

**Understanding how grade 11 Biology teachers mediate learning of the topic  
on transpiration**

**A thesis submitted in partial fulfilment of the requirements for the degree of**

**MASTER OF EDUCATION  
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**by**

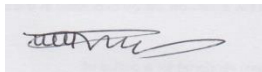
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**JANUARY 2015**

## DECLARATION

I, **Marian Kauna Nyanyukweni Frans (11F7109)** the undersigned, hereby, declare that the work contained in this thesis is my own original work and has not previously in its entirety or in part been submitted to any university for a degree. All the sources I have used or quoted have been indicated and acknowledged using complete reference according to Departmental guidelines.

Signature:



Date: 15 January 2015

## **DEDICATION**

I dedicate this thesis to my mother, Maria Johannes. Her guidance, support and motivation gave me the courage to work hard. Without her, I could never be the person I am today. From her I learned that one has to be strong to withstand life's challenges.

This thesis is also dedicated to my aunt Ndeapo Johannes who was my pillar of strength along the journey. Her support kept me going.

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## ABSTRACT

This study emerged in response to the poor performance in Biology at my school. The Ministry of Education Biology (NSSCO) Examiners' report (2011) for Paper 3 indicates that learners proved to have difficulties in designing experiments, failed to give a distinction between apparatus and the experiment. The 2012 Examiners' report on transpiration also highlights that learners were not exposed to practical work. Furthermore, the 2012 report notes that teachers need to work on their learners' drawing and spelling of terms.

It is against this backdrop that a qualitative study was conducted at a school in Oshikoto, using a sample of two teachers. The study's purpose was to investigate how grade 11 Biology teachers mediate learning of the topic on transpiration. Social Constructivism and Pedagogical Content Knowledge formed the framework used to analyse data gathered from document analysis, interviews and observations.

The study findings were that teachers use locally available material for demonstration during practical work, elicit prior knowledge, use a chalkboard to summarise content to learners, and use a question and answer method as strategies in mediating learning on transpiration. In addition, the teachers use homework, scaffolding activities, group work, code-switching, feedback on activities, as well as the use of analogies. Despite efforts by participant teachers to mediate learning of transpiration, shortage of equipment for conducting practical work, poor English proficiency among teachers and learners, and little emphasis on graphing by the syllabus proved to be barriers to their efforts. This study thus recommends that in order to improve on teaching transpiration, teachers need to co-plan lessons, conduct practical work, code-switch during lessons, ensure effective assessment, and include lessons on graphing. Furthermore, teachers need continued training on how to teach transpiration.

## **LIST OF ABBREVIATIONS AND ACRONYMS**

IK-	Indigenous Knowledge
LCE -	Learner-Centered Education
MBSEC -	Ministry of Basic Education Sport and Culture
MEC -	Ministry of Education and Culture
MoE -	Ministry of Education
NAMCOL -	Namibia College of Open Learning
NCBE -	National Curriculum for Basic Education
NIED -	National Institute of Education Development
NSSCO -	Namibia Senior Secondary Certificate Ordinary level
PCK -	Pedagogical Content Knowledge
PEEOE -	Predict, Explain, Explore, Observe and Explain
TIMSS -	Trends in International Mathematics and Science Study
ZPD -	Zone of Proximal Development

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## **CHAPTER ONE:           SITUATING THE STUDY**

*Concepts such as photosynthesis, respiration, and transpiration are dynamic, interactive and interdependent processes and not separate processes, which means that each process interacts with each other and depends on the others (Nanni & Plakitsi, 2013, p. 233).*

### **1.1 Introduction**

This chapter introduces my study, the focus of which was on understanding how grade 11 Biology teachers mediate learning of the topic on transpiration.

The first section of the chapter contextualises the study, followed by the research goal and questions, the theoretical framework underpinning the study, data generation techniques used, the potential value of the study, definition of concepts and the thesis outline. This chapter ends with some concluding remarks.

### **1.2 Context of the study**

Martin, Mullis, Foy and Stanco (2012) cited the Trends in International Mathematics and Science Study [TIMSS] 2011 international results in science as reporting that more countries displayed an increase in the fourth grade science performance. On the other hand, there was great variability among countries' eighth grade performance, with more countries showing improvements, and a few showing a decline. Some of the reasons for poor performance were related to poor working conditions, poor facilities and instructional materials, and negative attitudes towards science.

Tjiho (2014) highlighted that although thousands of Grade 12 learners in Namibia qualified to enter institutions of higher learning at the end of 2013, the overall performance of Namibian learners in Mathematics, English and sciences continued to be consistently poor. That poor performance was attributed to some schools suffering from under resourcing, limited learning materials and teaching equipment, and high learner-to-teacher-ratios.

For the past four years I have been teaching at such a school, I have observed poor performance in Biology. My assumption was that this could be attributed to various issues such as little practical work (paper 3) being done in some topics such as transpiration, poor

English proficiency among teachers and learners, poor linkages of Biology concepts to learners' indigenous knowledge [IK] and insensitivity to gender issues among teachers.

My interest to explore this study originated in 2001 when I was a biology learner myself. I felt then that topics such as transpiration that were not linked to the human body were not necessary and indeed I found them quite boring. Contrasting the perceived importance of plants by learners with their actual importance, Lewis (2010) noted that:

One important reason for using plants in learning is that the majority of people are generally poorly acquainted with plants, looking down on them or simply ignoring them and this tendency to overlook plants as plant blindness as most people can't see the forest or the trees. Our poor awareness of plants seems to be inversely related to their importance. Plants are absolutely vital to our existence. They are primary producers, converting the sun's energy and atmospheric gases into living matter through photosynthesis; almost all consumers including humans, depend on them directly or indirectly for food. Plants also supply us with a host of products, including medicines, fuel, fiber, building materials, paper, beverages, and perfume.... Thus learning about plants contributes not only to our appreciation of the complex web of life on this planet but also to our understanding of who we are as humans (p.4).

Kibirige and Van Rooyen (2006) also raised a concern that many learners find plant studies boring. Nanni and Plakitsi (2013) claimed that plant functions are a difficult topic for the students, partly because they are characterised by a number of concepts that make the teaching of these concepts difficult. As reflected in the epigraph, Nanni and Plakitsi (ibid.) also noted that photosynthesis, respiration, and transpiration are dynamic, interactive and interdependent processes, which means that each process interacts with each other and depends on the others. Thus a proper understanding of each concept also depends on understanding the others.

The Ministry of Education Biology [NSSCO] Examiners' Reports (2011-2012) on paper 3, in which transpiration was examined, highlighted issues that also helped motivate me to focus on transpiration. The 2011 report noted that designing an experiment proved difficult for some learners. The report also highlighted that when the learners were asked to describe how they would change the experiment to demonstrate the effect of wind on water uptake (Question 4(c)), the question totally confused the majority of the candidates. Candidates changed the apparatus apparently because they did not appreciate the difference between the apparatus and the experiment.

The 2012 Examiner's report further highlighted the following:

- Learners were not properly exposed to practical work and struggled to give correct names of apparatus and their functions e.g. Question 1(a) (i) on the potometer, an apparatus for measuring the rate of water loss from a plant;
- Learners were not familiar with simple experiments and general knowledge of science terms and that was still a matter of concern;
- Drawing skills of learners needed a lot of attention;
- Teachers needed to emphasise keywords like *list*, *name*, *suggest*, *state* and many more;
- Spelling of terms or concepts such as potometer was a reason for concern; and
- Explanations were given rather than the process – transpiration/transpiration rate (p. 65).

Knowing only some of the challenges faced by teachers, there could be more defects in learners' understanding and thus in addition to understanding how grade 11 Biology teachers mediate learning of the topic on transpiration, this study aimed to find out more from the teachers about the challenges they face when mediating learning of this topic. I was also interested in finding out what teachers were doing about these challenges and how their responses could be improved.

## **1.2 Potential value of the study**

Data gathered in this study might help novice Biology teachers who struggle to present this topic on transpiration to learners. It might also inform other stakeholders involved in the development of Biology materials by revealing teachers' experiences and challenges they face to help them develop materials based on the teachers' needs. The study might also provide useful insights for Biology Advisory teachers who are based at regional offices as well as Curriculum Developers at the National Institute for Educational Development [NIED]. This study might also be used by future researchers conducting research on topics in Life Sciences and/or Biology specifically on transpiration.

By providing some insights on how learners can make sense of scientific concepts, this study might also inform my own practice on strategies that I can use to make the topic on transpiration interesting and understandable to my learners.

#### **1.4 Research goal and questions**

The main goal of this study was to answer the following question:

How do grade 11 Biology teachers mediate learning of the topic on transpiration?

To answer the main question, the following sub-questions were asked:

- How do grade 11 Biology teachers help learners make sense of concepts on the topic on transpiration?
- What challenges do grade 11 Biology teachers experience when mediating learning of the topic on transpiration?
- In what ways do grade 11 Biology teachers deal with challenges faced by learners in making sense of the concepts on the topic on transpiration?
- In what ways can grade 11 Biology teachers improve mediating learning of the topic on transpiration?

The first three sub-questions were addressed in Phase One of this study and the last sub-question was addressed in Phase Two.

#### **1.5 The theoretical framework**

A child is capable of constructing new knowledge through interactions with more knowledgeable others who can be a teacher or peers. The teacher needs to provide learning opportunities which ensure an opportunity for complex interactions. Vygotsky's (1978) Social Constructivism and Shulman's (1987) Pedagogical Content Knowledge were seen as appropriate analytical tools for modelling the role of these interactions in this study.

## 1.6 Data generation techniques

To gather data for this study, I used the following data gathering techniques:

- Document analysis;
- Observations; and
- Interviews - semi-structured and stimulated recall.

I conducted a preliminary pilot study which was helpful in refining my data gathering methods, such as document analysis and semi-structured interviews. Also, as part of the pilot, I conducted stimulated recall interviews to verify data. This process of validation is called triangulation.

## 1.7 Definition of key concepts

The following key concepts are often referred to in this study:

**Transpiration** – Is the loss of water vapour from the plant leaves and stem through stomata and lenticels respectively.

**Mediation** – Is a teaching strategy aimed at developing learners' abilities to adapt flexibly to the demands of the learning environment.

**Practical work** – Is any science teaching and learning activity in which the learners, working individually or in small groups, handle or observe the objects or materials they are studying.

**Prior everyday knowledge** – Refers to knowledge that learners bring to class, which can be Indigenous Knowledge (IK) or Scientific Knowledge (SK).

**Scaffolding** – Refers to when a teacher controls the learning task by coaching a learner until s/he is able to solve a problem or perform a task. When a learner has mastered, the scaffolding is then removed slowly.

**Zone of Proximal Development [ZPD]** - Is the difference between what a child can do on its own and what the child can do with the assistance of the teacher.

## 1.8 Thesis outline

This thesis consists of six chapters.

**In Chapter 1**, I introduced this research study, present an overview of its context, and outline the research goal and questions. I also highlighted the theoretical framework, the data generation techniques, and provided information on the potential value of the study.

**In Chapter 2**, I provide an overview of literature on challenges and strategies in mediating learning of transpiration. The theoretical framework that underpins this study is also reviewed in Chapter 2.

**Chapter 3** first describes the research orientation and the methods used to gather data. The procedures used in order to gather data on how grade 11 Biology teachers mediate learning of the topic on transpiration are next described. Thirdly, I discuss ethical issues, validity and trustworthiness. Finally, in this chapter the limitations to this study are presented.

**Chapter 4** presents a narrative form of data generated from the document analysis, pre-interviews, stimulated recall interviews with the two teachers, and lesson observations. It also presents themes that emerged from processed data.

**Chapter 5** analyses and interprets data in terms of analytical statements developed from the emerged themes regarding teaching challenges and strategies in mediating transpiration. This analysis interprets data in relation to the literature reviewed in Chapter 2.

Finally, in **Chapter 6**, I draw conclusions from the study by:

- Providing a summary of the findings of the study;
- Highlighting implications of the findings for teachers, researchers and curriculum implementers;
- Making suggestions for the teachers in the light of these findings;
- Describing the limitations of the study and the need for further research;
- Discussing the lessons I have learnt from the study;
- Making recommendations; and
- Finally, by shedding light on personal reflections of my whole research journey.

## **1.9 Concluding remarks**

In Chapter 1, I attempted to contextualise the study, outlined the research goal and questions, shed more light on the theoretical frameworks that underpin this study. I also discussed the data generation techniques and the potential value of the study.

The next chapter focuses on literature reviewed in this thesis relating to mediating learning of the topic on transpiration.

## **CHAPTER 2: LITERATURE REVIEW**

*Teachers are more than facilitators, organisers, managers and discussion leaders; in order to introduce learners to cultural tools and conventions of the community of scientists, to devise learning experiences that are scientifically significant as well as meaningful and interesting to students, and to ask and answer critical questions, they must have a deep understanding of both scientific knowledge and scientific methods (Hodson & Hodson, 1998, p. 23).*

### **2.1 Introduction**

In this chapter, I discuss the literature that informed my study of mediating transpiration. I explore how teachers are understood to mediate learning of this topic, nationally and internationally. The aim is to review how strategies and challenges that teachers are faced with are perceived, as well as solutions that have been presented to help teachers improve mediating learning of transpiration.

This material is organised and presented in the following order: the Namibian curriculum view on teaching and learning is presented, followed by a description of transpiration, mediating learning of transpiration and ending by focusing on the theoretical framework that underpins my study.

### **2.2 Curriculum issues**

An important point made by the National Curriculum for Basic Education [NCBE] (2010) is that Natural Sciences contribute to the foundation of a knowledge-based society positively. Natural Sciences empower learners with the scientific knowledge, skills and attitudes that enable them to formulate hypotheses, to investigate, observe, make deductions and understand the physical world in a coherent scientific way. In this way, learners also acquire skills to manipulate and relate to the natural environment in the value-framework of the sustainable use of matter, energy and processes in both living and non-living things. But what approach should teachers use so that learners are empowered with the knowledge and skills highlighted above?

Today, the Namibian education system supports learner-centred education (LCE) rather than the teacher-centred approach which was mainly used before Namibia's independence in 1990. Nyambe (2008) notes that LCE was first adopted and tried out by South West Africa

People's Organisation's [SWAPO] educational activities in exile. After Namibian independence in 1990, LCE was then widely advocated as the philosophical approach that would reinforce teaching and learning in post-apartheid Namibian classrooms.

The Namibian Curriculum for Basic Education [NCBE] (2010) notes that preparation for a knowledge-based society requires a learner-centred approach to teaching and learning. The point of departure is always what learners know and can do, which means the teacher should make use of each learner's existing knowledge, skills, interests and understandings derived from previous experiences in and out of school (NCBE, 2010; Nyambe, 2008). This approach also highlights that learners acquire new knowledge through ways of working which are relevant and meaningful for them, and they learn how to apply their knowledge creatively and in an innovative way.

The Biology syllabus in the National curriculum directs a teacher on what to look at when teaching a certain topic so to ensure proper preparations. It identifies that learners should be able to:

- define transpiration;
- describe how the loss of water vapour is related to cell surfaces, air spaces and stomata;
- describe the effects of variation of temperature, humidity, and light intensity on transpiration rate;
- describe methods by which xerophytic plants can reduce transpiration rate, with reference to two named examples (Aloe, Euphorbia, Quiver tree);
- describe how wilting occurs; and
- discuss the adaptations of the leaf, stem and root to different environments, with emphasis on local examples (Namibia. Ministry of Education [MoE], 2009, p. 12).

The syllabus also suggests that for practical work, learners should be able to use a simple potometer to compare the rate of transpiration under different environmental conditions (MOE, 2009).

Having explored what the curriculum expects from the Biology teacher, the conceptual framework used to understand the task of mediating will be discussed next.

## **2.3 Conceptual framework**

This section focuses on a number of concepts I have used in order to understand mediating learning of transpiration.

### **2.3.1 The task of a mediator**

The word *mediator* derives from the Greek word *mesites*, which means to intervene (Fraser, 2006). Fraser explained that in general usage, a mediator usually means a neutral person who, by creating a win-win situation through communication, has to solve a dispute between two conflicting parties with diverse points of view. Fraser noted that in terms of the outcome-based teaching approach (which is similar to LCE in Namibia) currently followed in South Africa, learners are expected to take responsibility for their own learning and to be independent. Consequently, today's teachers have to forget about their traditional approach and accept their roles as mediators of learning.

Fraser (2006) highlighted that: teachers should effect communication between the learner and his/her environment, the learner's fellow learners and the learning contents or subject matter. Thus, the teacher is required to have a sound knowledge of his/her learning area and to be an inspiration to learners.

