one to apply what one should have learned. Ultimately, the failure to read with mental engagement becomes a major obstacle to academic progress as students encounter more difficult materials (Franzke *et al*., 2005:4).

This comment supports the finding of the current study that reading with a deep level of understanding results in a major challenge for students. However, one way to counter this passive stance towards reading is to teach active, comprehensive reading strategies that lead to the deep level understanding of text that is required at tertiary level.

Comprehensive reading is furthermore considered a higher-level process that requires the reader to make use of background knowledge and make inferences. Numerous theories on text comprehension differentiate between deep and surface level comprehension. (Gernsbacher, 1990; Kintsch, 1998; Van den Broek, *et al*., 1999; Franzke *et al*., 2005). The Kintsch theory can be explained as follows:

> Initial comprehension processes typically involve creating a coherent *textbase* from the words and sentences in the text. This *textbase* reflects both the local meaning relationships between individual sentences or propositions - the *microstructure* - and the global relationships that pertain between groups of propositions - the *macrostructure*. The *textbase* is basically what students or participants in an experiment produce when asked to recall the content. No normal text is entirely coherent, that is, with all the semantic relations spelled out. Hence, readers must infer these relationships with gap filling inferences, for example, relating pronouns to the proper referent, establishing the identity of synonyms, at the *microstructure* level, or the relation of a particular example to a superordinate topic, at the *macrostructure* level. Depending on a reader's knowledge and verbal skill, such inferences occur quite automatically during reading. Deeper level comprehension involves the construction of a situation model of the text meaning, that is, a memory representation that also includes multiple links to related information in

> readers' own knowledge base. The situation model thus refers to how the reader understands the situation described in the text in the light of what he or she knows of the topic (Franzke *et al*., 2005:4).

This description is particularly relevant for the current study as it explains the level of comprehension that is required to complete a summary map. As is evident from the findings in Chapter 4, participants were able to demonstrate comprehension at "textbase" level. Most were able to correctly answer comprehension questions that assessed the literal comprehension level but were not able to obtain an adequate score for inferential comprehension questions. Based on this explanation, the "memory representation" is exactly what is achieved when a relevant summary map is created. A relevant, usable summary map is, in other words, a representation of deep level comprehension. This further explains why a lack of deep level understanding will influence summary mapping ability and reiterates the importance of teaching strategies for reaching a deep level of understanding of a text.

As already stated in Chapter 2, comprehensive reading is addressed in the academic literacy module at the NWU as part of four reading strategies. These strategies are addressed in isolation but the most time is spent on comprehensive reading. The ability is taught by demonstrating aloud how to read actively. A lecturer would display the text overhead and read it aloud with a marker or pencil in hand while performing a text analysis by underling key words in the text, making notes and annotations in the margin to summarise or categorise ideas, asking leading questions, pointing out linking devises and asking the students to explain sections of the text. Thereafter, students are asked questions about the text in order to guide them to a more comprehensive understanding thereof and to ultimately test their understanding. Judging by the results of the experiment done in the current study, the current approach to the development of reading should be further enhanced to support students to reach the required level of comprehension.

One approach to reinforcing deep level comprehension is to make use of summary mapping or other summarising techniques. According to Mohaidat (2018), several studies have investigated the impact of mind mapping on comprehension. The consensus is that mind maps have a positive impact on comprehension. Mohaidat (2018:3) states that:

> Stankovic, Besic, Papic and Aleksic, (2011) determined that the mind map was the most powerful tool that could be used to improve reading comprehension as it enabled the learners to see the relations and links between the main ideas and the sub ideas in addition to the details and notes related to these ideas. Peng (2011) conducted a study in which he found that e-mind map (a soft copy mind map that was completed using mapping software) increased the level of reading comprehension because it combined the two parts of the brain. Benavides, Rivera and

> Rubio (2010) found that the e-mind map increased the reading comprehension level. Siriphanich and Laohawiryanan, (2010); Liu, Chen and Chang, (2010); Kim and Kim, (2012); and Hofland, (2007) conducted studies on learners that learn English as a second language. They found that the use of the mind map was an effective strategy in improving the learners' reading comprehension level. The study of Siriphanich and Laohawiryanan (2010) reached the same results.

In these studies, mapping techniques are applied during the teaching of theoretical content (or texts) and in many of these studies they are applied to young learners. The used maps are, in other words, completed with the support of educators, moving through the text paragraph by paragraph and constructing the map as they work through the text. Although they are referred to as mind maps the discussion of the techniques seem to be very similar to summary mapping.

Using a summary map to improve comprehension may seem contradictory as one needs deep level comprehension skills in the first place in order to summarise effectively. Therefore, using these techniques to improve comprehension may seem paradoxical. However, since mapping can improve deep level comprehension, but students are not yet equipped to complete relevant summary maps without the support of an educator or facilitator, it may be beneficial to supply them with an ideal summary map of a text every time they are confronted with a new text during the course of the semester. This will allow students to read the summary map in conjunction with the text, showing links and categories of ideas explicitly. These explicit links can then be compared to the text where links may be more subtle, as is also stated earlier in the Franzke *et al*. (2005:4) study: "No normal text is entirely coherent, that is, with all the semantic relations spelled out". Showing these relationships in an explicit way may result in better comprehension. This would further provide the students with more examples of appropriate summary maps, something that may also contribute positively to their own production of summary maps. When students are then, later in the semester, taught how to construct a summary map, the concept will already be known to them and they would have seen an application of the technique. Furthermore, the way that summary maps also demonstrate how information is related in the text could benefit the acquisition of another important element of text comprehension, namely coherence relations.

As stated in Section 2.2 coherence relations are believed to be of vital importance with regards to comprehension. It would therefore, be safe to say that it is important to address coherence relations if one is to improve deep level comprehension. In the current ALDE111 offering coherence is addressed by making students aware of linking devices such as discourse markers and how they facilitate coherence in a text. Some examples are provided to show the

relationships and students are asked to identify the ideas being linked. According to Grasser *et al*. (2002), the mere awareness raising of connecting devices in a text will, however, not be sufficient. They advocate that: “It is not sufficient to spend a day or two giving a lecture on the taxonomy of coherence relations. The process of identifying and interpreting such relations will need to be *overlearned* to the point of being automatic” (Grasser *et al.,* 2002:22). This implies that similar to the broadening of vocabulary discussed above, the use of connecting devices will also need to be practiced continuously. This may seem like an easy recommendation to implement but given that the curriculum for the AL module is already very full, it may be challenging to find additional time to practice these skills. The need for additional practice does, however, offer an opportunity to incorporate interactive and gamification tools like ‘KAHOOT!’. This is a free, online multi-player real-time quiz game that allows students to practice concepts like discourse markers or identifying linking devices in an engaging and entertaining manner. It furthermore offers lecturers immediate feedback that measures how well students acquired and integrated information. Lecturers could then adapt their teaching accordingly. Not only has this tool proved to be effective in improving student motivation, it has also been used successfully to foster and reinforce learning (Lin & Maarof, 2018).

Using other summarisation techniques to improve comprehension may also be beneficial. According to Franzke *et al*. (2005:6), many studies have demonstrated that summary writing can improve text comprehension. This will, however, require students to practice the skill regularly but constantly having to review these tasks and provide feedback can become overwhelming for educators. Spending a large amount of teaching time on such an approach is often simply not viable if the limited amount of teaching time and the remainder of the AL module content that needs to be addressed is taken into consideration. In order to address this issue, Franzke *et al*. (2005:3) propose an automated “computer tutor that offers an opportunity for students to practice summary writing with instantaneous feedback that is enabled by Latent Semantic Analysis (LSA)”. This LSA system analyses how words are used in a corpus to then:

> automatically constructs a representation of meaning that mimics the way human knowledge is structured. The knowledge representation constructed by LSA is incomplete in many ways, since its knowledge is acquired only from written texts. However, since texts are mainly about human experiences, perceptions, and conceptualizations, given a sufficiently rich textual input LSA can judge the meaning similarity of two texts as reliably as two human judges (Franzke *et al*., 2005:7).

A computer application called Summary Street that uses LSA, was developed to help students improve their summary writing. Franzke *et al*. (2005:8) explain that:

> when a student submits a summary to Summary Street for evaluation, it is transmitted via the Internet for analysis at the LSA servers. Feedback is returned almost instantly in the form of an engaging graphic interface, which lets the user know to what extent the summary adequately covers the main ideas and what topics need more work. The student uses the feedback to improve his/her summary through successive cycles of revising and feedback requests until it satisfies the criteria for content coverage and appropriate length.