In the same vein, and as reflected in the epigraph above, Hodson and Hodson (1998) maintained that teachers are more than facilitators, organisers, managers and discussion leaders. Teachers must have a deep understanding of both scientific knowledge and scientific methods (Hodson & Hodson, 1998). Understanding is needed so that teachers acquaint learners with cultural tools and conventions of the community of scientists. In addition, understanding scientific knowledge and methods helps teachers to devise learning experiences that are scientifically significant, meaningful and interesting to learners, and to ask and answer critical questions. Now that the role of a mediator has been explained, the next section discusses how the teachers can mediate learning of the topic on transpiration.

### **2.3.2 Mediation of learning of the topic on transpiration**

In this section, I have defined transpiration, highlighted some challenges a teacher as a mediator faces as well as strategies to improve mediating learning of transpiration.

### **2.3.2.1 What is transpiration?**

Transpiration is the process by which water is lost as water vapour from the aerial parts of a plant. Leaves lose water vapour through their stomata and stems lose water through lenticels (De Klerk, n.d.). Kadhila (2009) explained that with transpiration, water moves out of the leaves through the stomatal pore, and evaporates into the air as water vapour. Transpiration occurs mainly from the leaves through tiny holes called stomata (Kadhila, 2009).

The American Heritage Science Dictionary (2005) defines transpiration as the process of giving off vapour containing water through the stomata of the leaves. This dictionary explains further that more than 90 percent of the water sucked by the plant is lost by evaporation through the stomata. This is why a plant always needs water and why plants that live in dry areas have reduced leaf surfaces from which water can escape.

Transpiration is the process where plants absorb water through the roots and then give off water vapour through the pores in their leaves, or the loss of water by evaporation in terrestrial plants, especially through the stomata, accompanied by a corresponding uptake from the roots ( YourDictionary definition and usage example, n.d.).

### **2. 3. 3 Challenges in mediating learning of science topics (transpiration)**

Hershey (1996) recognised that the neglect of botany in teaching appears to be a long standing problem which may be caused by teachers' lack of interest in botany, the teachers' botanical illiteracy, or the teaching methods. Another issue raised by Hershey was weaknesses of botany teaching literature, which is scattered in hundreds of books and journals. These are available only at university libraries, which make botany literature inaccessible to most Biology teachers.

In addition, teaching science in English to learners who barely speak English except in the classroom, is a great challenge. Ferreira (2011) noted that teaching Biology to English second language learners made it difficult for teachers who were faced with the double challenge of teaching a particular subject in English while learners were still learning the language.

Kambeyo (2012) also highlighted that another key factor in the passivity of learners was poor English language proficiency. During his brainstorming sessions, practical activities sessions and focus group interviews, he had to translate almost all the questions into Oshiwambo for learners to respond.

In such circumstance where learners struggle to communicate in English, it seems the solution would be code-switching (provided learners share the same mother tongue), this is discussed in Section 2.3.5.5. In addition, Probyn (2009) suggested that one could help learners by repeating key concepts, speaking more slowly, using gesture and voice tone to support communication, consolidating concepts on the chalkboard, and by relating ideas to learners' own experiences as well as demonstrations.

Another challenge is that learners are not exposed to practical work. Practical work refers to “any science teaching and learning activity in which the students, working individually or in small groups, handle or observe the objects or materials they are studying” (Millar, 2010, p. 1). Practical work and field work are vital parts of science education which help learners to develop their understanding of science, appreciate that science is based on evidence and acquire hands-on skills that are essential if learners are to progress in science.

Kandjeo-Marenga (2011) recognised that the Namibian science curriculum requires Grades 11 and 12 Biology learners to acquire learning-processes and investigative skills. They are expected to conduct practical activities and take a practical examination at the end of secondary school. The Namibian Senior Secondary Certificate Ordinary Level [NSSCO] biology syllabus (2010) suggests that teachers should do practical work. For example, that a simple potometer should be used to compare the rate of transpiration under different environmental conditions.

But do all teachers have potometers at their schools to start with? For those who have them, are they using them? These questions triggered my interest to find out how grade 11 biology teachers mediate learning of the topic on transpiration, by paying attention to the use of a potometer as a tool to mediate this topic.

Kandjeo-Marenga (2011) maintained that most secondary schools in Namibia lack well maintained, modern laboratories and other resources. Some laboratories are too small, and some have inadequate student workstations. Most secondary schools in Namibia offer teacher demonstrations rather than group-experiment activities because they lack laboratories and equipment.

Kandjeo-Marenga suggested that in cases where there is not enough laboratory equipment, a teacher can demonstrate and allow learners to work on activities such as construction of tables. She also noted that during demonstration, the teacher should use dialogue (asking

questions/discussions), since learner-teacher and learner-learner dialogue is essential during demonstrations. To supplement such solutions to challenges discussed above, mediation strategies that science teachers could use are discussed in the subsequent paragraphs.

### **2.3.4 Mediation strategies during science lessons**

Hodson and Hodson (1998) discussed some interventions to ensure that science is taught effectively. They proposed strategies such as: scaffolding, timing intervention, the use of modelling, the role of language, and group work. These strategies are discussed in detail below.

#### **2.3.4.1 Scaffolding**

With **scaffolding** the teacher, an adult or a peer, who is an expert on the topic, controls the learning task by coaching so that the learner is able to solve a problem or perform a task. The scaffolding is slowly removed as a learner develops competence (Hodson & Hodson, 1998). These authors however, advised teachers to consider Vygotsky's (1978) Zone of Proximal Development [ZPD] when working on scaffolding tasks. As mentioned earlier, Vygotsky (1978) defined the ZPD, as the difference between what children can do on their own and what they can do with the assistance of the knowledgeable others. Goos (2004) also described the ZPD as the distance between a child's independent problem solving capability and the higher level of performance that can be achieved with expert guidance.

#### **2.3.4.2 Double stimulation**

Virkkunen and Newnham (2013) discussed *double stimulation* in the Vygotskian scaffolding process, which is about the introduction of neutral objects into the task of problem solving. Hedegaard, Edwards and Flear (2012) advocated *double move*, whereby learning tools are used to support theoretical knowledge in teaching practices. Hedegaard, et al. (2012) suggested the use of Information Technology (IT) and mobile technologies as tools that can help mediate between teaching practice and learning activity. Because of the motives children develop in their everyday lives, learners acquire understanding and skills in IT to become more engaged and dedicated users. Therefore, IT and mobile technologies can motivate children to acquire subject matter knowledge that children are engaged in. However, Hedegaard, et al. (2012) conceded that it is not always certain that these tools can help learners relate subject matter knowledge to their everyday knowledge.

### 2.3.4. 3 Timing intervention

Hodson and Hodson (1998) argued that both the nature and timing of teacher intervention are crucial, under the concept of *timing intervention*. The teacher should decide on how to attend to each learner in a way that is appropriate to her/him, taking into account the learner's unique zone of proximal development, including its affective and social components; and deciding when to encourage and support, when to direct or instruct and when to involve others (Hodson & Hodson, 1998).

In order for the teacher to model the learning process as an expert, it is important to ensure that the **modelled** investigations involve as many as possible of the individual process skills in which learners are expected to develop proficiency, and might reasonably be expected to employ in their own investigations Hodson and Hodson (ibid.) also suggested that predicting, observing, measuring, comparing, and recording in scientific contexts, using appropriate scientific concepts, can all be modelled by the teacher.

### 2.3.4.4 Classroom norms and goals

To expand on what Hodson and Hodson (1998) discussed, Lewis (2010) argued that differences in *class norms and goals* can lead to very different types of classroom activities and types of learning, even though teachers are aiming to cover the same content. Lewis suggested a model of active-plant-based teaching and learning based on a social constructivist approach. This model had five areas of practice derived from the general reform goals and social constructivist theory that are critical for learning:

- **Active engagement with phenomena.** Asking and refining questions related to phenomena, predicting and explaining phenomena, and having mindful interactions with concrete materials are the strategies suggested (pp. 21-22).
- **Use and application of knowledge.** Here six strategies are suggested for encouraging learners to use and apply prior knowledge are such as: teachers must consider learners' prior knowledge; activities must encourage learners to identify and use multiple resources; activities must involve learners in planning and carrying out investigations; learned concepts should be allocated time for reflection; and teachers must help learners take action to improve their world (pp. 22-23).

- **Multiple representations**, whereby teachers are urged to use varied evaluation techniques; and that learners should create products or artefacts to represent understanding, and revise these products or artefacts (pp. 23- 24).
- **Use of learning communities**. Four strategies are given, three of which are believed to be relevant for plant-based learning. The strategies are: learners use language as a tool to express knowledge; learners express, debate, and come to a resolution regarding ideas, evidence, concepts, and theories; learning should be situated in a social context; and that learners learn from knowledgeable others (pp. 24- 26).
- **Authentic tasks**, where the teacher is urged to make use of driving questions to develop meaningful understandings of important scientific concepts; ensure that the topic or question is relevant to the learner for learners' motivation; and teachers should also ensure that learning is connected to learners' lives outside school (pp. 26- 27).

With large class sizes that science teachers often have, teachers are advised to adopt group-based approaches, possibly involving peer tutoring and reciprocal teaching in which a learner assumes the role of teacher towards others (Hodson & Hodson, 1998).

Ip (2005) stressed that, after giving an activity, it is important for learners to know how well they are doing as they learn through *feedback*. It is also important to let learners know when they have made a mistake so that they learn from it and take corrective measures. Feedback should be given immediately because the longer the time gap between the completion of the work and its feedback, the less effective feedback becomes (ibid.).

The next section focuses specifically on teaching strategies to help learners understand transpiration.

### **2.3.5 Strategies for understanding transpiration**

This piece highlights some strategies that Biology teachers can use when mediating learning of transpiration. The strategies are summarised in

#### **2.3.5.1 Considering learners' prior knowledge**

Prior Knowledge can be in the form of indigenous knowledge [IK] that learners bring with from home and communities, or scientific knowledge [SK] which learners have learned from

science at school. Kibirige and Van Rooyen (2006) explained that indigenous knowledge is a legacy of knowledge and skills unique to a particular indigenous culture and involves wisdom that has been developed and passed on over generations usually by word of mouth.

Kibirige and van Rooyen (2006) recommended that the teacher identifies and designs classroom tasks that bring in elements of indigenous knowledge as a starting point for the exploration of scientific concepts and inquiry procedures. The teacher needs to identify the indigenous knowledge learners bring to class.

Barker (1998) argued that teachers should give learners opportunities to articulate their prior knowledge about plants and water relations. To stimulate discussions, a teacher could pose problems to the class about the best technique for watering plants, such as - where (soil or leaves), when (during or after sunlight), frequency (bulk or intermittent), and timing (day or night).

#### **2.3.5.2 Scientific investigations and practical work**

Barker (1998) suggested that learners should be allowed to design investigations and test their prior ideas and this could be rewarding. Questions to be asked could be: do uprooted plants survive better if their leaves are immersed in water? Do leaves take up dye? Do flowers give off water? Woodley (2009) noted that scientific investigations are core activities which support the development of practical work skills and aid to shape learners' understanding of scientific concepts and phenomena. He further clarified that scientific core activities include investigations, laboratory procedures and techniques and fieldwork.

Practical work is an inquiry and hands-on activity which makes it possible to transfer knowledge at higher order cognitive levels and creates curiosity in learners (Ruparanganda, Rwodzi & Mukundu, 2013). They added that practical work develops problem solving skills and a deeper understanding of the concepts and principles in biology for learners

Practical work is also an effective strategy in teaching transpiration. As alluded to earlier in this study, the Biology syllabus suggests practical work whereby learners are expected to use a potometer to compare the rate of transpiration under different environmental conditions. Learners are also expected to compare the relative number of stomata on the upper and lower epidermis of a leaf, using petroleum jelly. Lastly, learners are also expected to observe, draw and interpret leaves of xerophytes plants, both macroscopically and microscopically (MoE, 2009).

Yip (2003) suggested strategies for helping learners develop a better understanding of the relationship between transpiration and water uptake in plants. He noted that a laboratory activity using the Prediction-Observation-Explanation approach helps to engage learners working in small groups of 3-4. He proposed that all groups should design an experiment to test whether transpiration is important for inducing water uptake by the shoots using a bubble potometer. Learners are advised to present their designed potometers and their results, their limitations and discuss ways to improve their investigations. The NSSCO Biology syllabus (2010) also suggests learners use a simple potometer to compare the rate of transpiration under different environmental conditions (see Section 4.2.1).

Yip (2003) explain that by presenting learners with discrepant events, challenges them to resolve the cognitive conflicts with their existing knowledge. He commented that the process helps learners to construct a more scientific view of the relationship between water uptake and transpiration in plants. However, Ruparanganda, et al. (2013) noted that the majority of schools in rural areas do not have laboratories, and where they exist, they are poor equipped. They then argued that the consequence of the absence of practical work is that learners have to memorise practical work theoretically in order to pass their examination. Biology is a practical study, but theoretical work in the subject means that learners are not able to put their learnt knowledge into practice to solve actual life problems (ibid.).

### **2.3.5.3 Graphing**

One of the best ways to communicate the results of a scientific investigation is graphing, which creates an effective visual representation of data that have been counted, measured, and calculated (The College Board, 2012). Investigators can often easily see patterns in a carefully crafted visual display of data that may not be as readily apparent in a data table of numbers. Importantly, visual displays also can clarify how two measured variables affect each other. Effective graphs convey summary or descriptive statistics as part of the display (College Board, 2012). Without graphs, data becomes a ‘sea of numbers’ and many people have a difficult time understanding exactly what the data has shown (Comet, 2009).

Several studies have identified problems learners experience in constructing graphs. Secondary school children have problems with drawing, annotating and scaling axes (Kali, 2005). He added that another problem that learners face, which is not widely documented, is learners’ inability to assign variables to the appropriate axes. He also classified variables as *independent* and *dependent*:

**Independent variable:** The variable that can be controlled by the experimenter. It usually includes time (dates, minutes, hours,), depth (feet, metres), and temperature. It is always placed on the X-axis (horizontal axis).

**Dependent variable:** the variable that is directly affected by the independent variable. It is the result of what happens when the independent variable changes. It is always placed on the Y-axis (vertical axis).

#### 2.3.5.4 Use of analogies

To ensure better understanding of Biology amongst English second language learners, **analogies** are suggested, whereby new science concepts are related to what learners know. Ferreira (2011) explained that effective analogies can clarify thinking, help learners overcome misconceptions and create ways to enable learners to visualise abstract concepts. Although Hodson and Hodson (1998) have suggested the use of technical terms and symbols in preference to colloquial terms, and the use of familiar everyday words only in restricted and specialised ways by science teachers, Lemke (1990) argued that:

Students are not taught how to talk science: how to put together workable science sentences and paragraphs, how to combine terms and meanings, how to speak, argue, analyse, or write science. It seems to be taken for granted that they will just 'catch on' to how to do so... When they don't catch on, we conclude that they weren't bright enough or didn't try hard enough. But we don't directly teach them how to (p. 22).

Harrison and Treagust (2006) referred to analogies as *the personal construction of meaning*. Analogies are important because when learners study new concepts, meaningful learning proceeds when they find and visualise connections between a newly taught context and what they already know (ibid.). Even if appropriate analogies promote concept learning, the teacher should not assume that learners understand and appropriately map his/her analogies, but the teacher should rather summarise the analogies and interrogate learners' understandings of the individual or multiple analogies (ibid.).

Brown & Salter (2010) noted that analogies are used in science to develop insights into, hypotheses and questions about, and explanations of phenomena that are usually unobservable and need to be understood. A learner may be left with ill-defined ideas unless the teacher explains the analogy to ensure it is understood as intended and that misconceptions are minimised (ibid.). They gave an example of an analogy that could be used, of water flowing through a pipe which is often used as an analogy for blood flowing in a blood vessel.

### **2.3.5.5 Code-switching**

In Namibia, teaching of English has been greatly emphasised by the government through its ministry, as it has been in the Malaysian study of code-switching by Ahmad and Josoff, (2009). According to Probyn (2009), classrooms are the places where the tensions and conflicts around language policy and practice are most acutely experienced and teachers are faced with complex dilemmas that are both pedagogical and political. Many teachers who are in favour of the applications of communicative techniques in the language environment oppose any form of native language use during classroom instruction (Sert, 2005). Those who try to code-switch are viewed as ‘smuggling the vernacular into the classroom’, as many teachers regard code-switching as illicit, a sign of linguistic and pedagogic incompetence, rather than using a valid communicative strategy (Probyn, 2009).

On the other hand, Ahmad and Josoff (2009) acknowledged that the low level of English among learners (and teachers too) has brought about the need to code-switch. Code-switching is a supporting element used in communicating information in a social interaction (Sert, 2005), and this is why teachers employ code-switching as a means of providing learners with the opportunity to communicate and enhance learners’ understanding (Ahmad & Josoff, 2009). Furthermore, code-switching is used when the level of English used in the textbook is beyond the learner’s abilities or when the teacher has exhausted the means to adjust his/her speech to the learners’ level (ibid.).

However, if code-switching is used in classes which do not share the same native language, it may create problems, as some learners (though few) will be neglected (Sert, 2005). Probyn (2009) opposed this and stated that if teachers and learners generally share a common home language, a natural communicative response is for both teachers and learners to code-switch.

### **2.3.5.6 Chalkboard use**

A chalkboard is an important aid and can be used together with other aids for better clarification and drawing a particular diagram (Tulasi & Rao, 2004). They highlighted that a properly used chalkboard becomes an attraction point to hold learners’ attention. Buddle (2012) strongly supported the use of a chalkboard, arguing that when learners are following along with an instructor who uses a chalkboard, they become actively engaged in the content and forget about other distractions like their cellular phones.

### **2.3.5.7 Group work**

Windschitl and Thompson (n.d) described group work as a chance for learners to work independently of the teacher's overt guidance and in social settings. They argued that if designed properly, group work gives learners many opportunities to engage in science talk, to learn from others and to develop social behaviour.

Other advantages of group work are that it promotes opportunities for confronting different ideas; it helps learners develop ways of expressing their own point of view, and develops the capacity of listening and understanding others (Wong, 2001). Moreover, learners who have done group work display their growth in tolerance, ability to listen to others, and respect each other's views, as well as becoming considerate and helpful towards others (ibid.).

On the same note, group work improves learners' thinking and helps them to construct their own understanding of science content by strengthening and extending their knowledge of the topic (Lin, 2006). On the other hand, Wong, (2001) noted that often learners think that they can disappear when working in groups or one learner may take over the work while the others sit back. It is also usually the most talented learners who have difficulties in cooperating in group work (ibid.).

Teachers who allow learners to select who they want to work with can reinforce social divisions (on basis of gender, abilities) and isolate children who are not chosen (Blatchford, 2003). He suggested that the teacher sets up an activity in such a way that encourages all group members to talk and work together, and does not actually encourage individual working. So, in assigning learners to groups, teachers should mix genders, friends and non-friends (ibid).

### **2.3.5.8 Homework**

Any tasks assigned to learners by school teachers that are meant to be carried out during non-school hours is referred to as homework (Marzano & Pickering, 2007). Some teachers and parents support homework and some do not. Those that believe homework is necessary say it is crucial for the development of the learner and for the construction of his/her knowledge (Carbone, 2009). On the other hand, Cooper (2008) noted that some people believe that homework creates stress. He added that learners don't always get homework done because it was not explained enough for them to understand. Likewise, learners do not complete

homework because parents don't always understand how to help learners or feel unprepared to do so (Cooper, 2008; Marzano & Pickering, 2007).

To ensure homework given to learners is effective, learners should be given assignments to interview parents about opinions relating to their experiences, rather than structured learning tasks (Marzano & Pickering, 2007).

After focusing on the strategies that teachers can use in order to mediate learning of the topic on transpiration, the next section focuses on the theoretical frameworks that underpin my study.

## **2.4 Theoretical framework**

A theoretical framework introduces and describes the theory which explains why the research problem under study exists (Labaree, 2013). It also explains the meaning, nature, and challenges of a phenomenon, often experienced but unexplained in the world in which we live, so that we may use that knowledge to act in a more informed and effective ways (ibid.).

Labaree (2013) added that the theoretical framework consists of concepts, together with their definitions, and existing theories that are used for one's particular study. He maintained that the framework should demonstrate an understanding of theories and concepts that are relevant to the topic of one's and that will relate it to the broader fields of knowledge in the discipline.

In this study I focused on the Social Constructivism and Pedagogical Content Knowledge in order to frame my study of how grade 11 Biology teachers mediate learning of the topic on transpiration.

### **2.4.1 Social Constructivism**

McRobbie and Tobin (1997) defined social constructivism as a constructed knowledge which is socially mediated as a result of cultural experiences and interactions with others in that culture. They highlighted that learners prefer discussions of own ideas and those of fellow learners, and this helps them to achieve their goals of understanding. In addition, a learner prefers having another learner explain something he/she is not grasping. This helps a learner understand concepts, although teachers sometimes keep wanting to move on to other topics, which leaves no room for discussion (ibid.).

Moll (2002) explained that a child is capable of constructing new knowledge with the help of more knowledgeable others, and that the knowledgeable one can be a teacher or peers. He culminated with the point that a learner's new knowledge is understood to arise from a structured relationship between the external, cultural environment and his/her mind. Vogel (2004) indicated that if a teacher has to mediate learning, it requires complex interactions between the system and the environment, which makes sense that the learning opportunities which a teacher provides for children should afford the opportunity for complex interactions.

Central to social constructivism is that learners have to be central in the learning process and interact in the process of constructing new knowledge. Therefore, in this study, I intended to observe how the teacher interacted with learners, taking into consideration the learners' prior everyday knowledge, code switching, class discussions and the time allowed for discussions. This framework also helped me to examine documents like textbooks in order to see if the content presented in the textbook allows room for learners to interact or be engaged in some discussions.

#### **2.4.2 Pedagogical Content Knowledge [PCK]**

Shulman (1986) explained that PCK comprises the most powerful analogies, illustrations, examples, explanations, and demonstrations as ways of representing and formulating the subject, to make it comprehensible to others. PCK presents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of the learners, and presented for instruction (ibid.). Because learners are unlikely to appear before teachers as blank slates but rather bring prior conceptions and misconceptions, so the teacher needs knowledge of the strategies most likely to be fruitful in reorganising the learners' understanding (ibid.).

Pedagogical content knowledge is a combination of the two types of knowledge explained above (Mishra & Koehler, 2006). It is the knowledge and practice of teaching and learning that an educator can use such as classroom management, taxonomies, planning and assessment (ibid.). These authors further explained that "Content Knowledge" is the knowledge of subject content, which includes concepts, theories, ideas, frameworks, evidence and proof and established practices including ways to develop such knowledge.

Yip (2003) clarified that the teacher should be aware of the difficulties learners have with notions of transformation of matter, and take care to help learners generate robust links

between new understandings about transpiration and their previous learning about evaporation and the water cycle.

Similarly, Jones and Moreland (2003) summarised seven characteristics of PCK that a teacher should possess, these being: (1) the nature of the subject and its characteristics; (2) conceptual, procedural and technical aspects of the subject; (3) knowledge of the curriculum, including goals and objectives as well as specific programmes; (4) knowledge of student learning in the subject, including existing knowledge, strengths and weaknesses and progression of student learning; (5) specific teaching and assessment practices of the subject, for example, authentic, holistic, construct reference; (6) understanding the role and place of context; and lastly, (7) classroom environment and management in relation to the subject, for example, managing resources, equipment and technical management.

On a different note, Jones and Moreland (2005) stressed the planning of assessment for learning. They clarified that teacher subject knowledge is related to assessment procedures, since knowledge of the subject provides teachers with some focus for learning. Teachers should use their subject knowledge base for decision-making and what they are going to assess. In addition, sound teacher subject content knowledge positively affects decisions to change pedagogical strategies on assessment (ibid.).

This framework guided me during the classroom observation. I observed whether the strategies that teachers used during lesson presentation confused or helped learners understand transpiration. This helped me observe how the teacher's content of the topic matched with the way he/she presented the topic. Other aspects I observed from the lessons included the use analogies, illustrations, examples and demonstrations to ensure concepts were understood by learners. Moreover, PCK helped me examine the teacher's ability to plan the lessons, the use of LCE, integration of prior knowledge, use of scaffolding activities, clear up misconceptions arose and examine assessment activities given to learners

## **2.5 Concluding remarks**

This chapter looked at curriculum issues around transpiration in Biology, looked at the conceptual framework, discussed the task of a mediator, and mediating learning of the topic on transpiration. I also discussed challenges in mediating learning of science concepts, mediation strategies used during science lessons, and mediation strategies for understanding

transpiration. Finally, in this chapter, I discussed the theoretical framework that underpinned my study. The next chapter focuses on the methodology applied in it.

## CHAPTER THREE:

## RESEARCH METHODOLOGY

*A case study research is a qualitative research approach in which a researcher focuses on a unit of study known as a bounded system such as individual teachers, a classroom, or a school. In addition, a case study research is unique in that it leads to a different kind of knowledge compared to other kinds of research. It is rooted in the context of the study and is also related to the reader's knowledge, experience, and understanding as he/she compare and contrast to own experiences ( Gay, Mills & Airasian, 2009, p. 426).*

### 3.1 Introduction

In this chapter, the research orientation and the methods used to gather data are described. This chapter also presents the procedures used in order to gather data on how grade 11 Biology teachers mediate learning of the topic on transpiration. Finally, in this chapter, I present the limitations to this study and make some concluding remarks.

### 3.2 Research design and Orientation

This piece discusses the research paradigm and the qualitative case study that I have used to understand how the teachers mediate learning of transpiration.

#### 3.2.1 Interpretive paradigm

A research paradigm is believed to have an influence on the way knowledge is studied and interpreted (Mackenzie & Knipe, 2006). They argued that without a nominated paradigm as the first step in research, there is no basis for subsequent choices regarding methodology, methods, literature or research design. In developing an understanding of how grade 11 Biology teachers mediate learning of the concept transpiration, I used an interpretive paradigm. An interpretive paradigm (also known as the constructivist paradigm) is one in which the researcher generates or inductively develops a theory or patterns of meanings through the research process (ibid.). Cohen, Manion and Morrison (2011) explain that an interpretive paradigm seeks to understand the subjective world of human experience. Accordingly, in order to retain the integrity of the phenomena investigated, I made efforts to get inside the research participants and to understand them from within (ibid.) using a qualitative case study method.

### 3.2.2 Qualitative case study

Merriam (2002) explained that qualitative research is an effort to understand situations and interactions in their uniqueness as part of a particular context. She further explained that in qualitative research, words and pictures rather than numbers are used to convey what the researcher has learned about a phenomenon.

Merriam (2002) clarified that in qualitative research, there are likely to be descriptions of the context, the participants involved and the activities of interest. She added that data in the form of quotes from documents, field notes, participant interviews, and excerpts from video tapes, electronic communication, or a combination thereof are always included in support of the findings of qualitative study. Furthermore, the advantage of qualitative research is that the researcher can expand his/her understanding through both nonverbal and verbal communication, process data immediately, clarify and summarise material, check with respondents for accuracy of interpretation, and explore unusual or unanticipated responses (ibid.).

Qualitative research may use a case study design in which data analysis focuses on one phenomenon, which the researcher selects to understand in-depth regardless of the number of sites or potential participants for the study (McMillan & Schumacher, 2001). “A case study is an intensive study of a single unit for the purpose of understanding a larger class of (similar) units” (Gerring, 2004, p.342). According to Becker, Dawson, Devine, Hannum, Hill, Matuskevich, Travel and Palmquist (1994), a case study is a form of qualitative descriptive research that is used to look at individuals, a small group of participants, or a group as a whole. In a case study, researchers gather data about participants using direct observations, interview, protocols, tests, examination of records, and collections of writing samples (ibid.). In the same vein, Cohen, et al. (2011) defined a case study as “a single instance of a bounded system, such as a child, a clique, a class, a school and a clique; it provides a unique example of real people in real situations, enabling readers to understand ideas more clearly than simply by presenting them with abstract theories or principles” (p. 289).

In this study, qualitative data was gathered from two teachers using observations and interviews, hence adopting a case study method. Instead of working with a large group of biology teachers, the case of two teachers teaching transpiration helped me understand or make sense of the teachers’ teaching methods in mediating learning of the topic on transpiration.

Therefore, **the case** I investigated was:

- Two grade 11 Biology teachers mediating learning of the topic transpiration.

The **Unit of analysis** in this study was:

- Mediation of learning of the topic on transpiration.

### **3.3 Research goal and questions**

#### **3.3.1 Research Goal**

The main goal of this study was to understand how grade 11 Biology teachers mediate learning of the topic on transpiration.

#### **3.3.2 Research Questions**

To achieve this goal, I endeavoured to answer the following main question:

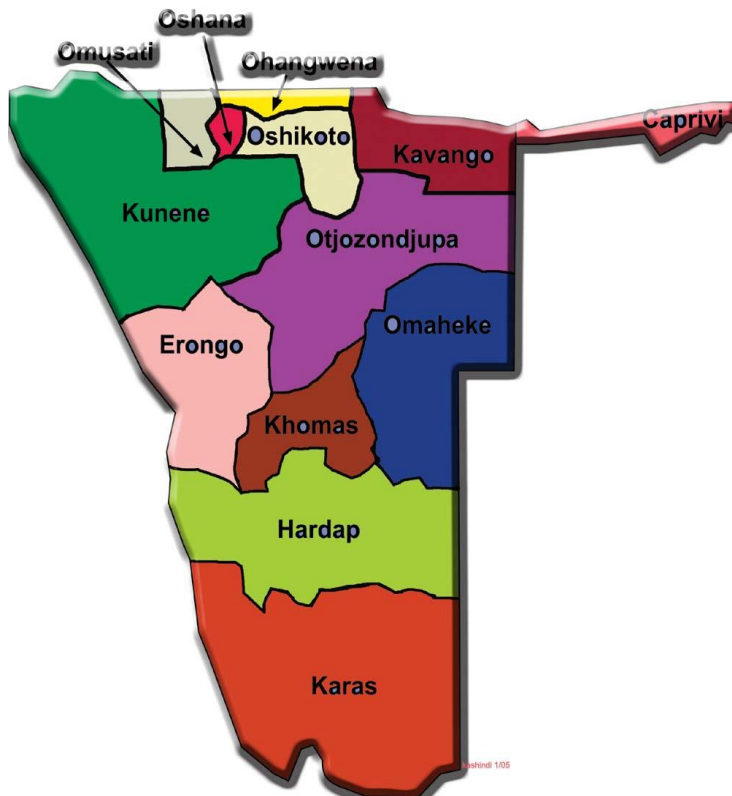
How do grade 11 Biology teachers mediate learning of the topic on transpiration?

To answer the main question, I asked the sub-questions I have highlighted in Section 1.4.

### **3.4 Research Sampling and site**

Creswell (2012, p. 206) state “In qualitative enquiry, the intent is not to generalise to a population, but to develop an in-depth exploration of a central phenomenon. Thus, to best understand this phenomenon the qualitative researcher purposefully or intentionally selects individuals and sites” In this study, I therefore purposively selected the site and sample. I identified one urban school, School Eagle (Pseudonym), in Oshikoto region where I was currently employed. I identified two grade 11 Biology teachers to be my research participants.

The school had 29 teachers of which 3 were Biology teachers, 5 institutional workers, and 691 learners of which 120 were doing biology in grade 11. Below is a map showing the different regions of Namibia, including Oshikoto where the study was conducted.



**Figure 1: Map of regions of Namibia. Source: [www.nantu.org.na](http://www.nantu.org.na): Retrieved on 03 December 2014**

### **3.5 Data gathering techniques**

For this study, data was gathered in two phases. Phase one aimed at answering research sub-questions 1, 2 and 3 while Phase Two aimed at answering research question 4.

#### **Phase One**

This phase aimed at answering the first three research questions, namely:

- How do grade 11 Biology teachers help learners make sense of concepts on the topic on transpiration?
- What challenges do grade 11 Biology teachers experience when mediating learning of the topic on transpiration?
- In what ways do grade 11 Biology teachers deal with challenges faced by learners in making sense of the concepts on the topic on transpiration?

Three methods to gather data to answer these questions, viz., **document analysis, interviews, and observations**. More data gathering techniques were used in order to ensure validity of the data gathered through the process called triangulation (Cohen, et al., 2011). In the next section, each of these data gathering techniques is discussed in detail.

### **3.5.1 Document analysis**

Creswell (2012) categorized documents obtained about a site or participants in a study as public and private records that include newspapers, minutes of meetings, personal journals and letters. The documents analysed in this study were: the NSSCO grade 11-12 Biology syllabus, grade 12 Examiners' reports for the years 2010 to 2013, textbooks and learners' work/exercise books. I also used the information from the Examiners' reports to strengthen the context of this study.

### **3.5.2 Interviews**

An interview is a conversation between two people (the interviewer and the interviewee) whereby questions are asked to obtain information from the interviewee (Champion, Champion & Hudson, 1994). Nieuwenhuis (2007) explained that in an interview, the interviewer asks the participant questions to gather data in order to learn about the ideas, beliefs, views, opinions, and behaviours of the participant. He adds that a qualitative interview aims to see the world through the eyes of the participant, and that interviews can be a valuable source of information, provided they are used correctly. In this study, I conducted semi-structured interviews and stimulated recall interviews, discussing each in turn below.

#### **3.5.2.1 Semi-structured interviews**

To gather information from the respondents, I used semi-structured interviews which were audio-recorded (Cohen, et al., 2011). A semi-structured interview is a qualitative method of inquiry that combines a pre-determined set of open-ended questions (questions that prompt discussion) with the opportunity for the interviewee to explore particular themes or responses further (Pritchard & Sweeney, 2010). A semi-structured interview helped me to discuss, identify, explore and probe new emerging lines of inquiry that were related to my topic (Nieuwenhuis, 2007). Questions in this type of interview were only set to give a guide, but I was able to pose new questions, based on the interviewee responses during the conversation. I conducted pre-interviews before observing the lessons in order to find out whether what teachers said in pre-interviews was what happened in the classroom.