An approach like this could work well in many contexts, giving students the opportunity to practice the ability in their own time and only submitting higher quality summaries to lecturers periodically. In the context of ALDE111 where the focus is more on reading and not the writing of summaries *per se*, it could be used purely as a tool for practicing and improving comprehension and summaries would not necessarily be assessed.

5.4. Identifying essential information

In order to summarise effectively you need to comprehend the text you are reading, be able to distinguish between main ideas and supporting information and to then express that information in your own words (Hedgcock & Ferris, 2009). In a similar way that identification of main ideas is important for summary writing, it is also a key ability for summary mapping. For the current study, main-idea identification is seen as a step subsequent to comprehension. This is an ability that entails a judgement on the part of the student about what parts of the text can be considered essential. It is currently addressed as a step in the summary mapping process, a pre-activity that students complete before they are prompted to construct summary maps. Grabe and Stoller (2011), however, believe that an understanding of the main ideas of the text should be at the heart of L2 reading instruction. They explain further that:

> The terms ‘reading comprehension’ and ‘main-idea comprehension’ are sometimes used synonymously, … Technically, however, reading comprehension is a broader term. Reading comprehension can include understanding and retrieval of details, facts and examples. Reading assessments often measure reading comprehension by including questions about details and fairly minor facts. In addition, reading comprehension may include expectations about connecting many facts and ideas, some of which are main ideas, but some of which may be relatively local or minor. Overall, however, the most important aspect of reading comprehension is main-idea comprehension (Grabe & Stoller, 2011:140).

They, in other words, reiterate here that main-idea comprehension is an intricate part of reading comprehension. In a consideration of the possible improvement of how main-idea identification is currently addressed in the module, Grabe and Stoller (2011) offer suggestions

as to how this level of main-idea comprehension can be achieved. One of these suggestions involve class conversation:

> Main-idea comprehension is effectively developed through class conversations identifying and exploring main ideas in the texts that students are reading, noting ways in which information connects across parts of the text, building linkages between two or more readings, and promoting connections between ideas in the text and student background knowledge (Grabe & Stoller, 2011:141).

Their suggestion thus entails creating the opportunity in class for students to discuss the text and use their collective background knowledge to identify and fully comprehend the main ideas of the text. Discussions in a group, or cooperation in the classroom, is by no means a new approach (Barham, 2002; Pell, Galton, Steward, Page, & Hargreaves, 2007). A particularly relevant study is that of Marzbana and Akbarnejad (2012). They tested how effective cooperative learning was in improving comprehension and came to the conclusion that "students who work collaboratively, learn faster and more efficiently, retain information better and have a positive attitude towards learning" (Marzbana & Akbarnejad, 2012:941). If such an approach were to be followed for AL, it would have a similar goal and could therefore yield similar results. This approach could be beneficial in the context of the current study because it would allow students to practice main idea identification in a different way, making use of collective background knowledge and having the opportunity to negotiate and discuss inferences to reach adequate main idea comprehension.

Other suggestions by Grabe and Stoller (2011:142) include a focus on text structure analysis and lexical signals to help students identify where the main ideas may be situated and what they may look/sound like. In the current AL offering, text structure is addressed, but only later in the semester as an introduction to essay writing. It may be beneficial to create awareness thereof as part of reading instruction early in the semester.

The recommendations listed here have the potential to improve the ability of students to identify essential information in a text and thereby enable them to improve on summary mapping skills.

5.5. Categorising information

Another challenge that was identified by the study was the categorisation of information. The importance of students being able to categorise and hierarchically organise information is reiterated by Ifenthaler *et al.* (2010). These authors suggest that guiding students to develop

the ability to hierarchical map out information might be beneficial in that it could help them to cognitively arrange and visualise the information.

From the analysis it is evident that participants struggled especially with identifying higher order ideas. One technique that could be beneficial in this regard is to demonstrate to students how a paragraph is constructed to include a main idea, how that idea is then further elaborated or supported, and how examples are used to illuminate the statement further. Focusing on the structure of paragraphs as well as the structure of the complete text (for example, how headings relate to the content of the paragraph as also suggested in the previous section) may draw specific attention to how information is presented. Increasing student awareness of text structure could, therefore, also assist in their categorising of important information. This could be demonstrated further by giving students different versions of the same text, but in each example adding more information to each level/category. In other words, a first example could contain only main ideas. A subsequent example could include the main ideas and supporting ideas in the text, and then one could present the complete text. This will draw attention to how a text cannot include a list of main ideas only but needs to include further explanation of such ideas. At the same time, one could sensitise students to how the different levels of information are categorised. Although this is already addressed in the ALDE111 module it is clear that more time needs to be spent on this part of the summary mapping process and that assuming that students will be able to categorise information after a short amount of time and little practice is not beneficial. How practical and logistically viable this solution is in terms of the already fully loaded ALDE111 offering remains to be seen.

Kuhn and Dean (2004:270) mention that metacognitive development is important and recommends that students be prompted to reflect on and evaluate their activities, and that techniques like asking probing questions about the activities may help students to focus on their activities and rethink the strategies they apply for completing tasks. If this approach could be applied to the summary mapping process it may ultimately lead to better organisation of summary maps. This relates to the finding stated in Chapter 4 that participants with higher summary mapping scores had a more holistic, or bigger picture approach to the task of constructing a summary map and did not go about it in a haphazard, stream of consciousness way like observed novices in the Dogusoy-Taylan and Cagiltay (2014) study. In other words, prompting students to reflect on their approaches to the task at hand could make them more aware of shortcomings in their approaches and ultimately guide them to a more appropriate strategy for categorising information. Many scholars recognise the value of reflection in teaching and learning (Maree & Van Rensburg, 2013; O'Farrell & Fitzmaurice, 2013; Mantzoukas, 2007; Ryan & Ryan, 2013). Reflective writing in the form of journaling is often

used, but Ryan and Ryan (2013) suggest that reflection should go beyond reflective writing, which can be superficial. Van Rensburg *et al*. (2018) advocate for a more critical approach to reflection that goes beyond a description of the event or activity to an evaluative position that critically judges what had happened and why it happened in order to improve learning and transform practice (Van Rensburg *et al*., 2018). One technique for achieving critical reflection is called a critical incident. According to Billings and Halstead (2012), a critical incident can be described as a technique used for reflection that prompts students to describe and analyse a specific meaningful occurrence in the classroom. If this is applied to the summary mapping task the different parts of the task can be analysed separately to determine a meaningful experience/occurrence in the process, helping students understand exactly where they can improve. According to the University of Edinburg (2023) there are many ways to set up such an assessment or activity. Longer, formal assessments can be used that calls for the comprehensive writing of a reflective essay or simple activities can be done that helps the student first create a sense of self awareness. Examples of such activities include writing a letter to your past self, asking oneself what skills/strengths made you capable of succeeding or what weaknesses may have contributed to an unsuccessful experience, or asking oneself what else could have contributed, until you cannot find anymore.

Reflective activities such as these may be beneficial not only for the improvement of categorisation abilities but for the improvement of the entire process. Activities such as these need careful planning and should be well suited to the context which it is to take place in (Van Rensburg *et al*., 2018). Introducing such an activity into the summary map teaching plan can be beneficial but will ultimately mean that time needs to be spent on the reflective activity as well as opportunities for students to then improve on any issues that may have emerged from the reflection. If this is possible a reflective activity could help improve summary mapping abilities of students.

5.6. Teaching summary mapping as a summarising skill

Numerous scholars (e.g., Hirvela & Du, 2013; Cordero-Ponce, 2000; Rose, 2001; Lin & Maarof, 2013; Kirkland & Saunders, 1991) all agree that summarisation can be considered a highly complex and cognitively demanding skill. In order master this complex ability both L1 and L2 speakers will require intense training (Kellogg & Whiteford, 2009). Because summarising is such a complex ability it is considered to be challenging to master for most second language learners. Kirkland and Saunders (1991) state that summarising is not a skill that will come readily to L2 students. Mohammad Hosseinpur (2015:70) similarly states that: “in these aspects, summarization is ‘one of the most demanding and challenging academic

activities' for EFL students". Because summary mapping is essentially a summarisation technique, the same skills will be necessary to complete an appropriate summary map. For this reason it would be fair to say that summary mapping could be considered a challenging academic activity. Even if the recommendations mentioned above for the improvement of vocabulary, deep level comprehension as well as identification and categorisation abilities prove to be effective, summary mapping should still be taught explicitly, especially to second or additional language speakers as it is done currently in the AL offering. This has also been reiterated by Frey *et al.* (2003:43) in stating that:

> it is worthwhile to utilize direct instruction of summary writing for struggling writers (Hare & Borchardt, 1984). Like other types of writing, improvement in summary writing is particularly resistant to a trial-and-error approach—a position that resonates in Fearn's admonition that "practice doesn't make perfect—practice makes permanent" (personal communication, August 1, 2001). As well, Hill (1991) reminds us that summary writing is more complex than it may first appear, but that when explicitly taught, these writers make progress.

The statement by Frey *et al*. (2003), in other words, emphasises that it is important to teach summarising skills in an explicit way and that it takes a substantial amount of practice to master.

The teaching strategy that is currently employed for summary mapping in the ALDE111 module addresses the steps to summary mapping in isolation, focusing firstly on supporting students with the learning of specific reading strategies. Secondly, it focuses on identifying main ideas in the text and selecting essential information, prompting students to write these ideas in the form of a list or table and, lastly, students have to draw the actual summary map. Thus, students are currently being taught summarisation skills, but these different steps or abilities are taught separately in a fragmented way across more than one study unit.

Coullie (2020:43) offers two relevant methods for effectively teaching summarising. The first suggestion is the application of a strategy by Denton *et al*. (2012:125) that includes the following six steps:

1. List the main idea for each paragraph;
2. Underline main idea statements;
3. Combine any ideas that could go together;
4. Number ideas in logical order;
5. Write a summary in one paragraph; and
6. Edit the paragraph.

This strategy is similar to the current summary map teaching approach with the exception of the last 2 steps not being a summary paragraph but a summary map. The difference is that the Denton (2012) approach offers a step-by-step guide to summarising. In the ALDE111 offering, summary mapping is not approached as a step-by-step guide in the sequential way suggested. Providing students with an explicit model like the Denton (2012) approach could be beneficial in that it creates specific steps for students to follow, making the teaching thereof more explicit and easier to understand. A step-by-step strategy for summary mapping, based on the Denton approach could look as follows:

1. Read the text actively.
2. Clarify unknown words and concepts for yourself.
3. Read each paragraph again and underline the sentence that contains the main idea of the paragraph.
4. Indicate supporting ideas by numbering/hi-lighting them.
5. Indicate examples by numbering/hi-lighting them.
6. Combine any main ideas together that go together.
7. Draw a diagram and plot your main ideas closest to the theme block of your summary map. Write down a summarised version of the main ideas into the blocks.
8. Now draw all supporting idea blocks that flow from your main ideas and write down a summarised version of the supporting ideas into the blocks.
9. Lastly draw example blocks that flow from your supporting ideas and write down summarised examples of these into the blocks.

The second suggestion offered by Coullie (2020) is the use of effective summary models as examples. Coullie (2002) emphasises that students could gain from seeing both good and bad examples of summaries. The use of lecturer completed example summary maps that accompany texts used in the class has already been discussed earlier in the chapter. This suggestion of also exposing students to inappropriate summary maps or having them assess the usefulness of both good and bad examples of summary maps may hold further benefits.

If all the challenges that students experience regarding abilities that precede the teaching of summary mapping (i.e. inadequate vocabulary knowledge, not understanding texts at a deeper level and having difficulty in identifying and categorising essential information) can be addressed first and thereafter summary mapping can be taught in an explicit manner as a summarising skill, it should enable students to use summary mapping to its full potential.

5.7. The optimal teaching model for summary mapping

The recommendations in the preceding section find considerable support in the literature and is discussed within the context of the AL intervention offered at the NWU, where the study is situated. These recommendations will, in the subsequent section, be integrated into a more generalised teaching model that could also be used in other contexts to support students in mastering summary mapping abilities. The model is firstly presented as a flow diagram in Figure 5-1, after which a comprehensive discussion thereof will follow.

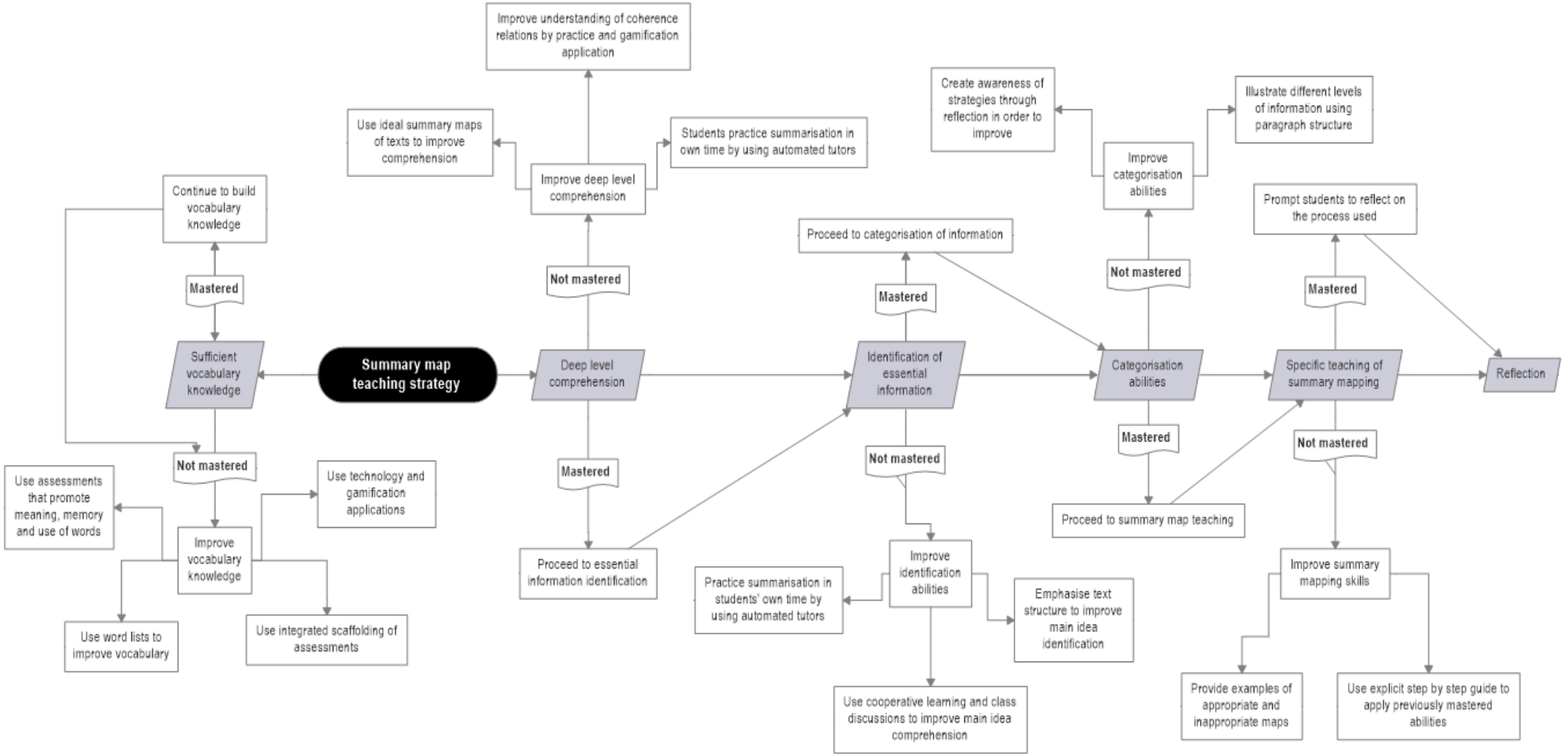


Figure 5-1 Process diagram depicting a teaching model for summary mapping

The proposed model in Figure 5-1 approaches the teaching of summary mapping in a sequential manner, ensuring that students master one ability before moving on to the next. In the process flow chart above the steps can be followed and, in each instance, a subsequent step is suggested based on whether the current task or ability has been mastered.

Referring to the model, vocabulary learning is placed on the left of what would be considered the start of the diagram. It does not form part of the larger sequence of tasks flowing to the right but should rather be seen as an overarching element that should be addressed throughout the duration of teaching. Students should constantly be motivated or prompted to apply strategies that can deepen and broaden vocabulary knowledge. These include broad vocabulary assessment that move beyond recognition and definition of words into memorisation and use of words, using word lists and using technology to improve vocabulary knowledge. Even if the student can demonstrate such knowledge to the point where it is considered to have been sufficient in terms of what is needed to complete an academic literacy module, the model suggests that students continue to gain vocabulary knowledge since it is considered a valuable academic pursuit to constantly improve vocabulary knowledge.