The other reason why I opted for this type of interview is that, unlike a structured interview, a semi-structured interview does not limit respondents to a set of pre-determined answers and instead allows respondents to discuss and raise issues that a researcher may not have considered. Therefore, the semi-structured interview allowed me to probe and ask follow-up questions (Cohen, et al., 2011). It took me 20 minutes and 38 seconds to interview Teacher 1, and 34 minutes and 10 seconds to interview Teacher 2. The longer interview with Teacher 2 reflected that there were more follow-up questions and issues that emerged during the latter conversation. Data gathered from these interviews were transcribed verbatim to facilitate analysis (see Appendix C).

### **3.5.2.2 Stimulated recall interviews (SRI)**

According to Lyle (2003), a stimulated recall interview (SRI) is an introspection procedure in which (normally) video-recorded passages of behaviour are replayed to individuals to stimulate recall of their concurrent cognitive activity. After the lesson observations with both teachers, we set separate dates in order to conduct stimulated recall interviews.

The SRI served to strengthen the validation process (see Section 3.7). SRI also helped me discuss with the teachers about what strategies and challenges had emerged from the observed lessons, as well as what strategies they could use to improve the way they presented transpiration to their learners.

### **3.5.3 Observations**

I employed observation in order to gather data from classroom presentations. Observation is about watching closely. Cohen, et al. (2011) explain that observation is more than just looking. Observation is looking (often systematically) at people, events, behaviours, settings, artefacts, routines and the researcher always takes notes systematically. He emphasised that the unique feature of observation is that it offers the researcher an opportunity to gather 'live' data from naturally occurring social situations. With observation, the researcher can look directly at what is taking place *in situ* rather than relying on second-hand accounts (ibid.). On the same note, Creswell (2012) defined observation as the process of gathering open-ended information by observing people and places at a research site. In this study at least three lessons per teacher were observed and these were video-recorded. Three lessons were necessary for me to familiarise myself with the classroom, for the learners to get used to my

presence and for the teachers to introduce the topic, during the first lesson. The second and third lessons were for the lesson observation.

#### **3.5.4 A pilot study**

Gay, et al. (2009) advised that in order to assess the research plan formally, one could field-test some aspects in a pilot study. They defined a pilot study as a small-scale trial of a study conducted before the full scale study in order to identify problems with the research plan. Although time and lack of participants to work with may be stumbling blocks to carrying out a pilot study, Gay, Mills and Airasian (2009) highlighted that “any pilot study, however even a small one should be considered a very worthwhile use of your time” (p. 116).

Before my field research, in January 2014, I tested my interview questions by interviewing one of the B. Ed science students at NIED in Okahandja. I did this in order to see how interview questions could be adjusted. Through this exercise I learnt that I needed to use simple English, delete some questions from the list, and that some new questions might arise during an interview, depending on the interviewee responses. Another crucial thing I learnt was that probing is necessary in order to get clear and in-depth data during an interview. The next section focuses on Phase two.

#### **Phase two**

This phase was aimed at answering the fourth research sub-question, which is:

What can grade 11 Biology teachers do to improve mediating learning of the topic on transpiration?

In this phase the researcher, together with the teachers, developed a lesson plan. This lesson plan will be used for revision with Grade 12 learners, since the topic had been taught to the Grade 11 learners already. This collaborative approach to lesson design was in itself reflected on and reported in the thesis. At the end in this phase, together with the teachers, we reflected on lessons presented and discussed the way forward to improve our practice.

**Table 1: Tools, Methods, Data to be gathered and the Purpose**

<b>Phases And Stages</b>	<b>Method used to gather data</b>	<b>Data gathered</b>	<b>Purpose</b>
Phase 1  Stage 1	Document analysis  - Syllabus  - Grade 11-12 Biology Textbooks	What the documents say about transpiration	To get insights about how the transpiration is presented in these documents, and to contextualise my study.
Stage 2	Conducted a pilot study on my research questions to Science Med. classmates at NIED Okahandja. I also interviewed one B Ed. Honours student who is a grade 11-12 biology teacher at NIED.	To get insights on how teachers help learners make sense of concepts when mediating learning of transpiration, challenges faced, how they deal with them, and on how to improve.	To test the data gathering tools, especially the interview questions and improve where necessary.
Stage 3	I interviewed two Grade 11 Biology teachers	To get teachers views on how to help learners make sense of concepts when mediating learning of transpiration, challenges faced, how they deal with them, and on how to improve.	To get teachers' views on how they help learners make sense of concepts, challenges they face, how they deal with them and how one can improve the mediation of learning of transpiration.
Stage 4	Observed two Grade 11 Biology teachers presenting transpiration.	To see how teachers help learners make sense of concepts when mediating learning of transpiration, challenges they face and how they deal with them in the classroom.	To see the real situation in order to get primary data from classrooms and validate data from interviews.

Stage 5	Transcribed the videos as well as the audio recorded data  Watched the videos with each of the two teachers and did stimulated recall interviews. This helped to lead us to Phase 2.	To present data from interviews and observations.	To make sense of data and analyse it.
<b>Phase 2</b>  Stage 6	Together with the teachers, developed a lesson on the use of a potometer, the teachers taught. The lessons were video recorded and we watched the videos together.	How to use a potometer to measure the rate of transpiration and recorded results on the graph.  Together with the teachers, we reflected on the lessons taught and developed a model lesson.	To see how to improve on teaching transpiration collaboratively.

### 3.6 Data analysis

Qualitative data analysis involves organizing, accounting for and explaining the data; in short, making sense of data in terms of the participants' definitions of the situation, noting patterns, themes, categories and regularities (Cohen, et al., 2011, p. 537).

The theoretical framework built from Social Constructivism and Pedagogical Content Knowledge [PCK] helped to analyse data (see Section 2.3). Social Constructivism provided a guide on how a teacher is supposed to interact with the learners, whether the teachers considered learners' Prior Everyday Knowledge, allowed code switching, and if they motivated the learners to take part in classroom discussions or not. PCK also helped identify the strategies that the teachers used to help learners understand transpiration. Thus, instead of simply identifying anything that made sense during the interviews and observations, I categorises data into themes that matched descriptions in the framework. The framework then helped me to come up with themes and I could not have made sense of the data without the framework.

The data themes were analysed using a colour coding strategy. Coding has been defined by Creswell (2012, p. 559) as "the process of segmenting and labelling text to form descriptions

and broad themes in the data and coding enables the researcher to identify similar information in order to make sense of it”.

To make sense of data gathered, Creswell (2012) suggested that one could divide data into different codes for emerging themes. He argued that coding as an inductive process of narrowing data into a few themes. In this study pink color was used to highlight ideas on how teachers make help learners to make sense of concepts, yellow to highlight challenges they face, green to highlight ideas on how teachers deal with challenges and blue to highlight ideas on how to improve the mediation of learning transpiration (See Appendix C).

### **3.7 Data validation**

Validating findings means that the researcher tries to determine the accuracy or the trustworthiness of the findings through strategies such as **triangulation** or **member checking** (Creswell, 2012, p. 259). As referred to earlier (Section 3.5.4), a pilot study was conducted. Also to verify data, different data gathering methods were used, such as document analysis, semi-structured interviews, observed lessons, and stimulated recall interviews after watching the videos with the teachers, this process is called triangulation. Triangulation is the process of corroborating evidence from different individuals, types of data, or methods of data collection (Creswell, 2012).

This study ensured that the teachers were given opportunities for member checking. Creswell (2012) defined member checking as a process in which the researcher asks one or more participants in the study to check the accuracy of the account. The researcher asks participants about many aspects of the study, such as whether the description is complete and realistic, whether the themes are appropriate, and if the interpretations are fair and representative (ibid.). For member these purposes the transcripts were given to the participants to check that what they had said in interviews was what was written on transcripts.

### **3.8 Ethical considerations**

Qualitative researchers need to be sensitive to ethical principles because of their research topic, face-to-face interactive data collection, an emergent design, and reciprocity with participants (McMillan & Schumacher, 2001, p. 420).

Creswell (2012) suggested that it is important to respect the research site and the people at that site (the school community in this case) by gaining permission before entering, by disturbing the site as little as possible during a study, and by viewing oneself as a guest at the place of study.

I requested permission from the Circuit Inspector, school principal and the two Biology teachers (see Appendices A and B). Confidentiality and anonymity was guaranteed to all the participants (although when reviewing the videos, this was a challenge). Withdrawal was allowed at any time and voluntary participation was ensured at all times.

### **3.9 Limitations of the study**

Though it was much easier to work with a small sample, working with the two biology teachers from one school was not representative enough for all biology teachers in the Oshikoto region let alone Namibia at large.

Although conducting a study at a school where I worked was a practical benefit, it presented some challenges such as that the teachers could not take me seriously when it came to agreeing on interviews and observations. Furthermore, due to the teachers' busy schedules and other commitments, lessons could not be observed on consecutive days as planned. Finally, working with only one voice recorder and a video camera, made it difficult to hear what all learners said while working in groups.

### **3.10 Concluding remarks**

This chapter discussed the research design and orientation, research goals and questions, the research sampling and site the data gathering techniques. These were followed by discussion of the data analysis methods, data validation process and ethical considerations. Finally, I looked at the limitations of the study. The next chapter focuses on data presentation and analysis.

## **CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS**

### **4.1 Introduction**

This chapter presents data gathered from document analysis, interviews and observations. In Section 2.2 the official Namibian government instructions and guidelines applicable to the topic of transpiration were analysed. This chapter presents analysis of two textbooks used by the teachers. These documents were analysed to establish to what extent teachers were guided on the topic on transpiration and how the two textbooks presented it. That was followed by interviews and observations, providing data on how the two teachers mediated learning of this topic.

### **PHASE ONE**

#### **4.2 Document analysis**

The Government documents analysed were the Namibian Senior Secondary Certificate (Ordinary level) NSSCO] grade 11 Biology syllabus (Ministry of Education [MoE], 2009). A syllabus review provided insights on how the syllabus guides the teachers in order to present the topic on transpiration to the learners. It also provided insights on how the syllabus guided teachers regarding practical work on transpiration was also analysed. The analysis is also presented of two grade 11-12 Biology textbooks that teachers used, namely, Biology for Namibia (1<sup>st</sup> edition) (De Klerk, n.d) and the Namibia College for Open Learning [NAMCOL] Biology Module 1 (Kadhila, 2009).

##### **4.2.1 The grade 11-12 Biology syllabus**

The syllabus highlights the general objectives and the specific objectives of the education system. The syllabus also highlights what is suggested for practical work. Figure 2 shows a page from the syllabus.

TOPIC	GENERAL OBJECTIVES Learners will:	SPECIFIC OBJECTIVES Learners should be able to:
<b>7. Transportation</b>		
<b>7.1 Transport in plants</b>	<ul style="list-style-type: none"> <li>Know water uptake, transpiration and translocation in plants, and understand the importance of these processes for plants</li> </ul>	<ul style="list-style-type: none"> <li>identify and describe the structure of a dicotyledonous root and stem as seen under a light microscope (epidermis with root hairs, cortex, phloem, xylem)</li> <li>describe the uptake of water by osmosis</li> <li>describe the pathway by which water enters a plant, crosses the root, moves up through xylem vessels, enters leaf cells, and leaves the plant through stomata</li> <li>describe the mechanism of water uptake and movement in terms of 'pull' from above, creating a water potential gradient through the plant</li> <li>define <b>transpiration</b> as the loss of water vapour from a plant (mostly from the leaves)</li> <li>describe how the loss of water vapour is related to cell surfaces, air spaces and stomata</li> <li>describe the effects of variation of temperature, humidity and light intensity on transpiration rate</li> <li>describe the methods by which xerophytic plants can reduce transpiration rate, with reference to two named examples (e.g. Aloe; Euphorbia; Quiver tree)</li> <li>describe how wilting occurs</li> <li>discuss the adaptations of the leaf, stem and root to different environments, with emphasis on local examples</li> </ul>
	<ul style="list-style-type: none"> <li>Know that phloem is responsible for the transport of organic substances</li> </ul>	<ul style="list-style-type: none"> <li>define <b>translocation</b> in living phloem sieve tubes as the movement of sucrose and amino acids from regions of production or of storage to regions of utilisation in respiration or growth</li> <li>describe the translocation of applied systemic pesticides in phloem throughout the plant</li> </ul>

*Suggestions for practical work:*

- use a simple potometer to compare the rate of transpiration under different environmental conditions
- carry out an investigation to compare the relative number of stomata on the upper and lower epidermis of a leaf, using petroleum jelly
- observe, draw and interpret prepared slides of roots and stems, including the structure of xylem and phloem tissue
- observe, draw and interpret leaves of xerophytes plants, both macroscopically and microscopically
- observe the epidermis of a leaf using clear nail varnish to study the structure and distribution of stomata

**Figure 2: A page from the syllabus dealing with transpiration (Ministry of Education [MoE], 2009)**

#### 4.2.2. Textbook 1: Biology for Namibia (1<sup>st</sup> edition)

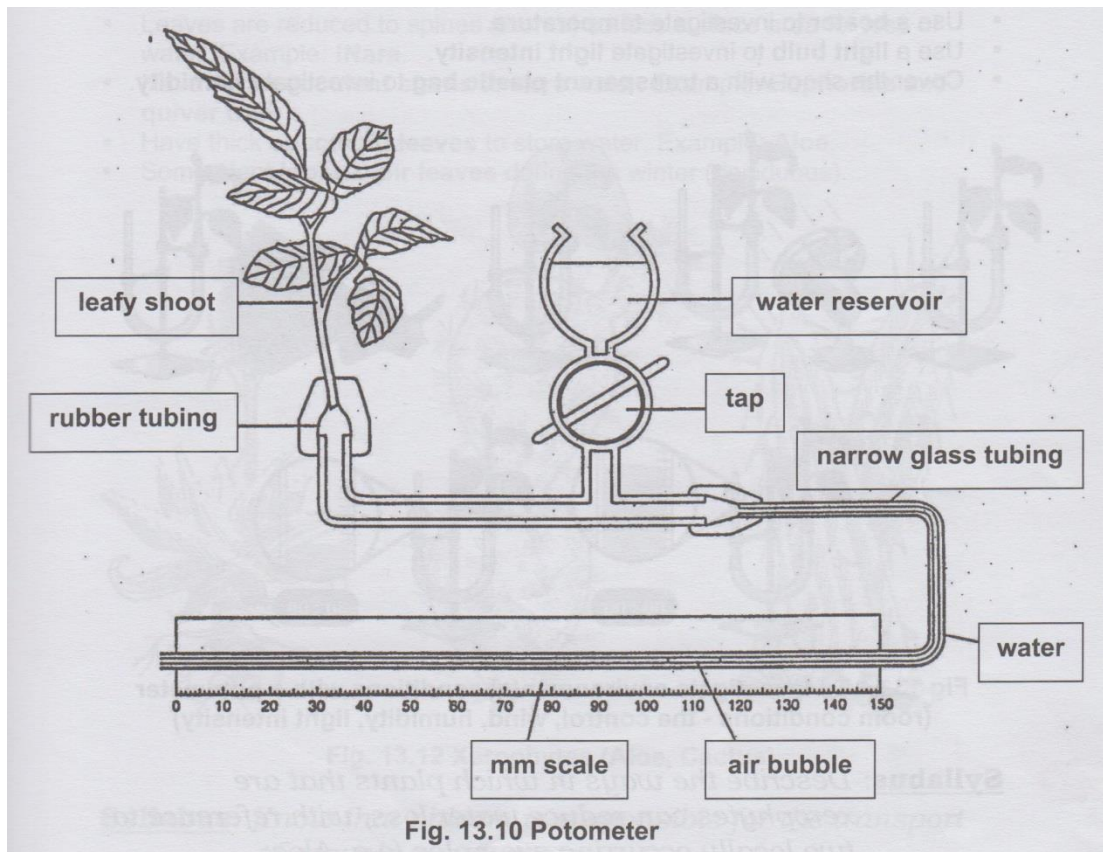
I examined how the content was presented in this textbook. It outlined what needs to be taught regarding the topic on transpiration (the Biology syllabus objectives) on the first page before the content is presented. It also outlined what the Biology syllabus suggests for practical work. The content on transpiration was presented according to syllabus objectives, in other words the content presented first was an answer to the first syllabus objective and so on until all objectives were covered.