The first ability in the teaching model sequence is for students to acquire a deep level of understanding while reading. If this has not been mastered yet, three suggestions for improvement is proposed, including the use of example summary maps that accompany texts to improve comprehension as well as addressing coherence relations in an adequate and repetitive way until it becomes exceedingly familiar to students. Gamification applications and technology can also help to improve the understanding of coherence relations. Automated software to help students practice summaries in their own time can further be useful and depending on the context in which this model is used, these practiced summaries can also be assessed. Once deep level understanding of a provided text can be demonstrated, the next ability can be addressed. As is evident from the discussion earlier in this chapter, a deep level of textual understanding is particularly difficult to master and may require an extensive amount of time to develop adequately. This ability is not only key to successfully acquiring summary mapping skills but is also essential for academic literacy in general. It is therefore crucial that students be afforded a fair chance of mastering this ability, in terms time and effort spent on the acquisition of the ability.

Once this level of comprehension is mastered, the next ability addressed by the model is identification of essential information. Suggested ways to improve this ability include improving main idea comprehension through cooperative engagement and class discussions as well as using text structure to help students identify sentences that contain main ideas. The continuation of summarisation practicing is further recommended at this stage as it should

also improve students' ability to comprehend and identify pertinent information in texts. Upon mastery of this ability, the following ability to be addressed is that of the categorisation of information.

If the ability to categorise information has not been mastered yet, recommendations for improvement include the use of paragraph structure to illustrate different levels of information commonly included in texts as well as using specific reflection activities to guide students to areas of improvement and to then provide opportunities for them to improve, whether it be categorisation abilities or other abilities in the process. Reflective activities will only be possible after the entire summary mapping process has been completed but will nonetheless be useful for further improvement of the strategy.

The last step in the teaching model involves finally teaching summary mapping in an explicit step by step way involving the application of all the previously mastered abilities. The use of example summary maps can also be beneficial at this stage, not only to help students master the final step, but also to encourage critical analysis of summary maps. This could further help students when they complete the final reflective activity indicated by the model to engage critically with their own summary maps.

In an application of the proposed model, it may be found that students move more rapidly through the model once they have mastered the capacity for deep level understanding because this ability can also influence all the subsequent abilities. One should, however, be cautioned against the temptation of skipping abilities in the sequence since, although deep level understanding is crucial in the process of summary mapping, it is not the only ability involved in successful summary mapping, as the study has pointed out.

5.8. Conclusion

The success of the proposed model rests heavily on the ability of users to successfully teach strategies for deep level comprehension and to allocate an ample amount of time for students to master this ability. This challenge seems to be the cornerstone of not only summary mapping abilities but academic literacy abilities in general. The immediate concern in the context of the NWU is that there may not be ample time to properly address the issue of deep level comprehension as it is a skill that needs to be practiced and honed over time. If there is not enough time to address the issue of deeper level comprehension, students will not have the opportunity to be fully prepared to proceed to the subsequent steps in the summary mapping process. If this can, however, be achieved, the subsequent tasks should be less challenging for students at the onset, which will in turn greatly improve their chance of

mastering them as well, thereby ultimately mastering summary mapping. Only then would the teaching of summary mapping enable students to fully reap the benefits of this useful study tool.

CHAPTER 6 CONCLUSION

6.1. Introduction

This study has reiterated the notion that students entering tertiary education are often underprepared in terms of the academic literacy abilities required to complete a degree successfully. In order to support these students, the NWU offers two academic literacy support modules in the first and second semester of the first year of study. In the first semester module students are introduced to strategies that help them access, process and produce information. As part of this offering, summary mapping is introduced as a summarising skill that involve all these abilities. Despite efforts to successfully teach summary mapping, students continue to struggle with completing such maps, hindering them from using this tool optimally towards their studies. The purpose of this study was to investigate the process of mapping in order to determine which part/s of the process is challenging for participants or what process causes a participant to produce a relevant, useful summary map. In the first chapter the following research questions were posed:

1. How (what process) do students (use to) create summary maps to summarise information for learning?
   a. How do students' comprehension levels of texts, relate to their production of a summary map?
   b. How do students' ability to select the relevant information in a text relate to their production of a summary map?
   c. How do students' ability to organise selected information into a logical structure relate to their production of a summary map?

2. What are the implications of the findings for the teaching methods used to teach summary mapping abilities?

Eye tracking has not been used in many studies that relate to summary mapping, although it lends itself particularly well to the investigation of this process because it has been used to study separate elements of this process previously. This method, together with the use of data sets collected with other research instruments enabled the researcher to gain insight into the process followed by participants and not only the summary map that was produced. In this study a literature review was included to point out where in the current body of research this

study would provide useful insight. An empirical investigation was also conducted, based in part on prominent aspects identified in the literature review.

This chapter will provide a concluding overview of the findings of the study and what the implications are for summary map teaching. The limitations of the current study will also be discussed as well as avenues for further research.

6.2. Overview of the current study

In the first chapter the issue of underprepared students entering university as well as the importance and relevance of teaching summary mapping as an academic literacy tool was discussed. Reference was also made to how challenging the task of teaching such an ability is, especially if it is to be taught in such a way that it enables students to use the tool to its full capacity. Eye tracking was presented as a feasible method for investigating the process of summary mapping and the approach to the study was briefly discussed, stating that eye tracking could be used in conjunction with other data sets to answer the research questions of the study.

The second chapter comprises an overview of existing research conducted in the field of mapping and eye tracking as well as the limited number of studies combining the two fields. The theoretical foundation of summary mapping was discussed starting from Ausubel's (1963) theory on cognitive organisation which stated that new knowledge could only be acquired if it is linked to or organised in relation to what is already known. Ausubel then developed a technique called advance organisers and this work formed the theoretical foundation for three major lines of research into mapping, each with its own type of map. A summary map, as it is referred to in the current study, is primarily a summarisation technique and was also categorised as such in the provided comparison between different map types.

The relation between reading and summary mapping was furthermore discussed in the chapter, starting with a discussion on how reading is the most common way of accessing information in an academic context. It is therefore the main focus of the ALDE111 support module. In order to complete a relevant and well-structured summary map one needs the ability to read comprehensively but this is not the only ability that is required for summary mapping. Summary mapping also requires a great deal of processing and ultimately also production of information in a diagrammatical form. Novak and Gowin (1984:49) state that the representation of important information in a diagrammatic structure not only teaches students to differentiate between essential and non-essential information like numerous other summarising techniques, but also enables the student to arrange the information into a

structure that makes logical sense which, subsequently, makes it easy to recall. This reiterates the usefulness of teaching this technique as part of an academic literacy support offering.

Eye movement research was the next section that was discussed in Chapter 2. Although the measurement of eye movements and the subsequent interpretation of set movements are used in many fields such as reading research, it is not used very often to investigate mapping. This section in Chapter 2 pointed out that the way participants move their gaze between points within particular relevant areas of interest is very relevant because the duration of the gaze could be indicative of what the brain processes at that particular moment in time. This information, combined with the additional data sets in this study provided valuable insight into the cognitive processes taking place during summary mapping.

The small number of studies that have made use of eye tracking to investigate mapping were discussed in the subsequent section of Chapter 2. The most relevant study states that “the nature of the CM [concept map] development process is not a well-studied issue for researchers ...” (Dogusoy-Taylan & Cagiltay, 2014:82). The current study is, therefore, situated at this juncture and offers valuable information that could potentially improve summary map teaching.

The study set out to investigate the posed research questions by firstly testing the level of comprehension of the participants using a comprehension test based on a chosen text. Thereafter they were requested to indicate the most important information in a section of the chosen text and to then draw a summary map of the selected information, while their eye movements were being recorded by an eye tracker. The data was analysed statistically to determine any correlations. The processes followed by participants were also coded and compared.

6.3. Summary of findings

The summarised findings of the study will be presented in two separate sections in this concluding chapter. Section 6.3.1 will summarise the findings that addressed the first three sub-questions of the study and Section 6.3.2 will focus on the two main research questions of the study.

6.3.1. Section 1 Summary of findings addressing sub-questions

In terms of how comprehension levels, selection of essential information and organisational abilities relate to summary mapping ability, the findings illuminated by the analysis of the data

show firstly that there seems to be a lack in the overall level of text comprehension. The low average comprehension test score indicates that participants could not demonstrate the high level of understanding that is required to complete a relevant and useful summary map of a text. The correlation between comprehension (including vocabulary) and summary map scores further show that a low level of comprehension prevents optimal performance in a summary map task.

The observed correlation between the amount of selected information and the summary map scores, secondly, indicates that the ability to differentiate between essential and non-essential information is a critical step in the mapping process and that participants who failed to do so also scored low in the summary map task.

Lastly, low scorers struggled with the categorisation of information. Participants either failed to categorise the information at all or failed to categorise the information logically. The difficulty experienced by participants could be attributed to the lack of deep level understanding of the text, but based on further investigation it could not be assumed that this was the only cause. Participants seemed to struggle especially with higher level categorisation, and this impacted severely on summary mapping ability. In Table 6-1, the observed correlations and conclusions that pertain to the sub-questions of the study are summarised.

Element of mapping task	Observed correlation		Summary map score
Comprehension levels	r = 0.539	Significant correlation	Summary map score
Selection ability	r = 0.682	Significant correlation	Summary map score
Categorisation ability	Only 38% of participants were able to categorise information effectively and they were in the top 3% of summary map scorers.		Summary map score

Table 6-1 Summary of correlations pertaining to sub-questions posed

From these findings it is evident that all steps in the summary mapping process were challenging for participants and should therefore be addressed in a teaching model for summary mapping.

6.3.2. Section 2 - Summary of findings addressing the main research questions

6.3.2.1. Question 1 – How do students create appropriate summary maps to summarise information for learning?

From the findings related to the frequently observed acts during the process of mapping, it was determined that lower scorers spent more time on the act of reasoning. This could indicate a difficulty in dealing with the task, in other words, showing that lower scorers found the task more difficult. Furthermore, lower scorers seemed to struggle to fully understand and internalise the text despite it not being their first encounter with the text (the text was read during an earlier phase of the study). This was seen in the way these participants often needed to reread the text during the process. High scorers generally did not need to reread the text as often as low and average scorers. The process that average scorers followed was similar to high scorers during the part of the task that involved reading and selecting information, but they mirrored the process of low scorers for the part of the task that involved drawing the summary map. This could indicate that even though they initially felt they understood the text and moved on to the mapping task they in fact needed to reread the text often during the mapping process. Figure 6-1 presents a summarised version of the recorded acts during the process has been included. In this figure the detailed list of observed acts has been categorised according to the three main tasks in the summary mapping process, namely reading, selecting information and writing for the three groups. In this simplified version it is evident that high scorers managed to produce more and better information with the least instances of reading. The pattern looked similar, though all instances were proportionately lower, for average scorers and the low scorers had a different reading to writing ratio.

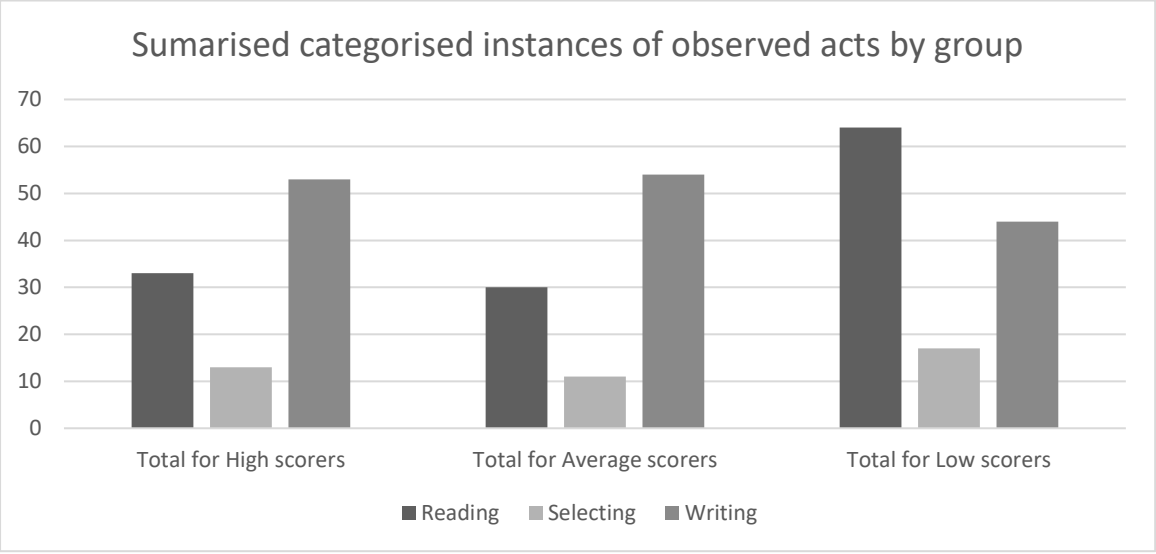


Figure 6-1 Number of categorised acts per group

Similar conclusions could be drawn from the three eye-tracking parameters that were used to analyse the processes followed by the three groups. For most of the high scorers, fixation count between map and text followed a similar pattern. For the average scorers, the fixation count was much higher on the text than on the summary map. They fixated on the text almost as much as the high scoring group, but did not focus on the maps as much and produced summary maps of poorer quality. The low scoring group fixated on the summary map almost as much as the average group, but the text fixation was lower. This indicated that average scorers clearly knew that the information they required to complete the map was located in the text, but had trouble extracting it. The lower scorers focused on the maps in a similar way to average scorers but could not produce maps of similar quality and they did not move back to the text as often to attempt to find the information where it was located.

Average fixation durations per group showed no significant difference between the groups. Although conclusions can sometimes be drawn about perceived difficulty of a task when comparing average fixation duration, no significant difference was observed for this study.

The third eye-tracking parameter that was used is dwell time or visit duration. The results show that the dwell time on maps for Group 1 is much higher than for the other two groups. This indicated, in other words, that high scorers spent more time moving within the AOIs of the map. Groups 2 and 3 spent much more time in the AOIs of the text compared to Group 1. These findings support the process data and also show that high scorers mostly read the text once and did not reread the text much thereafter during the mapping part of the task, whereas average and low scorers referred back to the text more often. That could explain the longer dwell times seen in the high scoring group.

From the findings it is evident that every step in the summary mapping process is potentially challenging for students. It could be argued that if the first challenge of deep level comprehension could be addressed it should also improve all subsequent levels, but the findings suggest that it should not be assumed that supporting students in only this ability will be sufficient. In order to successfully teach summary mapping abilities, all the challenges should be addressed and, more importantly, mastered before the next step is attempted.

6.3.2.2. Question 2 – What are the implications of the findings for the teaching methods used to teach summary mapping abilities?

In order to address summary mapping skills successfully in a support module a number of recommendations have been proposed in Chapter 5. These recommendations are summarised below.

Vocabulary should be approached in a way that not only teaches coping strategies for unknown words but actively attempts to motivate students to broaden their vocabulary. This can be done by focusing on all five proposed steps of vocabulary learning to ensure that students do not only learn the meaning of a new word but are also able to remember and use such words productively. Vocabulary lists can further be beneficial and the use of gamification applications can improve student motivation.

To improve deep level comprehension, summarisation techniques are suggested to help students fully understand what they are reading. Even though they are not yet equipped to complete summaries early in the semester, ideal summaries or summary maps could be provided as a technique to improve comprehension and foreground how information can be categorised. Additional techniques and approaches to improve coherence relations are also recommended.

Due to the high student numbers in the Academic Literacy modules at the NWU and the overwhelming burden this places on lecturers at the NWU, the use of automated tutors is recommended to help students practice summarisation skills before they submit official assessments. The automated way in which these skills could be practiced can improve deep level comprehension. Another relevant recommendation for the study is the use of groupwork or class discussions, giving students the opportunity to gain deep level understanding of texts through sharing background knowledge and explaining the text to each other in a group.

Recommendations concerning the teaching of categorisation abilities include a focus on text structure. The first recommendation in this regard focuses on showing specifically how main ideas are expanded into paragraphs by demonstration and discussion. Furthermore, the benefits of reflection were also discussed and it is recommended that students be given the opportunity to reflect on the summary mapping process as a further learning opportunity.

Even if all these challenges can be addressed as part of the academic literacy offering, it is still recommended that summary mapping be taught explicitly in a step-by-step fashion, once the other abilities have been mastered.

In terms of a general teaching model that could also be applied in contexts other than the ALDE111 module of the NWU a teaching model process diagram was provided in Chapter 5. This model proposes that the summary mapping process be taught in a sequential format, ensuring that one ability is fully mastered before the next is attempted. The process diagram guides the user through the teaching process recommending a next step at every juncture. A summarised version of this model is included in Figure 6-2.