The content on the topic of transpiration is presented in the following order:

- Description of transpiration;
- Advantages and disadvantages of transpiration;

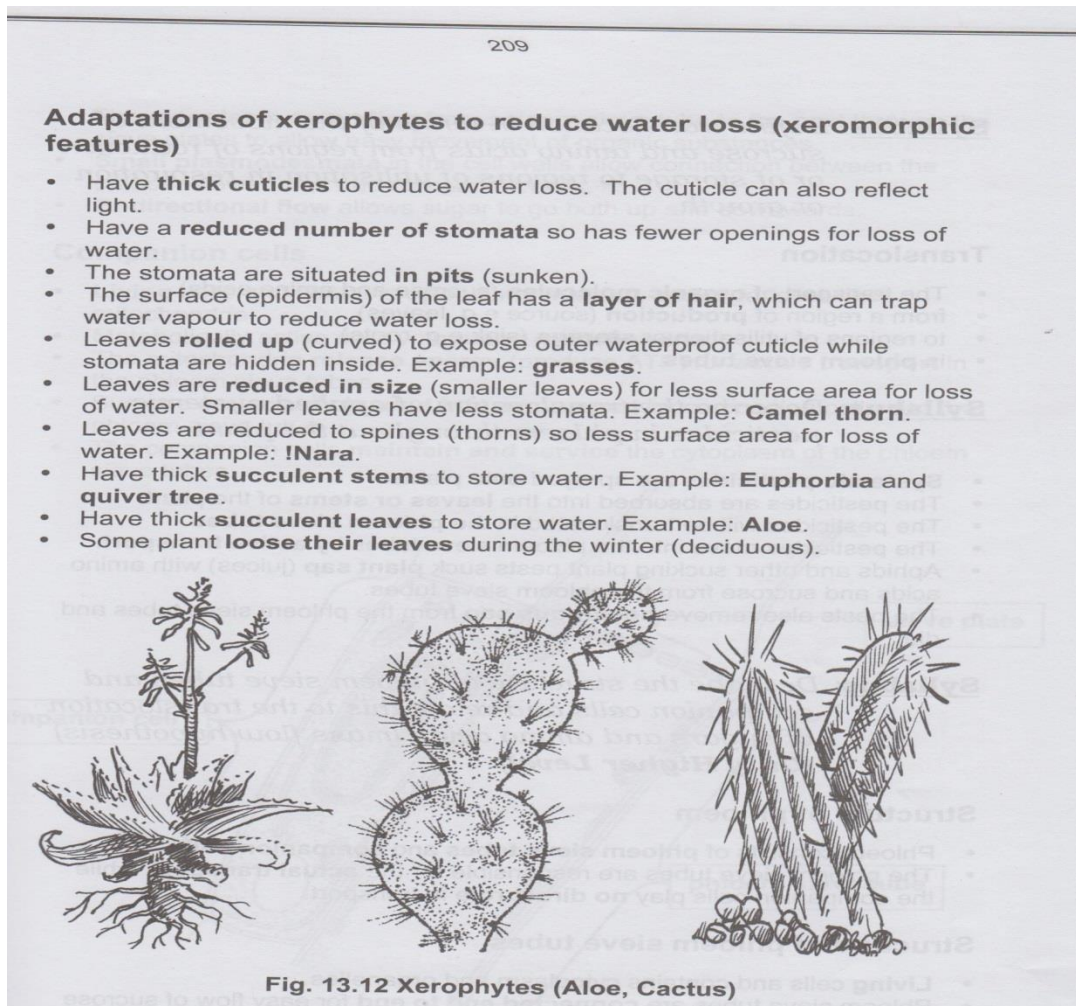
- Explanation on how environmental conditions affect the rate at which water vapour diffuses out of stomata and affects the rate of water uptake;
- Description of how wilting occurs;
- The use of a simple potometer to compare the rate of transpiration under different environmental conditions;
- Precautions when setting up a potometer;
- How to use a potometer for different environmental conditions;
- A description on the ways in which plants that are xerophytes can reduce water loss, with reference to two locally occurring examples; and
- Adaptations of xerophytes to reduce water loss.

The textbook included diagrams of a labelled potometer and of examples of xerophytes on pages 207 and 209 respectively (see diagrams below). However, the textbook did not provide activities for learners on transpiration. The potometer was illustrated as below.



**Figure 3:** A diagram of a potometer from Biology for Namibia (1<sup>st</sup> edition) (De Klerk, n.d, P. 207)

Examples of Xerophytes were presented as below.



**Figure 4: Examples of Xerophytes as they appear in Biology for Namibia (1<sup>st</sup> edition) (De Klerk, n.d, P. 209)**

#### 4.2.3 Textbook 2: NAMCOL Biology Module 1

This textbook provided a few objectives on how transpiration should be taught, it had clear notes on transpiration, the pictures of a potometer and xerophytes were clear, and it also provided more activities for the learners regarding transpiration.

The content on the topic of transpiration was presented in the following order:

- Definition of transpiration;
- Activity 6 on observation of water that collects in a plastic bag tied around the leaves and stem of a plant placed in a container of water;
- Activity 7 on the use of cobalt paper to test for the presence of moisture ;

- Water movement in the leaves and transpiration;
- Activity 8 on water movement through the leaf;
- Water potential gradients in the leaf;
- Upward movement of water through the plant;
- Factors affecting the rate of transpiration;
- Activity 9 about transpiration;
- Measuring and comparing the rate of transpiration;
- Activity 10 on the use of a potometer to compare transpiration rates under different conditions;
- Adaptations to living in dry conditions;
- Activity 11 on succulent plants found in Namibia; and
- Check your progress (pp. 211-221 & 227).

Below are some of the diagrams and activities from the textbook on pages 211 and 212.

**Hint**  
Carefully remove the leafy shoots from a tree or bush growing wild.

**ACTIVITY 6**

This practical activity will take about 20 to 30 minutes to set up and will need to be looked at over a few days.

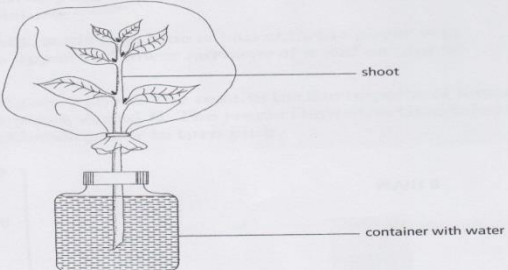
**Looking at transpiration**

You will need:

- two leafy shoots, about 30 cm long
- two clear plastic bags, big enough to cover the shoots
- two transparent containers, such as plastic drink bottles
- some clean water.

- 1 Cut two leafy shoots from a tree or bush.
- 2 Fill the containers with clean water and put each shoot in a container.
- 3 Mark the containers **A** and **B**.

4 Tie a plastic bag around the leaves and stem of the plant in container **A** as shown in Figure 7.



The diagram shows a leafy shoot with three leaves and a stem. The stem is inserted into a container filled with water. A clear plastic bag is tied around the stem and leaves, covering them completely. Labels 'shoot' and 'container with water' point to their respective parts.

**Figure 7** A leafy shoot in container A

- 5 Remove the leaves from the shoot in container **B**.
- 6 Tie the second plastic bag around the shoot just as you did for container **A**.
- 7 Place both containers side by side near a window.
- 8 Each day, look to see if there are any drops of liquid collecting on the inside of the plastic bags.
- 9 Write down what you see in your notebook and explain your results.

**Figure 5: NAMCOL Biology Module 1 (Kadhila, 2009, Pp. 211-212). Activity on transpiration**

### **4.3 Pre-interviews**

This piece presents data that emerged from the pre-interviews I conducted. The pre-interviews were conducted before the lessons were observed in the classrooms.

#### **4.3.1 Teachers' profiles**

In this study, I worked with two participant teachers. They taught at the same school, "School Eagle", in Oshikoto region (see Section 3.4), where I was also employed. Teacher 1 (T1) held a Bachelor's degree in Education from the University of Namibia majoring in Biology and Mathematics. Apart from having taught grades 11-12 Biology for six years, she also taught grades 11-12 Mathematics. Teacher 2 (T2) held an Advanced Diploma in Education from the University of Zimbabwe, majoring in Biology. At the time of the study he was enrolled as a fourth year student for an Honours degree in Education with the University of Namibia, majoring in Biology and Home Economics. Teacher 2 had taught grades 11-12 Biology for six years, and also taught grade 10 Life Science.

Prior to observing lessons, interviews were conducted with the two teachers at the school to find out how they helped learners make sense of concepts on the topic on transpiration, what challenges they experienced in that task and how they deal with such challenges. The interviews also aimed at finding out ways in which grade 11 Biology teachers could improve mediating the learning of the topic on transpiration. Data from these interviews is presented in the following section.

#### **4.3.2 How teachers help learners to make sense of concepts**

In their interviews the teachers indicated that they used different types of strategies in order to help learners make sense of concepts on the topic on transpiration. Below are the strategies that they highlighted.

##### **Use of local materials**

When asked about how they helped learners make sense of concepts on the topic on transpiration, it came out clearly that both teachers made use of locally available materials to demonstrate transpiration. Teacher 1 said the following:

...you can even come up with a potometer is one example to demonstrate transpiration to see how plants up-take water and again it shows you how the plants lose water. I think you can just take a plant, although it is not a potometer. You can just take a branch of a tree, then you put it in water, then you cover it with plastic again...you can simply use an open can, then we

put pure water, and take a branch of a plant, that I prefer to use to measure the rate of transpiration...just any type of material that can be found in the environment instead of using potometer". (Appendix C, I-T1: 37, 49).

Teacher 2 indicated that he made use of locally available material to demonstrate transpiration, and he noted that: "...sometimes I have to improvise to make my own Potometers by using the available material and then, this in all it will convince learners and then they will believe that it is real plants normally lose water through their leaves". (Appendix C, I-T2: 19)

Something I found interesting was that both teachers said they made use of locally available materials, which was also observed in class, where teachers had to guide learners in setting up experiments using local material (See appendix B, O-T1: 1 and O-T2: 8).

### **Use of analogies**

From the interview, it emerged that Teacher 1 uses analogies to describe concepts. She said that: "*They can understand if you describe concepts at the beginning of the lesson....you can even ask them to run, they start sweating, then you explain to them that, same applies to plants, but for plants it's not because they exercise or they run, but because of higher temperature*". (Appendix C, I-T1: 17, 21).

There is a possibility that this teacher confused some learners as the analogy implies that higher temperature causes the plant to transpire. The teacher could have clarified that higher temperature causes the plant guard cells which control the stoma where water is released to the atmosphere to open, while colder temperature causes the openings to close. When stomata are open, there is an increased rate of transpiration.

Although Teacher 2 did not comment on the use of analogies during the interview, in the lessons I observed, he used analogies to help learners make sense of concepts, where he explained how temperature and wind affect the rate of transpiration using an example of washing clothes (See appendix D, O-T2: 124).

### **Considering prior knowledge**

Teacher 2 highlighted that he helped learners make sense of concepts by introducing a lesson by relating to what learners already know. He said that:

About transpiration this topic is a... almost common in all natural science subject especially learners they normally meet this subject this topic either in Agriculture, or in Life science back to lower grades and even now in Biology. For me to introduce this topic to them, they normally consider the parts of the plant that are involved in the absorption of water, either

from the soil, and the other parts like the leaves that normally let water move out of the plant. By looking at their functions of those parts and then as a result (Appendix D, I-T2: 10).

Although Teacher 1 did not highlight that she considered learners' prior knowledge when teaching, in one of the lessons I observed, she asked learners to define transpiration before giving them the correct definition (See Appendix D, O-T1: 12).

### **Guidance on practical work**

Teacher 2 indicated that he guides learners on how to set up and use equipment for practical work. He pointed out that:

But before learners use that Potometer I have selected out of other Potometers, it is me who has to...aa...make rehearsals for the learners aa... that, first of all, the Potometer it is used like this, like this part of...like if I have to be specific for example, aa...when you are setting Potometer, we have to make sure that there is no air in the Potometer, aa...that is why the Potometer is normally set under water, aa... to avoid bubbles. Because some of those bubbles may interfere with the experiment and you may not able to see or to get the results that you want to get (See appendix C, I-T2: 51).

Teacher 1 did not mention that she guides learners on practical work to help learners understand concepts but it came up in the interview when she was asked how she ensured that when the class worked on drawings, girls also get a chance to draw. She said:

It starts with when you make it that individual can come up with this, and it should be done under supervision, otherwise if it is not done under supervision of the teacher again, they can ignore fixing the part and come up with the model. And, but if you do that and you make it an issue for each and everybody, under your supervision, I hope next time they would like to involve or to take part in such project (Appendix C, I-T1: 130).

### **Questions and answer strategy**

In an interview, Teacher 2 affirmed the use of questions and answer as a strategy to help learners understand concepts of transpiration. He said the following:

Sometimes or immediately after the lesson, I also, ask questions, oral questions, aa...and then apart from oral questions I also set questions basing on potometers, just to see whether learners have understood or they did not. And then, I also...set some very short questions, in other words I also set test s that are related to potometer and then that test it has to be given to learners. Then, as a result, I am testing their knowledge. Whether they have understood the

function of a potometer, whether they have understood what transpiration is all about or what is that causing transpiration in plants and how can transpiration be stopped. In all those things I asked through oral questions, through class activities, and through test (Appendix C, I-T2: 67).

Teacher 1 did not mention that she uses the question and answer strategy to help learners understand concepts, although it transpired in her observed lessons. For instance, at the beginning of the lesson, she asked learners to define transpiration (See appendix C, O-T1: 16). In addition, she asked learners to explain how light intensity affects the rate of transpiration (Appendix C, O-T1: 166).

After having looked at how teachers help learners make sense of concepts on the topic on transpiration, the next section presents data on the challenges teachers face.

### **4.3.3 Challenges faced by the teachers**

The paragraphs below present challenges that teachers identified while mediating learning of the topic on transpiration. These are summarised also in Section 4.4.3, together with the proposed solutions.

#### **Difficulties in defining concepts**

When I interviewed Teacher 1 on the challenges she faced while teaching on transpiration, she commented that learners had difficulties in defining concepts, saying: *“Sometimes, they can’t define the concepts well, knowing that it is a loss of water from the plant leaves to the atmosphere in the form of water vapour, but they don’t really get where the water comes from, they don’t detect ... and how do the plants get water until such a process, until to the end where they lose water.* (Appendix C, I-T1: 55).

#### **Difficulties with graphs**

Teacher 1 also pointed out that learners also had difficulties working with graphs, saying:

...they do have a problem working on the graphs, in terms of working out, we call it a scale on the X-axis, to present the scale on the X-axis and also on the Y-axis, and it is quite challenging, also when it comes to plotting...plotting graphs, I think it is an individual work, and if they fail, it can be a boy or a girl who just don’t understand how to go about plotting the graphs. So, there it is equally (See appendix C, I-T1: 87, 112).

### **Girls expect boys to draw for them**

Regarding girls expecting girls drawing for them, Teacher 1 said the following: “*Biological drawing is where mostly I experience gender issues, where girls, they can’t do much in terms of drawing, they always expect their male counterparts to do the drawings for them*”.

(Appendix C, I-T1: 108).

### **Learners cannot spell scientific concepts**

Another challenge experienced by Teacher 1 was that learners cannot spell scientific concepts, which she highlighted follows: “*...these learners express themselves, they are more in English, they ignore using Biological concepts, I think maybe Biological are too difficult for them to...acquire them*” (Appendix C, I-T1: 137).

Next, I present the challenges identified by Teacher 2.

### **Language barrier**

Teacher 2 indicated language barrier as a challenge he was usually faced with while teaching the topic on transpiration and noted that: “*Challenge number one it can be the language barrier...Most of our learners are from rural areas and they have got a problem of English. And mind you that the language that we use in Biology is not really English, these are scientific words*” (Appendix C, I-T2: 81, 84).

### **Shortage of equipment**

Teacher 2 also identified a shortage of equipment as a challenge to presenting transpiration, saying: “*Another problem that I normally encountered here is...the availability of materials. When I am presenting my lessons, I normally do things theory instead of practicals due to lack of material*” (Appendix C, I-T2: 89).

### **Poor relationship between the community and the school**

A poor relationship between the community and the school was another challenge that Teacher 2 highlighted. He pointed out that:

The community sometimes does not look at our ideas as if perhaps we are trying to take money or rob, to take money out of their hands, it is not like that... when maybe for example when you send the learners to go and get something and parents were not willing to help... We... we were supposed to do a certain practical, a practical about...it was about food

testing, but then when I sent my learners each one to bring just a type of food from their houses, most of the parents were refusing to give assistance and then this one has forced me to go and buy some items at an open market, eee...because learners did not come with anything because parents have failed me (Appendix C, I-T2: 97,100, 105).

### **Problems in spelling scientific concepts**

Teacher 2 also spoke about spelling ability as a challenge to his learners. He said: *“the spelling is a problem to them, aa...most of them are failing to spell words in the right way* (Appendix C, I-T2: 134).