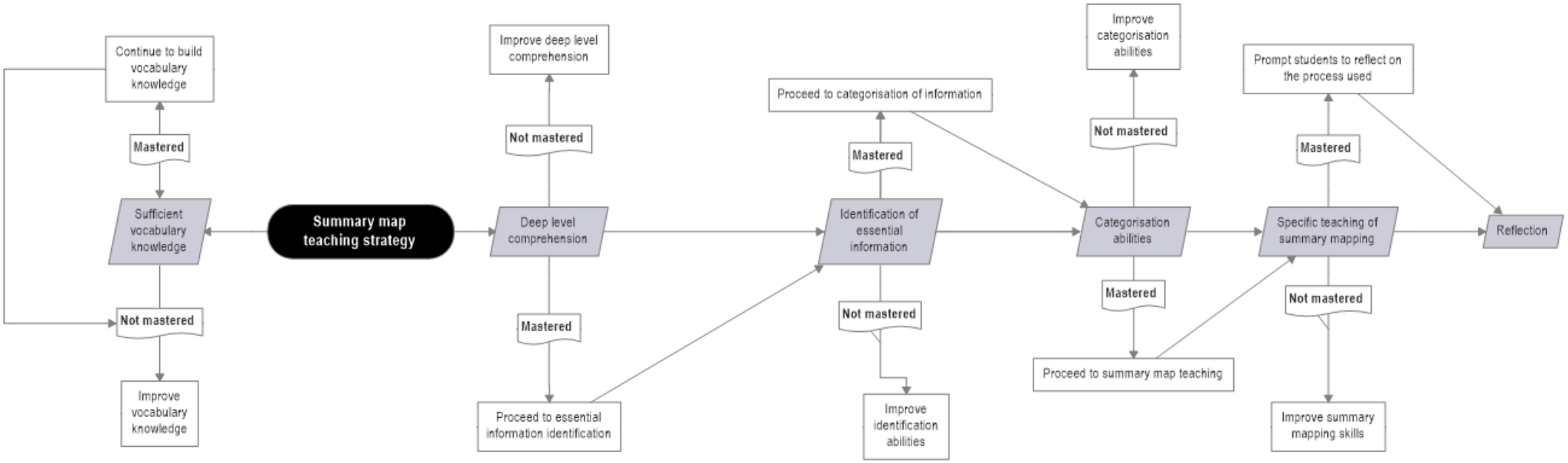


Figure 6-2 Summarised version of teaching model process diagram

6.4. Limitations of the study

Although the process of summary mapping could be investigated thoroughly to answer the posed research questions posed in this study, there were a number of limitations to the study.

The first limitation was that the sample size used was relatively small. The small number of mapping studies that made use of eye tracking that are reported in Chapter 2 do not have significantly large numbers of participants and the sample sizes of these studies vary significantly. The Dogusoy-Taylan & Cagiltay, (2014) study included 29 novice participants and 6 expert participants. The Amadieu *et al*. (2009) study had 24 participants. Bisra (2010) tested 50 participants. Durugbo (2021) had only 4 participants. Lui (2014) used 44 and 42 participants respectively. In the Nesbit *et al*. (2007) study, 36 participants were tested. Ponce & Mayer (2014) used on average 20 participants per group and the Malčík *et al*. (2016) study tested 16 participants. Although the number of participants tested in these studies are relatively small, they are in many cases still much larger than the sample size of the current study. This limited the number of generalised assumptions that could be made with a large sample size. Despite this limitation relevant qualitative data could still be collected that resulted in rich case studies. Ideally, additional research will need to be conducted with a larger sample to corroborate the findings at a time when situational factors such as COVID would have less of an impact.

Secondly, another limitation of the study is that it did not investigate students' perceptions, preferences or experience regarding summary mapping. Gathering such information could have further informed a teaching model that also addresses these aspects. If, for example students had the opportunity to comment on whether they liked using summary maps or found them helpful, such perceptual data could have informed challenges with motivation. The same is true for students' experience in using mapping. If participants indicated that they had previous experience with mapping, that could possibly have given more insight into the process they followed.

A third limitation of the study was the limited number of vocabulary questions used in the comprehension. Although this is standard in terms of what is normally tested during the AL offering at NWU, a more detailed, categorised vocabulary test that included both general and academic items, could have provided better insight into possible teaching approaches to improve vocabulary.

The final limitation of the study pertains to the conditions of the experiment. Although every effort was made to mimic a natural environment and set-up, it was not possible for participants

to complete the summary maps on a piece of paper lying flat on a table. In order to obtain usable recordings with the eye tracker, participants completed the summary maps on a board that was set up in an upright position, as is discussed in Chapter 3. This is not a natural position for writing and resulted in a somewhat artificial experience for the participants.

6.5. Avenues for further research

This study has produced a number of noteworthy findings regarding the summary map processes of participants and recommendations could be made in terms of a teaching model for summary maps. The most obvious and useful avenue for further research will be to implement the proposed summary map teaching model in the NWU context in order to determine if it could indeed improve the summary mapping abilities of students. If the model does succeed in improving summary mapping abilities it will, furthermore, be interesting to investigate the impact of using this tool optimally over a longer period of time for senior students.

Another useful contribution could be made if a larger and more diverse group of participants could be tested to compare the processes followed by students from other universities and backgrounds.

In Chapter 5 of the study, reference is made to automated tutor software that uses Latent Semantic Analysis to give instantaneous feedback to students after they have submitted summaries of texts. It could further be worthwhile to investigate the possibility of using a similar approach to develop software within the ALDE111 context that could help students practice summary maps in the same way.

6.6. Conclusion

The issue of students being underprepared for tertiary education is a complex one to address and will probably remain pertinent in the near future. As long as this is the case, students will need support in gaining the necessary abilities to successfully engage with academic content at tertiary level. Mapping and particularly summary mapping has proved to be a useful tool that can support this endeavour and should therefore be taught in such a way that students are able to use the tool productively.

This study showed that currently, every step in the summary mapping process is challenging for the students. The mismatch between the level of comprehension that was demonstrated, and the level of comprehension needed for successful summary mapping is the first and

arguably most important challenge to address in a teaching approach. Addressing this issue could potentially also partially improve the subsequent steps in the summary mapping process, but ultimately all the challenges should be addressed adequately. Recommendations for the improvement of deep level comprehension, identification of essential information and categorisation of information were provided in the form of a sequential model where each individual ability needs to be mastered before one can move on to the next ability. Therefore, if the recommendation for the proposed teaching model is applied, each step in the summary mapping process should be mastered before a subsequent step is attempted. This approach may ensure that students are able to productively apply and use the summary mapping tool to its optimal capacity.

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ANNEXURE A TEXT FOR READING COMPREHENSION

Our Vanishing Night

Most city skies have become virtually empty of stars

- If humans were truly at home under the light of the moon and stars, we would go in darkness happily, the midnight world as visible to us as it is to the vast number of nocturnal species on this planet. Instead, we are diurnal creatures, with eyes adapted to living in the sun's light. This is a basic evolutionary fact, even though most of us don't think of ourselves as diurnal beings any more than we think of ourselves as primates or mammals or Earthlings. Yet it's the only way to explain what we've done to the night: We've engineered it to receive us by filling it with light.
- This kind of engineering is no different than damming a river. Its benefits come with consequences—called light pollution—whose effects scientists are only now beginning to study. Light pollution is largely the result of bad lighting design, which allows artificial light to shine outward and upward into the sky, where it is not wanted, instead of focusing it downward, where it is. Ill-designed lighting washes out the darkness of night and radically alters the light levels—and light rhythms—to which many forms of life, including ourselves, have adapted. Wherever human light spills into the natural world, animal behaviour like migration, reproduction and feeding—is affected.
- Most of humanity lives under intersecting domes of reflected, refracted light, of scattering rays from overlit cities and suburbs, from light-flooded highways and factories. Nearly all of nighttime Europe is a nebula of light, as is most of the United States and all of Japan. In the south Atlantic the glow from a single fishing fleet—squid fishermen luring their prey with metal halide lamps—can be seen from space, burning brighter than Buenos Aires or Rio de Janeiro.

Birds

- Light is a powerful force, and on many species it acts as a magnet. This process is being studied by researchers such as Travis Longcore and Catherine Rich, co-founders of the Los Angeles-based Urban Wildlands Group. The effect of light is so powerful that scientists speak of songbirds and seabirds being "captured" by searchlights on land circling and circling in the thousands until they drop. Birds are also are apt to collide

with brightly lit tall buildings because they migrate at night. Immature birds on their first journey suffer the most.

- Some birds like nightingales, sing at unnatural hours in the presence of artificial light. Scientists have determined that long artificial days—and artificially short nights—induce early breeding in these birds. And because a longer day allows for longer feeding, it can also affect migration schedules. One population of Swans wintering in England put on fat more rapidly than usual, priming them to begin migration early. The problem, of course, is that migration, like most other aspects of bird behaviour, is a precisely timed biological behaviour. Leaving early may mean arriving too soon for nesting conditions to be right.

Nocturnal mammals

- Insects have the tendency to cluster around streetlights, and feeding at those insect clusters is now ingrained in the lives of many bat species. In Sweden Horseshoe bat began to vanish after streetlights were installed, because those areas were suddenly filled with day-feeding Pipistrelle bats. Other nocturnal mammals, including desert rodents, possums, and badgers forage more cautiously under the permanent "full moon" of light pollution because they've become easier targets for predators.

Reptiles

- Nesting sea turtles, which show a natural predisposition for dark beaches, find fewer and fewer of them to nest on. Frogs and toads living near brightly lit highways suffer nocturnal light levels that are as much as a million times brighter than normal, throwing nearly every aspect of their behaviour out of joint.

Dealing with light pollution

- Of all the pollutions we face, light pollution is perhaps the most easily remedied. Simple changes in lighting design and installation yield immediate changes in the amount of light spilled into the atmosphere and, often, immediate energy savings.
- It was once thought that light pollution only affected astronomers, who need to see the night sky in all its glorious clarity. And, in fact, some of the earliest civic efforts to control light pollution—in Flagstaff, Arizona, were made to protect the view from Lowell Observatory, which sits high above that city. Flagstaff has tightened its regulations since then, and in 2001 it was declared the first International Dark Sky City. By now the effort to control light pollution has spread around the globe. More and more

cities and even entire countries, such as the Czech Republic, have committed themselves to reducing unwanted glare.

Effect of light pollution on humans

- For the past century or so, we've been performing an open-ended experiment on ourselves, extending the day, shortening the night, and short-circuiting the human body's sensitive response to light. For humans, light pollution may take a biological toll. At least one new study has suggested a direct correlation between higher rates of breast cancer in women and the nighttime brightness of their neighbourhoods.
- In the end, humans are no less trapped by light pollution than the frogs in a pond near a brightly lit highway. Living in a glare of our own making, we have cut ourselves off from the light of the stars and the rhythms of day and night. In a very real sense, light pollution causes us to lose sight of our true place in the universe, to forget the scale of our being, which is best measured against the dimensions of a deep night with the Milky Way—the edge of our galaxy—arching overhead.

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ANNEXURE B COMPREHENSION TEST

Participant:

INSTRUCTIONS

- Answer all questions on this paper.
- Pay particular attention to language and style.

Sec. A	Sec. B	Total
/8	/18	/26

Read the text provided and answer the questions that follow.

Section A: Vocabulary

1. Provide words from the paragraph 1 that refers to: (2)

   a) creatures that feed at night _____

   b) creatures that feed during the day _____

2. Look at the word 'evolutionary' (par. 1).

   a) From which noun is the word 'evolutionary' derived? (1)

   _____

   b) Explain the meaning of 'evolutionary fact' as used in the text? (2)

   _____

   _____

   _____

3. The words tendency in par. 6 means the same as _____in the same paragraph. (1)

4. In paragraph 5, 'winter' is used in a verb form. Write down verb form of the word and explain the meaning thereof. (2)

   _____

   _____

   _____

[Section A = 8 marks]

Section B: Text comprehension

1. What causes light pollution? (1)

_____

2. Why do squid fishermen use lights when fishing according to the text? (1)

_____

3. In par. 3, nighttime Europe, most of the United States and Japan compared to a nebula of light. Explain this fitting comparison (question 3) in your own words. (2)

_____

_____

_____

_____

4. Name three ways birds can be affected by light pollution according to par.5. (3)

_____

_____

_____

5. What does the "permanent full moon" refer to in paragraph 6? (1)

_____

6. Explain in your own words why many nocturnal mammals have to forage more cautiously (par.6). (2)

_____

_____

7. Why does light pollution affect astronomers? (1)

_____

8. Indicate whether the following statement is true or false and motivate your answer. (3)

Humans are adapted to living in darkness.

_____

_____

_____

9. Complete the following table of bird types and how they are affected by light pollution by referring to par. 4-5 of the text. (3)

a)	Songbirds and seabirds	• _____ • _____
b)	_____	• Sing at unnatural hours with artificial light.
c)	Swans	• Long days and short nights induces early breeding and affects migration patterns • _____ _____ _____

[Section B = 18 marks]

ANNEXURE C TEXT SELECTION FOR SELECTING AND SUMMARY MAPPING

Birds

1. Light is a powerful force, and on many species it acts as a magnet. This process is being studied by researchers Travis Longcore and Catherine Rich, co-founders of the Los Angeles-based Urban Wildlands Group. The effect of light is so powerful that scientists speak of seabirds being "captured" by searchlights on land circling and circling in the thousands until they drop. Birds are also apt to collide with brightly lit tall buildings because they migrate at night, immature birds on their first journey suffer the most.
2. Some birds like nightingales sing at unnatural hours in the presence of artificial light. Scientists have determined that long artificial days—and artificially short nights—induce early breeding in these birds. And because a longer day allows for longer feeding, it can also affect migration schedules. One population of swans, wintering in England put on fat more rapidly than usual, priming them to begin migration early. The problem, of course, is that migration, like most other aspects of bird behaviour, is a precisely timed biological behaviour. Leaving early may mean arriving too soon for nesting conditions to be right.

Nocturnal mammals

3. Insects have the tendency to cluster around streetlights, and feeding at those insect clusters is now ingrained in the lives of many bat species. In Sweden the Horseshoe bat began to vanish after streetlights were installed, because those areas were suddenly filled with day -feeding Pipistrelle bats. Other nocturnal mammals, including desert rodents, possums, and badgers forage more cautiously under the permanent “full moon” of light pollution because they've become easier targets for predators.

Reptiles

4. Nesting sea turtles, which show a natural predisposition for dark beaches, find fewer and fewer of them to nest on. Frogs and toads living near brightly lit highways also suffer because nocturnal light levels are a million times brighter than normal, throwing nearly every aspect of their behaviour out of joint.

ANNEXURE D CONCENT FORM

Ethics Committee for Language Matters (ECLM)

INFORMED CONSENT FORM

DATE:

ECLM Authorization

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM

TITLE OF THE RESEARCH PROJECT: Summary maps: Using eye tracking to investigate where students go wrong

REFERENCE NUMBERS: NWU NWU-01124-20-S7

PRINCIPAL INVESTIGATOR: N. Schutte

ADDRESS: NWU Vaal Campus Hendrik van Eck Boulevard Vanderbijlpark

CONTACT NUMBER: 016 910 3488

You are being invited to take part in a research project that forms part of my PhD. Please take some time to read the information presented here, which will explain the details of this project. Please ask the researcher any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research is about and how you could be involved. Also, your participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part. Prior to publication of the study's results (or the point that publication is in process), you may also withdraw the data you generate.

This study has been approved by the **Ethics Committee for Language Matters (ECLM) of the Faculty of Humanities of the North-West University (NWU-01124-20-S7)** and will be conducted according to the ethical guidelines and principles of the international Singapore Statement on Research Integrity (2010) and the ethical guidelines of the National Health Research Ethics Council. It might be necessary for the research ethics committee members or relevant authorities to inspect the research records to make sure that we (the researchers) are conducting research in an ethical manner.

What is this research study all about?

- *This study will be conducted in the eye tracking laboratory of the NWU Vaal campus and will involve a threefold experiment, consisting firstly of a comprehension test based on a selected text, secondly, marking of important information in a section of the text and lastly the drawing of a mind map of the text section in consecutive experiment sessions while wearing an eye tracker. The researchers have been trained to use the methods mentioned in the previous sentence.*
- *Approximately 30 participants will be included in this study.*
  The objectives of this research are: To determine the differences in task completion and the process applied between students who underperform in mind mapping and students who perform well in mind map summaries, in order to optimise the teaching model for mind mapping abilities to support these students.

Why have you been invited to participate?

- *You have been invited to participate because you are a first year students from the North-West University' Vaal Triangle Campus.*

- *You have also complied with the following inclusion criteria: You are enrolled for the ALDE modules.*
- *You will be excluded if: you are younger than 18 years of age.*

What will your responsibilities be?

- *You will be expected to firstly complete a comprehension test based on a selected text, secondly, mark important information in a section of the text and lastly to drawing of a mind map of the text section in consecutive experiment sessions while wearing an eye tracker.*

Will you benefit from taking part in this research?