### **Difficulties in drawing diagrams**

The teacher echoed that learners have difficulties in drawing graphs and noted that: *“Most of all, our learners do not know how to draw, drawing is a problem, aa...esp...they lack Biological drawing...”* (Appendix C, I-T2: 174).

### **Content is not presented clearly in textbooks**

Teacher 2 expressed that the way the content on the topic on transpiration was presented in the Biology Module 1 was not clear, and that activities in textbooks were of poor quality. About the content, the teacher expressed the following: *“...it is somehow clear, aa...therefore if you just give it to learners that, this content is all about or this part is all about transpiration, learners on their own may not be understanding or may not understand it* (Appendix C, I-T2: 213).

About the activities, he said: *“some of the books, they have activities, but these activities in the books are of poor quality”* (Appendix C, I-T2: 228).

### **Girls are not active during practical work**

Teacher 2 also stated that girls are not quite active during practical work. He voiced the following:

Boys are more active than girls...aa...because even when I am directing them or instructing them to construct their photometers, for example, boys are the first one to finish and the girls finish later. But if you compare these potometers that are made by boys and those that are made by girls, obvious you can, you will be convinced that the potometers that are made by boys are more accurate than those that are made by girls. Therefore now, when girls are

comparing their potometers with boys, most of the girls, they feel shy (Appendix C, I-T2: 245).

Both teachers spoke about problems related to language though they differed a bit in their interpretations. For example, Teacher 1 highlighted that learners had difficulties in defining concepts and that they could not spell scientific concepts whereas Teacher 2 highlighted the language barrier and spelling. Teacher commented that learners have difficulties with drawing graphs and biological drawings. Another similarity was in gendered performance differences. Teacher 1 reported that girls expected boys to draw for them and Teacher 2 reported that girls were not active during practical work. The only significant differences between the teachers' reports of challenges were that only Teacher 2 reported a poor relationship between the community and the school and that the content was not presented clearly in textbooks.

Having presented challenges that teachers face, the next sections summarises of challenges faced by each teacher and how they deal with them.

#### 4.3.4 How Biology teachers deal with the challenges they face

Below is a table summarising the challenges faced by Teacher 1 and how she dealt with the challenges while mediating learning of the topic on transpiration.

**Table 2: Challenges faced by Teacher 1 and how she dealt with them**

<b>Challenges faced by Teacher 1</b>	<b>How Teacher 1 dealt with the challenges faced</b>
Learners had difficulties in defining concepts.	Explained concepts even if they appear clear in textbooks. <i>“I think it is only the teacher who needs to clarify the concept to the learners, to make sense of how transpiration happens in real life situation”</i> (see Appendix C, I-T1: 67).
Learners had difficulties in working with graphs.	Gave more practical work. <i>“I think they can just be given more practical work... can give as many work to measure the rate of what...what and every time you ask them to plot their results on the graph”</i> ( Appendix C, I-T1: 96, 99).
Girls generally expected boys to draw graphs for them.	Ensured each learner worked on graphs individually. <i>“It starts with when you make it that individual can come up with this, and it should be done under supervision, otherwise if it is not done under supervision of the teacher again, they can ignore fixing the part and come up with the model. And, but if you do that and you make it an issue for each and everybody, under your supervision, I hope next time they would like to involve or to take part in such project”</i> (Appendix C, I-T1: 130).
Learner could not spell scientific concepts.	Wrote on the board and deduct marks for any incorrect spelling. <i>“All the new concepts, for the new introduced topic should be written on the chalkboard and should be spelled out correctly and should be pronounced also correctly... You underline where... what is wrong and I usually just initiate with ‘sp’...I</i>

	<i>train them, I always tell them, I will deduct marks for seeing an incorrect spelling, and that can enable them seriously to, to practice, and keep on writing so that they know how to spell out those concepts correctly”(Appendix C, I-T1: 153, 161).</i>
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The following table presents challenges Teacher 2 faces and how he deals with the challenges.

**Table 3: Challenges faced by Teacher 2 and how he deals with them**

<b>Challenges faced by Teacher 2</b>	<b>How Teacher 2 deals with the challenges faced</b>
Language barrier	Though not confident to say so, the teacher code-switched and simplified scientific concepts. “... and mind you the language we use in <i>Biology is not really English, these are scientific words. And sometimes it’s really difficult for me to translate them in their mother tongue... I do not, I am not failing to translate or to translate these Biological words or scientific words to their mother tongue. But I try by all means to simplify these scientific words for my learners to understand”</i> (Appendix C, I-T2: 84, 118, 87).
Shortage of equipment	Improvised by using locally available material. “ <i>since some of those apparatus are not available in our school. So..., sometimes I have to improvise to make my own Potometers by using the available material... I normally improvise to make the Potometers, the Potometer is not normally constructed by me, but it has to be constructed by learners themselves”</i> (Appendix C, I-T2: 19, 31).
Poor relationship between the community and the school.	The teacher compensated by trying to do things on his own when the community did not get involved in the activities given to learners. “... <i>most of the parents were refusing to give assistance and then this one has forced me to go and buy some items at an open market, aa...because learners did not come with anything”</i> (Appendix C, I-T2: 107).
Learners had difficulties in spelling scientific concepts.	The teacher corrected concepts that were incorrectly spelt when marking and when giving the feedback. The teacher also underlined the concept spelt incorrectly, and referred learners to the co Biology teacher as well. “ <i>I try to correct it through marking and even during the corrections when I am giving feedback to them... I underline the word which is not well spelled, and then I put ‘sp’ stand for spelling... I normally refer them also to my co teacher, co Biology teacher in case maybe, because I normally think that maybe is it, is the problem with me or with the learners”</i> (Appendix C, I-T2: 136,139, 152).
Learners had difficulties in drawing graphs.	The teacher tried explain how to draw graphs. “ <i>I normally explain to learners clearly the differences between the independent variable, or depended variable...I clearly tell my learners like that. For example, when you look at a time and temperature, now you can see that temperature is depending on time, that means temperature is dependent variable and time is independent variable. Therefore, temperature has to be on a vertical of the line, that is Y-axis time it has to be on the horizontal line, that is X-axis”</i> (Appendix C, I-T2: 182).
Content was not presented clearly in textbooks.	The teacher tried to define terminologies and gave summaries on the chalkboard. “ <i>You try to define some problems, terminologies there, try to define them so that learners understand more clearly, then after you have explained it, you also try to summarise or to give a short summary on the chalk board whereby learners can copy it and put it down in their summary books”</i> (Appendix C, I-T2: 217).

Activities in textbooks were of poor quality.	The teacher set activities with co Biology teacher, in line with the Biology syllabus. <i>“I then come in with my own activities that I set, but these ones are based on the syllabus, because if you are not setting activities basing on the syllabus, still your activities will be regarded as of poor quality. So therefore, I try my best to set my own activities but when I am setting these ones, normally I call my co Biology teacher to set them together”</i> (Appendix C, I-T2: 232).
Girls were not active during practical work.	The teacher tried to discourage from laughing at girl’s work. <i>“I also try to balance the situation whereby I sometimes tell my learners especially boys to say, do not laugh at others, even though their potometers are not as good as yours. You are all one person, you are all my learners”</i> (Appendix C, I-T2: 254).

Tables 2 and 3 summarised challenges faced by the teachers and how they dealt with them. The next paragraphs summarise ways teachers can improve mediating learning of the topic on transpiration.

When interviewed, Teacher 1 suggested co-teaching by saying:

It is very important...seriously if you experience difficulty in the topic, you just need to go to your colleague for guidance. Or one can say, let me observe you, when you present this topic because I find it quite challenging. And then from there... Yes, it is boring, because you are just talking about plants, they can’t see movement of water, it takes place inside, but... if you observe, if you read more books, if you do your preparations well and consult your colleagues (Appendix C, I-T1: ).

About ways to improve mediation learning of the topic on transpiration, Teacher 2 suggested engaging learners in one’s lesson, and co-planning of activities. He said: *“...try to involve learners in your presentation...try also to set your activities together with your co teachers in that particular subject, don’t do things on isolation”* (Appendix C, I-T2: 337).

He also highlighted the importance of lesson preparation by commenting that: *“...you should also prepare before you teach. That means you should consult your syllabus”* (Appendix C, I-T2: 349).

Moreover, Teacher 2 suggested that a teacher should give an activity or a test after having completed the topic: *“...at least after you presented or during the presentations, try to give either class activities to learners and then after you have completed the topic, try to give a test to learners, just to see how far they have understood”* (Appendix C, I-T2).

It is clear that both teachers stressed the importance of team work, as they echoed co-teaching, setting of activities together with a co-teacher, co-planning and observing a

colleague, in order to improve the ways in which teachers mediate learning of the topic on transpiration. Teacher 2 added that one needs to consult a syllabus and give activities or tests to learners after a topic had been taught.

#### **4.4 Lesson observations**

After conducting pre-interviews with the teachers, I observed them teaching the topic on transpiration. This was done to supplement data generated from document analysis and interviews. Observations thus helped me to gather ‘live’ data on how grade 11 Biology teachers mediate learning of the topic on transpiration.

Through this exercise, I was able to observe how the two teachers helped learners make sense of concepts, that is, their strategies. I was also able to identify some challenges the teachers faced as highlighted in interviews and how they dealt with these challenges. I also learned from these teachers regarding the strategies they use which will help me improve my own practice.

Three lessons were observed for Teacher 1 and two from Teacher 2. Each lesson lasted for about 40 minutes. Each lesson was video-recorded by a critical friend and I was able to take field notes using an observation schedule. After the two lessons were observed, Teacher 2 was given an opportunity to reflect on his own lessons (see Appendix C) while watching the videos with him. Afterwards, feedback was given to him in anticipation that this would assist in improving his teaching strategies. Data presented below is from my field notes as well as the video-recorded lessons.

##### **4.4.1 Teacher 1 (O-T1)**

Having looked at all three lessons, below are the strategies and challenges I observed from Teacher 1.

##### **Lesson 1 (40 minutes)**

##### **Use of locally available materials for demonstration**

After introducing us to the class, the teacher started the lesson by trying to engage the learners in the activity, which was demonstration using locally available material. She sent one girl to go and fetch a shoot from a nearby tree, introduced the topic and wrote “Transpiration” on the board. By trying to engage the learners in an activity, the teacher

guided the learners in doing a demonstration of how a plant takes up water using a simple potometer, and she said:

While we are waiting, she brings for us a nice shoot with a stalk, and now I require someone to fix it please. Now, what we need to do, only when we do it we can then define what transpiration is all about. Can you do it for me? I will tell you what to do. What you need to do, you take this plastic and that shoot, I want you to tie this plastic there, and I don't know where to place it, you look, maybe your colleague can tell you where to place it if you want to see how transpiration can take place (See appendix D, O-T1: 3).

### **Boys are eager to fix things**

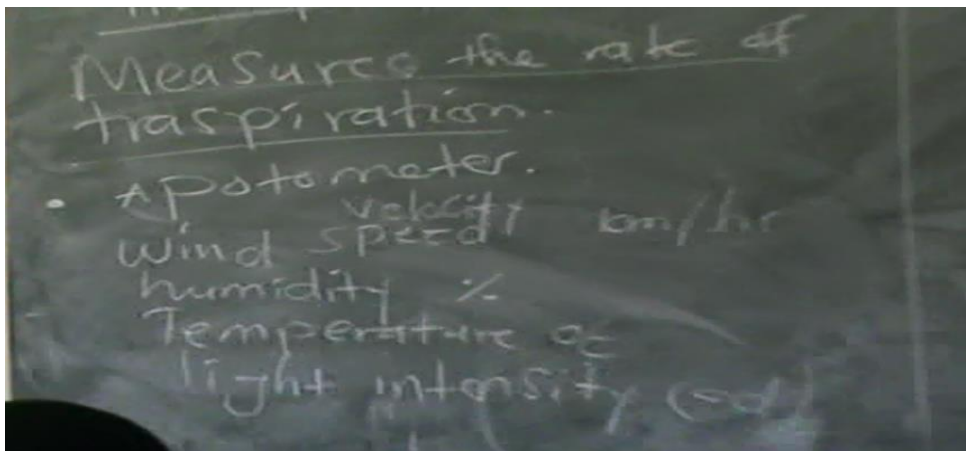
Although it was a girl who went to get the shoot, it was a boy who tried to fix it on the container, which demonstrated how boys are often eager to fix things in a science classroom (Appendix D, O-T1: 9).

### **Eliciting learners' prior knowledge**

While explaining how the potometer works, the teacher tried to ask learners on what they know about transpiration. In doing this, the teacher explained by trying to relate to what the learners know. She said: *“Can I have a definition or someone who can define for me, maybe to start with, if you have an idea of what is all about transpiration. Can I have just somebody to define for me what transpiration is all about. Okay, who wants to tell us what is transpiration?”* (Appendix D, O-T1: 14).

### **The use of the chalkboard to summarise the content to learners**

Another strategy observed from this teacher was writing on the board to summarise concepts to learners (see Figure 6 below).



**Figure 6: The use of a chalkboard**

### **Question and answer (dialogue)**

Teacher 1 motivated learners to ask questions during the lesson. Below is the conversation:

*T1: Okay, do you have a question?*

*LF1: Yes X...*

*TT1: Okay, that is good!*

*LF1: It is like I am not understand the word still day. As it is that on a windy day the rate of transpiration is increase. Is means that when there is no wind, the rate of transpiration decrease?*

*TT2: Yes, it is. That is what you call calm day, the day is just calm, no wind, it is still day, no wind. The rate of transpiration will be lower. During the windy day, obvious the rate will be high.*

*TT1: Questions? Is it clear?*

*L1: Yes*

### **Scaffolding learners to set up an experiment**

Teacher 1 ended the lesson by explaining or guiding to learners how to set up a potometer, . Below is what she said:

*TT1: ... please be careful, make sure that there is no air bubbles inside here... So we expect is that to see some drops of water inside the plastic and to see bubbles that are being formed to indicate the uptake of water by the plant. ...this plastic should be wider enough. And when you are always making an experiment, we are always having a control and the experiment. ...Then when you look for the two plant shoot, one you put it in the container, you label your container A, and you label your container B. In container A, you place one plant shoot and in container B, you place one plant shoot. Then once you do that, only one container you are going to tie it with a plastic. The type of plastic I advise you to use, have you seen those ones, the soft one? A bread plastic ... as long as you make sure that no holes to make your experiment fair and please make sure that there will be no bubbles... I think two or one, as a class. One just, this group, yours is a controller, container B is yours. Container A, is for this group. They must be placed on the side at the same time.*

The lesson ended with the teacher explaining the activity that learners had to work on as homework and that learners had to work in two groups.

### **Lesson 2**

This was a continuation of the previous lesson and the focus was on the factors affecting transpiration rate and learners had to work on an activity.

## **Beginning by eliciting learners' prior knowledge**

Teacher 1 began a lesson by referring learners to the previous activity of how transpiration takes place. A container of water with a plant shoot that was set yesterday was brought to learners' attention so that they could see that transpiration had taken place as there was a reduction in the water level. Below is what happened in the class:

*TT1: Although we have tried to just elaborate on how to measure the rate of transpiration using a... using the simple transpiration experiment... I want to know the level of water, I don't know how full was it according to your experiment, and I can see a lot of water in that plastic, and now I want you guys to tell me how was your level of water. Is the level of water remaining the same? Or you can see that it goes down?*

*LL1: It goes down!*

*TT1: Are you sure that it goes down? In which container? We have two containers here, which one do you want to tell me that the level of water goes down?*

*LL1: Container B...*

*TT1: Okay, So now, what does that mean now?*

*LF1: Transpiration*

*TT1: That means that, the more the plant is losing water, the more it's taking up what?*

*LL1: Water*

*TT1: Water... through the process of what?*

*LL1: Transpiration*

The lesson continued with the teacher asking learners to list the factors that affect the transpiration rate and their units of measure. Learners got stuck with the light intensity unit of measure and the teacher had to tell learners that the unit of measure is Candela which she also wrote it on the board (see Appendix D, O-T1: 345).

## **Group work**

After explaining factors affecting transpiration, the teacher handed worksheets to learners to work in three groups. Learners were asked to plot data on factors affecting transpiration rate, such as humidity, temperature and light intensity, on graphs. The teacher explained what learners were expected to do in their respective groups and she had this to say:

*TT1: Okay, now these are the units to measure all the factors affecting the rate of transpiration. For now, I prepared data for you. Now, I want you to plot this data according to the experiment. I had mine that you did not see and it is where I gathered this data, and now I want you to plot them on the graph... The first group, group A, you can do humidity, take a graph paper from that book, then you plot your humidity information. The second one, group B, you are going to plot wind velocity or wind speed and at the same time plot the graph for temperature or for wind velocity. Here you choose temperature or velocity and once you do that, draw the possible curve. We have to do it quickly now, as long as we have seen*

*our results, what is happening and that is what our graph can tell us, according to the results we get here.... I have level one for group A, two for group B, and three, group C. (Appendix D, O-T1: 356).*

### **Code-switching**

Although the teacher spoke in English to explain, learners used Oshiwambo to communicate with each other while working on the task in their groups and only a few communicated in English (Appendix D, O-T1: 401). Below are some of the learners' conversations:

*LG3: Do we write here? Mpano itapu shangwa (We can't write here)...temperature...*

*LG3: Tetii, ninga, shangaa (Okay, do, write)... one is eight... to tameke pombanda kokatable (you start at the top of the table).*

*LG1: Itale oku (Bring it here), to tameke pevi (You start at the bottom)... zero with 26.*

*LG1: To tameke pombanda (You start at the top)... (Another suggestion from a different girl). 100 with zero...*

*LG2: oonumba ndhono odhina ngaa omahala gethike pamwe? (Do those numbers have the same spaces between?)*

Individual learners were not left out of the group work. The teacher moved from group to group ensuring that learners were working on the task, and that they were labelling correctly. When the bell rang, learners handed their tasks to the teacher.

### **Lesson 3**

The teacher began the lesson by reflecting on the previous lesson. She said: *"Yesterday we looked at different factors affecting the rate of transpiration. We were just busy with the practical of all the factors affecting the rate of transpiration. I gave you to plot...this group one, I gave you to plot which factor?"* (Appendix D, O-T1: 480).

### **Feedback on learners' activity**

This lesson mainly focused on the learners' previous task. Together with the learners, the teacher discussed what each group was expected to do and how they were supposed to do it.

### **Learners' difficulties in working with graphs**

From the tasks marked, it emerged that learners tried to work on their tasks although their plotting, labelling on x and y- axes, and responses to the questions on the different curves were not done perfectly. It was apparent that learners struggled to work on their graphs as the teacher spent most of the time trying to explain what they were expected to do. Below is part of what transpired during the lesson (Appendix D, O-T1: 503):

*TT1: The rate of transpiration decrease. Can you see that? (Teacher pointing at Group one's curve). That means, if there is a lot of amount of water vapour in the atmosphere, that tells us that... transpiration rate will decrease. But why didn't you put it on paper? Okay, that is just how one can describe a curve. What I found is... People you were supposed to choose a good topic. Whenever you are given such a thing, you are always having a title on top of your graph, you were supposed to create that. Then from there, as you can see, transpiration is measured in what? In cubic centimetres and there is per hour... So now, that is why it should be written here on the Y-axis, transpiration rate, then you put in brackets the unit for transpiration, in which it can be measured. Then from there what you need in terms of humidity, yes humidity, they have put percentage in brackets (Pointing at the graph).*

*TAl: So meaning that, you draw your graph like this...and this is your Y-axis, and this is your X-axis. If here you write relative humidity, the units for humidity in which it can be measured should be written in bracket. Then you indicate percentage, and then one can read. Then on this side, is where you write transpiration rate and the unit is, because is the amount of water vapour...centimetre cubes, hour... like that as it is given to you (Teacher draws a graph on the board and puts all labels on x and y- axes.). And on top here, were should always have a title...*

The lesson ended when the teacher finished giving feedback to the learners.

These three lessons were presented in a proper sequence as per syllabus guidelines and learners had to do practical work although there was no proper potometer. However, the teacher could not address the last three specific objectives of the lesson in her presentations as outlined by the syllabus (see section 4.2.1). Her feedback touched a little on the closure of the stomata to prevent loss of water from the leaf when light intensity increases (see Appendix D, O-T1: 640).

#### **4.4.2 Teacher 2 (O-T2)**

As with Teacher 1, Teacher 2 was observed in order to find out strategies he used in mediating learning on transpiration, the challenges he faced and how he solved them. Due to other responsibilities, he was only observed for two lessons. Looking at each lesson, below are the strategies and challenges observed from this teacher.

##### **Lesson 1**

The teacher started the lesson by informing the learners of the new topic transpiration. He then moved on to show the locally collected material to be used to construct a potometer one by one. The following paragraphs summarise some strategies observed from the teacher and some challenges he faced.

## **Use of locally available material for demonstration**

At the very beginning of this lesson, the teacher instructed a learner (girl) to construct a potometer. Ensuring that the learners are aware of precaution measures while setting up a potometer, the teacher guided learners by saying the following: “*Open the bottle, make a hole on the lid of that bottle, take a branch, put it in the hole, now put it in the bottle and close it*” (Appendix D, O-T2: 14).

The teacher continued to explain on how learners should set up the potometer by stating clearly that learners should ensure that there were no air bubbles that could interfere with the results.

With the help of the chalkboard, the teacher continued to explain the water uptake from the soil through root hairs, into the xylem in the roots, to the braches and leaves of the plant where some of the water would be used for photosynthesis.

## **Elicitation of learners’ prior knowledge**

Before Teacher 2 went on to explain how transpiration takes place, he tried to lead learners to that topic by asking a few questions to check on what the learners know. The conversation below shows what happened:

*TT2: But not all the water will be used for photosynthesis, but where will it go?*

*Teacher pauses and gives a chance to learners to answer.*

*LM2: Evaporate*

*LF2: In the atmosphere*

*TT2: Very good, some of the water will be lost by the plant leaves into the air, through what...through which structure?*

*L2: Stomata*

*TA2: Stomata openings (while labelling stomata on the leaves drawing on the board)*

*TT2: Stomata are certain openings in the leaves whereby plants normally lose their water in the plant. Now, such a process whereby plants are losing water through stomata, that’s what we call?*

*L2: Transpiration*

*TA2: Yes, very good! (Teacher writes an arrow on stomata and writes transpiration on the board)*

*TT2: That is what we call transpiration. Now, can we define transpiration this time?*  
(Appendix D, O-T2:58).

## **The use of a chalkboard to summarise points**

In order to explain factors that affect that affect transpiration rate to the learners, the teacher made use of the chalkboard as shown below:

*TA2: Erases the board and writes factors that can affect the rate of transpiration.*

*TT2: These factors can be...*

*L2: Temperature*

*TT2: Can be temperature, very good. What else?*

*LM2: Wind, humidity...*

*TA2: Teacher writes the three factors on the board*

*TT2: Now, if these are the factors, we are going to look at each, one by one. How temperature affect the rate of transpiration, how humidity can affect the rate of transpiration and wind, how it can affect the rate of transpiration.*

*LM2: What about light intensity?*

*TT2: Light... should we put it in the same line as temperature?*

*L2: Yes*

*TA2: Writes light intensity closer to temperature and puts it in brackets. (Appendix D, O-T2: 108).*

## **The use of analogies**

An analogy was one of the methods Teacher 2 used to demonstrate how temperature affects the rate of transpiration. He said:

*TT2: I am going to give you an example of temperature and you can try the rest.*

*L2: Yes*

*TT2: Should I give you a very good example of washing?*

*TA2: Now, when you wash your clothes... (Writes wash on the board). After you have washed your clothes you have to hang them on the line (draws line of hanging clothes on the board).*

*TT2: When you hang them on the line, the reason is for them to get dry. But if the temperature within the environment is not so high, don't expect your clothes to get dry. So, if there is no wind, don't expect your clothes to get dry. Therefore, I am saying, if the temperature is too low, your clothes will take so long to get dry. If there is no wind, your clothes will take long to get dry. Therefore, the higher the temperature, the higher the rate of transpiration and the lower the temperature...*

*L2: The lower the rate of transpiration (Appendix D, O-T2: 121)*

### Question and answer (dialogue)

Though the teacher continued to make use of the chalkboard, he also tried to pose more questions throughout the lesson and learners were given a chance to respond. Below is one of the parts of the lessons observed where the teacher asked questions:

*TT2: That means, if the temperature is high, more heat is provided and then as a result, transpiration will be higher. If the temperature is too low, transpiration will be low, there will be no transpiration during low temperature. How can humidity affect the rate of transpiration?*

*L2: High humidity, low trans...*

*TT2: One person, one person...*

*A boy raises a hand and stands*

*LM2: If the humidity is higher, the transpiration will be low, due to the moisture in the atmosphere.*

*TT2: What if humidity is low?*

*LM2: The rate of transpiration will be high (same boy)*

*TT2: The rate of transpiration will be high, in low humidity?*

*L2: Yes*

*TT2: Good, very good! What is humidity? I don't know what humidity is.*

*L2: Is the amount... (chorus)*

*TT2: You like to talk together (points a boy)*

*LM2: Is the amount of water vapour in the atmosphere*

*TT2: The amount of water vapour in the atmosphere... How is wind normally affect the rate of transpiration?*

*L2: Wind, wind... (chorus)*

*TT2: How is wind affect the rate of transpiration? (Teacher repeats when learners remained silent). Anyone brave enough to stand up and tell us? Uhhh...?*

*LM2: When wind blows, remove the excess water in leaves' surface which slow down the rate of transpiration.*

*TT2: Pardon...?*

*LM2: When the wind blows, remove the excess water on the surface of the leaves and low down the rate of transpiration (boy repeats). (Appendix D, O-T2:133).*

## Challenge

### A few learners asked questions during the lesson

Although the teacher asked most of the questions, learners were also given a chance to ask questions. When some learners posed questions, they were either too short or not clear. Some learners laughed at a learner who posed the question because the questioner struggled to phrase it. When the class laughed, the teacher tried to support the questioner by redirecting the question to the class (see Section 4.4.2). Below is one of these conversations:

*TT2: I see only boys are participating, boys are the only ones asking questions, what about girls?*

*LF2: When will be the humidity high?*

*L2: Laugh*

*TT2: When do you think the rate of humidity will be high?*

*TT2: Is it during the day or during the night? Is that your question?*

*LF2: On cloudy day or rainy day? (Same girl asking again)*

*TT2: During...*

*TT2: During the rainy time, like what was said. Someone else...?*

*LM2: You said that plant cannot die? Due to the amount of water in the container?*

*LL2: The whole class laughed*

*TT2: Alright, that is the question to the class, who can try to provide an answer? Who can try to provide the answer to the question? (Teacher repeats when learners were silent). Can you repeat the question?*

*TT2: Alright, there was a hand there (pointing to the back). Who's hand was up here?*

*LM2: The plant cannot die because, there is low water concentration.*

*TT2: Come on again*

*LM2: The plant has low water concentration (lowered voice)*

*TT2: Very good! What were you saying? (Pointing to another boy) (Appendix D, O-T2: 247).*

This lesson ended with a conversation in the class. As mentioned earlier, learners were given an opportunity to ask questions related to factors affecting the rate of transpiration. The learners and the teacher helped to provide answers to those questions.

## Lesson 2

### Elicitation of prior knowledge

The teacher tried to reflect on the previous lesson by asking learners to reflect on the previous lesson. He asked learners to define transpiration and referred them to the potometer as an instrument used to measure the transpiration rate. The teacher also asked learners to explain the different factors that affect the rate of transpiration, explained the transpiration pull by drawing diagrams on the board. The lesson ended when the teacher tried to explain to learners the methods by which xerophytic plants can reduce transpiration rate, using the chalkboard to highlight main ideas.

Adaptations highlighted were having a few stomata on top of the leaf and many on the underside to reduce transpiration; having small leaves as on thorn trees (like the one next to the class) so as to reduce transpiration unlike other plants that have broader leaves; plants having a waxy layer to reflect light back; some plants drop-off their leaves; some plants have a trapped thick layer near the leaves; some plants are succulents. Learners were also given an opportunity to list all the plants that have special adaptations as they were taught in previous grades. The teacher also explained that some stomata of plants are found sunken on the leaves and because learners could not understand what the word 'sunken' meant, the teacher had to code-switch.

### Code-switching

When one learner asked the teacher to explain what sunken meant, the teacher code-switched and below is part of the conversation:

*L2: What does it mean by sunken?*

*TT2: Let me put it in Oshiwambo, aa... Okay... Omafo amwe...ou weteko, eestomata dimwe kiimeno, eshi to tale oya fa ya ninginamo lelalela. Omwa mona omunhu nande ngeno oho tala omunhu fimbo limwe e to mu tala momesho, oho mono kutya oku na omesho e li mwii, miikololo hashoo?* Translated: Some of the leaves... you see, some of the stomata on plants, It appears sunken when you look at it. Have you seen that sometimes when you look at a person in his or her eyes, you see that the eyes appear dipped, within the skull isn't?

*LL2: Laughter in the class*

*TT2: Sunken eyes... Omesho omaninginamo, keeli kombanda, hasho? Maara opuna ngoo omunhu u mwe e na omesho matunhumana.* Translated: Eyes that appear dipped, are not raised, isn't? But there are those with eyes that appear raised.

*LL2: Laughter in the class*

*TT2: Now, the stomata are appearing in that form, that are a bit inside the leaves, not so outside the leaves, not so on the surface of the leaves, they are called sunken leaves. Therefore, if stomata are sunken like that, they are all reducing the rate of what?*

*L2: Transpiration (see Appendix D, O-T2: 590).*

Towards the end of the lesson, the teacher tried to summarise the main points from what transpiration is all about, and how plants have adapted to reduce transpiration rate. The learners were then informed that they were going to be given a task that they had to do during the afternoon study time and finish at home on their own.

**Table 4: A summary of the strategies observed from the teachers**

<b>Strategies</b>	<b>Teacher 1</b>	<b>Teacher 2</b>
Use of locally available material for demonstration during practical work	√	√
Elicitation of learners prior knowledge	√	√
Use of a chalkboard to summarise content to learners	√	√
Question and answer (dialogue)	√	√
Homework		√
Scaffolding	√	
Group work	√	
Code-switching	√	√
Feedback on activities	√	
Use of analogies		√

From the table above, it was evident that teachers used similar strategies to help learners make sense of concepts on the topic on transpiration. The differences being that Teacher 2 did not scaffold learners. This could be because he gave the task to learners as homework where learners worked on their own, hence no group work given and no feedback was provided. On the other hand, Teacher 1 did not make use of analogies to clarify concepts.

#### **4.5 Stimulated recall interviews**

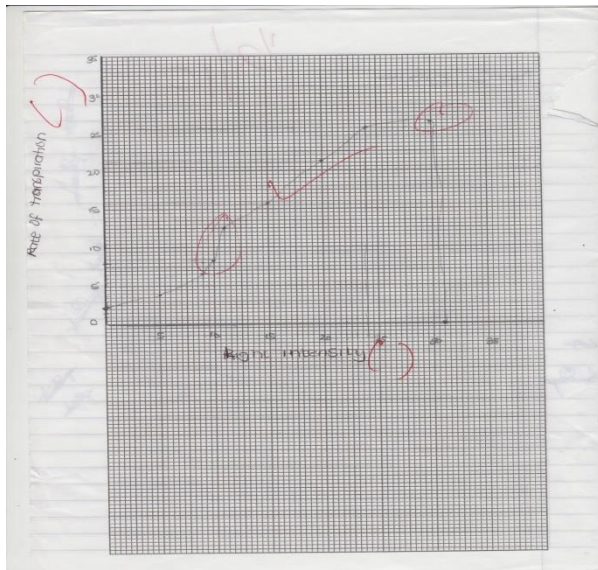
##### **Teacher 1**

After watching the video of her lesson with Teacher 1 was asked to reflect on what went well and where she needed to improve. She was excited to see herself teaching. She expressed that although she tried her best to present the topic well, she needed to clarify the concepts more to the learners. She also felt that she could have better explained the unit of light intensity Candela (cd) to the learners. She also indicated that she needed to make use of learners' prior

knowledge. She noted that learners responded in a chorus and that there were too many in each work groups which led to some of them not being fully engaged in the lesson.

When asked to talk about challenges that learners face during the lessons, which made it difficult for learners to understand transpiration, she had this to say:

*“Plotting graphs and use of units on the X and Y axis are some of the challenges learners face. They cannot differentiate between dependent and independent variables. Learners also fail to relate concepts to the situation on real life as humidity and temperature are observed in most weather situation” (see appendix C...SR1-T1).*



**Figure 7: A graph constructed by learners in a group.**

Figure 4.5 above shows a graph constructed by learners in a group. Its numerous errors demonstrate that they had difficulties when working with graphs.

Teacher 1 was asked to highlight challenges that she faced while teaching the topic. She reported that he found it a challenge to conduct practical work seeing that there were no materials like a potometer so that sometimes teachers needed to improvise.

Teacher 2 was also asked to suggest strategies that she might use to help learners understand transpiration better. She suggested that she would make sure learners were divided to work in smaller groups. She would also make learners work on activities individually; and use of the learner-centred approach by giving more practical work to learners.

## Teacher 2

This teacher could not wait to watch the video as he was also excited to watch himself teaching. He indicated that his voice projection was good and learners participated actively. On the other hand, he suggested ideas on how he could improve. He stressed that he needed to introduce a learner-centred approach rather than the teacher-centred approach which he used (and this contradicted his earlier claim that learners were actively involved). Teacher 2 commented that he needed to move around the classroom and monitor all learners in the classroom instead of being stationed in front of the classroom. He also noticed that he under-utilised the chalkboard which he could have used more to summarise the main points while teaching. He further indicated that learners needed to get feedback after writing an activity instead of being given marked scripts with no feedback.