- *The direct benefits for you as a participant will probably be extra practice in and feedback on mind mapping abilities.*
- *The indirect benefit will probably be gaining insight into your mind mapping process.*

Are there risks involved in your taking part in this research and how will these be managed?

- *The risks in this study, and how these will be managed, are summarised in the table below:*

Probable/possible risks/discomforts	***Strategies to minimize risk/discomfort***
Because you will be asked to do three experiments it is possible that you will become tired.	The researchers facilitating your completion of the experiments will give you a 15-minute break, with some refreshment (a juice or a piece of fruit) between experiments.

- *However, we do believe that the benefits to you and to science (as noted in the previous section) outweigh the risks we have listed. If you disagree, then please feel free not to participate in this study. We will respect your decision.*

- *Should we learn, in the course of the research, that someone is harming you, or that you are intending to harm someone, then we must tell someone who can help you/warn the person you are intending to harm.*

Who will have access to the data?

- *Anonymity (that is, in no way will your results be linked to your identity) will be ensured by allocating a participant number to every participant which will be used in the research project. Confidentiality (that is, I/we assure you that we will protect the information we have about you) will be ensured by the protection of personal information. No personal information of any kind will be made available in any way during the course or after completion of this research project. Reporting of findings will be anonymous by again referring only to the participant number.*
- *Only the researchers will ever have access to personal information. Data will be kept safe and secure by locking hard copies in locked cupboards in the researcher's office and for electronic data it will be password protected.*
- *All co-coders will sign confidentiality clauses.*
- *Data will be stored for 3 years in the office of the researcher or password protected if stored electronically.*

What will happen to the data?

The data from this study will be reported in the following ways: The reporting and discussion of data in the PhD study as well as in published articles that may follow. In all of this reporting, you will not be personally identified. This means that the reporting will not include your name or details that will help others to know that you participated (e.g., your address or the name of your school).

This is a once-off study, so the data will not be re-used.

Will you be paid/compensated to take part in this study and are there any costs involved?

No, you will not be compensated to take part in the study, but refreshments will be supplied between experiments. Scheduling of sessions will be managed in such a way that you will not have to travel especially for the purpose of participating. There will thus be no costs involved.

How will you know about the findings?

- The general findings of the research will be shared with you by making the published PhD available in the library
- If you would like feedback on your personal results, then you are welcome to book a session with the researcher.

Is there anything else that you should know or do?

- You can contact the researcher (Nicole Schutte) at 016 910 3488 if you have any further queries or encounter any problems.
- You can contact the chair of the Ethics Committee for Language Matters (Prof C van Eeden) at 016 910 3442 or chrizanne.vaneeden@nwu.ac.za if you have any concerns or complaints that have not been adequately addressed by the researcher.
- You will receive a copy of this information and consent form for your own records.

Declaration by participant

By signing below, I ……..……. agree to take part in a research study entitled:

I declare that:

- I have read and understood this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions to both the person obtaining consent, as well as the researcher (if this is a different person), and all my questions have been adequately answered.
- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.
- I understand that what I contribute (what I report/say/write/draw/produce visually) could be reproduced publically and/or quoted, but without reference to my personal identity.
- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- I may be asked to leave the study before it has finished, if the researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.

Signed at (*place*) .....…..…….. on (*date*) ……...……. 20....

....

Signature of participant **Signature of witness**

- You may contact me again ☐ **Yes** ☐ **No**
- I would like a summary of the findings of this research ☐ **Yes** ☐ **No**
- I would like feedback on my functioning/wellbeing as reflected in the questionnaires I completed ☐ **Yes** ☐ **No**

The best way to reach me is:

Name & Surname: _____

Postal Address: _____

Email: _____

Phone Number: _____

Cell Phone Number: _____

In case the above details change, please contact the following person who knows me well and who does not live with me and who will help you to contact me:

Name & Surname:

_____

Phone/ Cell Phone Number /Email:

_____

Declaration by person obtaining consent

I *(name)* ……..…… declare that:

- I explained the information in this document to ……..
- I encouraged him/her to ask questions and took adequate time to answer them.

- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) .....…..……. on (*date*) ……...…….. 20....

....

Signature of person obtaining consent **Signature of witness**

Declaration by researcher

I *Nicole Schutte* declare that:

- I explained the information in this document to ……..
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) .....…..……. on (*date*) ……...…….. 20....

..... **Signature of researcher.....**

.... **Signature of witness**

Adapted from: Original informed consent form of the Ethics Committee for Language Matters.

ANNEXURE E ETHICAL CLEARANCE CERTIFICATE

PO Box 1174, Vanderbijlpark
South Africa 1900

Tel: 016 910-3111
Fax: 016 910-3116
Web: http://www.nwu.ac.za

Faculty of Humanities
Tel: 016 910 3442
Email: Chrizanne.vaneeden@nwu.ac.za

13 October 2020

Dear Ms Nicole Schutte and Prof G Butler,

ETHICS CLEARANCE/APPROVAL

This letter serves to inform you that your ethics application was approved by the Ethics Committee for Language Matters (Humanities).

Ethics application number: NWU-01124-20-S7.

Project leader: Prof G Butler

Applicant: Ms. Nicole Schutte

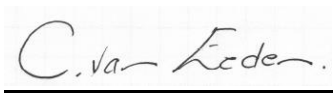
Project title: Mind map summaries using eye tracking to investigate where students go wrong.

Duration: October 2020 to October 2021.

Ethics approval date: 30 September 2020.

Your acceptance of the reviewers' recommendations is appreciated and your research will be conducted in line with such recommendations. The Ethics Committee for Language Matters wishes you well with your research project.

Yours sincerely



Prof. C. van Eeden

Chair: Ethics Committee for Language Matters

Original details: (10057013) P:\Daleen\ECLM\Prof C van Eeden-letter.docm
10 September 2019

File reference: 9.1.5

ANNEXURE F GATEKEEPER COMMITTEE CLEARANCE CERTIFICATE

Private Bag X6001, Potchefstroom
South Africa 2520
Tel: +2718 299-1111/2222
Web: http://www.nwu.ac.za
Research Data Gatekeeper Committee

NWU RDGC PERMISSION GRANTED / DENIED LETTER

Based on the documentation provided by the researcher specified below, on 14/06/2021 the NWU Research Data Gatekeeper Committee (NWU-RDGC) hereby grants permission for the specific project (as indicated below) to be conducted at the North-West University (NWU):

Project title: Mind-map summaries using eye tracking to investigate where students go wrong.

Project leader: Prof G Butler
Researcher/Project Team: N Schutte

Ethics reference no: NWU-01124-20-A7
NWU RDGC reference no: NWU-GK-21-025

Specific Conditions:

- Due the COVID-19 pandemics the Committee would like to advice the researcher to practice the necessary caution and adhere to the National Covid-19 Guidelines when conducting research with participants.
- The researcher may not make use of the TALL results without consent for this specific research from the prospective participants.
- The researcher should appoint an independent mediator to assist in inviting, acquiring consent and data collection which should be provided to the researcher as anonymised data should the researcher eventual want to include her own students in the research project.

Approval date: 14/06/2021 **Expiry date: 13/06/2022**

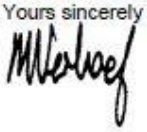
General Conditions of Approval:

- The NWU-RDGC will not take the responsibility to recruit research participants or to gather data on behalf of the researcher. This committee can therefore not guarantee the participation of our relevant stakeholders.
- Any changes to the research protocol within the permission period (for a maximum of 1 year) must be communicated to the NWU-RDGC. Failure to do so will lead to withdrawal of the permission.
- The NWU-RDGC should be provided with a report or document in which the results of said project are disseminated.

Please note that under no circumstances will any personal information of possible research subjects be provided to the researcher by the NWU RDGC. The NWU complies with the Promotion of Access to Information Act 2 of 2000 (PAIA) as well as the Protection of Personal Information Act 4 of 2013 (POPI). For an application to access such information please contact Ms Annamarie De Kock (018 285 2771) for the relevant enquiry form or more information on how the NWU complies with PAIA and POPI.

The NWU RDGC would like to remain at your service as scientist and researcher, and wishes you well with your project. Please do not hesitate to contact the NWU RDGC for any further enquiries or requests for assistance

Yours sincerely



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Prof Marlene Verhoef
Chairperson NWU Research Data Gatekeeper Committee

Original details: (22351930) C:\Users\22351930\Desktop\test 2.docm
13 November 2018

Current details: (22351930) M:\D68\18533\Monitoring and Reporting Cluster\Ethics\Applications RDG\C\Updated RDGC Permission Letter.docm
15 November 2018

File reference: 1.1.4.3