When I asked Teacher 2 to reflect on challenges faced when he taught the lesson, he indicated that learners were shy, could not express themselves in English and learners failed to define terminologies such as xerophytes.

Regarding the challenges that he faced when mediating learning of the topic on transpiration, Teacher 2 stated that his department does not have apparatus such a potometer or even a science laboratory. He then suggested what he might do to improve on the lesson presentation. He would give more activities and feedback to his learners. He would give more practical work to learners instead of just teaching theoretically.

Below is a table summarising the challenges faced by learners and teachers as well as the strategies suggested by the teachers to improve on the presentations of the topic.

**Table 5: A summary of what emerged from stimulated recall interviews (SRI)**

	<b>Teacher 1</b>	<b>Teacher 2</b>
Challenges faced by learners	<ul style="list-style-type: none"><li>- Difficulties in plotting graphs and in using X and Y axes.</li><li>- Learners could not differentiate between dependent and independent variables.</li><li>- Failure to relate concepts like humidity and temperature to real life.</li></ul>	<ul style="list-style-type: none"><li>- Learners were too shy to ask questions</li><li>- Learners could not define concepts such as xerophytes</li></ul>
Challenges faced by teachers	No materials like a potometer	<ul style="list-style-type: none"><li>- No apparatus such a potometer</li><li>- No science laboratory</li></ul>

Strategies to improve	<ul style="list-style-type: none"> <li>- More clarification of concepts</li> <li>- Building on learners' prior knowledge</li> <li>- Dividing learners to work in smaller groups</li> <li>- Giving activities to learners to work individually</li> <li>- Learner-centred approach through giving more practical work.</li> </ul>	<ul style="list-style-type: none"> <li>- Monitoring all learners in the classroom by moving around</li> <li>- Making use of the chalkboard to summarise main points</li> <li>- Giving feedback on learners activities</li> <li>- Use of a learner-centred approach</li> </ul>
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Although Table 5 indicates only a few challenges arising from teachers' reflections on the particular lessons from the table above, more challenges might have been identified depending on the nature of activities given to learners and questions posed during the lessons.

From looking at marked activities given to learners I learned that all had difficulties in plotting graphs and labelling the x and y axes. During the second lesson given by Teacher 1, learners spent much time debating and arguing while trying to figure out the x and y axes and plotting, even though the teacher explained at the beginning (see Appendix D, O-T1: 386,390, 416, 456...). Although Teacher 2 did not highlight graphing seeing that the activity was done as homework (where learners worked on their own) and there was no feedback given, when I looked at the activity that he marked, it was apparent that his learners had the same problem (See Appendix D).

From the lessons observed, it is also evident from the short sentences that learners spoke, that they were shy to speak in English and to respond to questions or ask. In some cases, others laughed at those who tried to say something. Those learners who tried to say something, struggled to formulate sentences and one could struggle to make sense of what they were trying to say (See appendix D, O-T1: 133, 308, 338... and O-T2:202, 265, 483, 674...). It seemed likely that learners' poor English proficiency is one reason why they failed to explain concepts by linking them to their prior knowledge as highlighted by the teachers.

Both teachers mentioned that they were challenged by a lack of science equipment available at their schools, especially the potometer. The teachers' teaching strategies differed, except where they spoke about the use of learner-centred education, because both could pick up from the videos that they spoke more than the learners were engaged.

## PHASE TWO

This phase was aimed at answering the fourth research sub-question, which was:

In what ways can grade 11 Biology teachers improve mediating learning of the topic on transpiration?

In this phase the teachers and I collaboratively developed two fully scripted model lessons. These lessons were taught as revision lessons, since the topic had been taught to Grade 11 learners already. The items for these lessons were selected in consultation with the two teachers. We selected especially challenging features of the unit and presented our “best shot” at effectively teaching it. We also co-designed our potometer. We felt a need to use PowerPoint slide show software where pictures could be shown in colour to make the lesson live to learners. Colour pictures were taken from the internet. It took us almost the whole day preparing the lesson. At some points we got stuck and had to ask advice from other teachers as well as the biology subject advisor for the region. Although three lessons were prepared, we also designed a topic task that learners had to write during the afternoon study session. Below is lesson one of the three lessons that we designed (see Appendix E).

### 4.6 Lesson 1

**4.6.1 Syllabus objectives:** Learners should be able to:

- Define transpiration as the loss of water vapour from a plant (mostly through the leaves);
- Describe how the loss of water vapour is related to cell surfaces, air spaces and stomata;
- Describe the effects of variation of temperature, humidity and light intensity on transpiration rate.

### 4.6.2 Introduction

The teacher tests for learners’ prior knowledge by asking them to define transpiration.

- Transpiration is the loss of water vapour from the plant leaves, through stomata.

Teacher asks what are stomata and where do we find most of them?

-Stomata are pores on the plant leaves through which CO<sub>2</sub> and O<sub>2</sub> diffuses in and out of the leaf during photosynthesis and causes water vapour to leave during transpiration. There are more stomata on the lower epidermis than the upper epidermis.

### 4.6.3 Main part of the lesson

The teacher asks learners to refer back to the internal and external structures of the leaf. After the listing is complete, the teacher will show the transverse section of the leaf, using Power Point.



**Figure 6: Transverse Structure of a leaf as used in the slide show. Source: [www.enchantedlearning.com](http://www.enchantedlearning.com)**

### How the loss of water vapour is related to cell surfaces, air spaces, and stomata.

Using the chalkboard and the leaf section, the teacher explains the following:

- Water in the mesophyll cells form a thin layer on their surfaces;
- The water evaporates into the air spaces in the spongy mesophyll;
- This creates a higher concentration of water molecules in the air spaces of the leaf than in the atmosphere outside; and
- Water diffuses out of the leaf into the surrounding air through the stomata, by diffusion.

The effects of variation of temperature, humidity, and light intensity on transpiration rate.

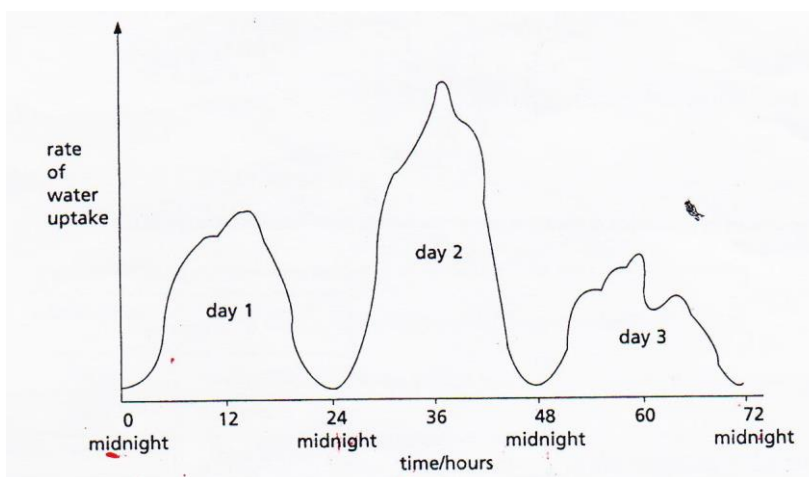
Transpiration speeded up by	Transpiration slowed down by
Dry air	Humid air
High temperature	Low temperature
Moving air	Still air
Bright light	Dim light

#### 4.6.4 Consolidation

- What is transpiration?
- One should be able to label the transverse structure of the leaf, esp. stomata, air spaces and the mesophyll layer (palisade, spongy).
- How water loss is related to cell surfaces, air spaces, and stoma.
- Conditions affecting transpiration rate.

#### Activity 1

1. (a) Name the biological process by which a plant loses water to the air. (1)  
(b) State two other processes which are involved in the movement of water from the roots to the leaves (2)
2. Figure 9 shows the rate of water uptake by a plant over a period of three days.



**Figure 7: Rate of water uptake over three days**

- (i) Using information in Figure 9:
  - (a) Account for the rate of water uptake at midnight (2)
  - (b) Suggest reasons for the differences between the rates of water uptake on days 2 and 3 compared with day 1 (3)

**Total [8]**

#### Homework

Learners should do the following:

- Define Xerophytes
- Identify examples of xerophytes in their communities and their names in Oshiwambo.
- Prepare for presentation in the classroom during the next lesson.

#### **4.7. Concluding remarks**

This chapter presented qualitative data that emerged from several different data gathering techniques including document analysis, interviews, and observations. The document analysis of the syllabus provided data on how the teachers are guided to teach transpiration. The textbooks provided information on how the content of transpiration is presented in the textbooks.

Data from pre-interviews and observations revealed strategies teachers use to help learners make sense of concepts, the challenges teachers face and how teachers deal with challenges learners face. Data from stimulated recall interviews showed how teachers planned to improve on teaching transpiration.

This chapter also presented part of the lesson plan as a combined effort on how to best to present transpiration to learners. In the next chapter, I analyse, interpret and discuss findings from different data sets presented in Chapter 4.

## CHAPTER FIVE: INTERPRETATION AND DISCUSSION OF FINDINGS

*Categories and patterns emerge from the data rather than being imposed on data prior to data collection (McMillan & Schumacher, 2001, p. 462).*

### 5.1 Introduction

This chapter interprets and discusses findings on how teachers mediate learning of transpiration, supported by data gathered from document analysis, interviews and observations. The discussion is strengthened by literature and personal viewpoints. In order to structure the findings, I developed analytical statements from my research questions, as outlined in Chapter 3. For convenience, the research questions that guided my study are repeated below:

- How do grade 11 Biology teachers help learners make sense of concepts on the topic on transpiration?
- What challenges do grade 11 Biology teachers experience when mediating learning of the topic on transpiration?
- In what ways do grade 11 Biology teachers deal with challenges faced by learners in making sense of the concepts on the topic on transpiration?
- In what ways can grade 11 Biology teachers improve mediating learning of the topic on transpiration?

Bearing in mind the research questions outlined above, four analytical statements were developed for interpretation and discussion, as shown in Table 6. In accordance with the epigraph, the categories and patterns emerged from the data rather than being imposed on data prior to data collection. The analytical statements were inductively developed from examining the data. These statements aimed at providing answers to my research questions. They are outlined in Table 6, followed by a detailed discussion of them.

**Table 6: Analytical statements and the research questions to which each analytical statement is responding**

<b>Data source</b>	<b>Theme</b>	<b>Analytic statement</b>	<b>Research question(s) addressed</b>
Interviews and observation	Strategies in making sense of transpiration concepts	Uses of various strategies help learners make sense of concepts on the topic on transpiration	1
Interviews, observations	Teachers' challenges and ways to deal with such challenges	Teachers partially deal with challenges in mediating learning of the topic on transpiration	2
Interviews, observations	Challenges faced by learners and ways to solve them	Learners are faced with challenges in making sense of concepts on transpiration	1 & 3
Stimulated recall interviews and lesson plan	Reflecting on lessons & Transpiration model lesson plan	A reflection on lesson presentations and co-planning a lesson can improve mediating learning of transpiration	4

## **5.2 Analytical Statement 1:**

### **Uses of various strategies help learners make sense of concepts on the topic on transpiration**

Vogel (2004) noted that mediation requires complex interactions between the system and the environment, which requires that the learning opportunities which teachers provide for children should afford the opportunity for complex interactions. This is why social constructivist theory was used in this study, helping to understand the role of the teacher as a mediator and explore the strategies they use in mediating learning of transpiration. The same theory considers that knowledge is socially constructed, McRobbie and Tobin (1997) and

Moll (2002) support that a child is capable of constructing new knowledge with the help of more knowledgeable others, who can be a teacher or peers.

According Hodson and Hodson's (1998) explanation, a deep understanding of both scientific knowledge and scientific methods is needed by teachers to enable them to devise learning experiences that are scientifically significant, meaningful and interesting to learners, and to ask and answer critical questions. Similarly, Fraser (2006) put it that the teacher as a mediator is required to have a sound knowledge of his/her learning area and to be an inspiration to learners.

The presentation in this section has six sub-sections namely: Elicitation of learners' prior knowledge, use of the chalkboard, code-switching, use of analogies, practical work, and scaffolding activities.

### **5.2.1 Elicitation of learners' prior knowledge**

Though not used many times, teachers did elicit learners' prior knowledge (PK) mainly at the beginning of the lessons when they tried to reflect on previous lessons even if PK could be used throughout the lessons. Although teachers were aware of the need to test what learners already know regarding the new topic, they seemed not well informed on how they could elicit learners' prior knowledge throughout the lessons. The following is an example of what was observed from the lesson observation:

E1: T1 *"Can I have a definition or someone who can define for me, maybe to start with, if you have an idea of what is all about transpiration. Can I have just somebody to define for me what transpiration is all about. Okay, who wants to tell us what is transpiration?"*

Despite the limited knowledge on how teachers can elicit prior knowledge during the lessons, prior knowledge in my opinion is a powerful strategy that can bring enthusiasm and learner engagement to the classroom. This is because learners like and enjoy it when examples used in the class come from what they experience in everyday life or what they have learned in their communities. However, the teacher should watch out for misconceptions that learners may bring to the lesson and should clarify such misconceptions.

### **5.2.2 Use of the chalkboard**

The use of a chalkboard is good strategy to use and it is reliable because it does not need electricity to operate. If it is put to good use, it brings about learner engagement in the lesson.

Tulasi and Rao (2004) indicated a chalkboard as one of the most important but quite neglected classroom aids which can be used together with other aids for better clarification and for drawing a particular feature. They also highlight that, if properly used, a chalkboard becomes an attractive point and holds learners' attention. In the same vein, Buddle (2012) who strongly supported the use of a chalkboard, explained that when learners are following along with an instructor who uses a chalkboard, they become actively engaged in the content and (hopefully) forget about other distractions like cellular phones.

During the lesson observations, both teachers made use of the chalkboard to summarise points and also to draw graphs and diagrams. Although the chalkboard was used by Teacher 2, some learners did not take notes as the teacher was only stationed at the front of the classroom. This teacher did not make sure that all learners were engaged in the lesson by taking notes. He acknowledged during the stimulated recall interview, that not all learners were engaged and indicated that he needed to walk around the class as a way of improvement (see Section 4.4.2).

### **5.2.3 Code-switching**

Chapter 2 discussed that teachers employ code-switching as a means of providing learners with the opportunity to communicate and enhance their understanding (Ahmad & Josoff, 2009). Furthermore, code-switching is used when the level of English used in the textbook is beyond the learners' abilities or when the teacher has exhausted the means to adjust his/her speech to the learners' level (ibid.). On the other hand, many teachers who are in favour of the applications of communicative techniques in the language environment oppose any form of native language use during classroom instruction (Sert, 2005).

In all lessons observed, there was an element of code-switching. For Teacher 1, all her presentations were in English but when learners worked on an activity in groups, they communicated in Oshiwambo. Below is a part of a conversation that learners had in their groups:

*LG3: Do we write here? Mpano itapu shangwa (We can't write here)...temperature...*

*LG3: Tetii, ninga, shangaa (Okay, do, write)... one is eight... to tameke pombanda kokatable (you start at the top of the table).*

*LG1: Itale oku (Bring it here), to tameke pevi (You start at the bottom)... zero with 26.*

*LG1: To tameke pombanda (You start at the top)... (another suggestion from a different girl).  
100 with zero...*

*LG2: oonumba ndhono odhina ngaa omahala gethike pamwe? (Do those numbers have the  
same spaces between?)*

In this case, code-switching was used as a supporting element used in communicating information in a social interaction (Sert, 2005). Learners spoke in Oshiwambo while working in groups and this is how they interacted socially. The teacher seemed to be fine with learners speaking Oshiwambo, although she continued speaking English during all lessons.

It may be that the teacher did not want to ‘smuggle the vernacular into the classroom’ as Probyn (2009) termed it.

Teacher 2 code-switched in an attempt to explain some concepts that learners could not clearly understand. One of the moments observed was when the teacher was trying to explain what it was meant by sunken stomata. Apparently, the learners were either hearing the word for the first time or they could not understand the teacher’s pronunciation. Below is what the teacher said:

*L2: What does it mean by sunken?*

*TT2: Let me put it in Oshiwambo, aa... Okay... Omafo amwe...ou weteko, eestomata dimwe kiimeno, eshi to tale oya fa ya ninginamo lelalela. Omwa mona omunhu nande ngeno oho tala omunhu fimbo limwe e to mu tala momesho, oho mono kutya oku na omesho e li mwii, miikololo hashoo? Translated: Some of the leaves... you see, some of the stomata on plants, It appears sunken when you look at it. Have you seen that sometimes when you look at a person in his or her eyes, you see that the eyes appear dipped, within the skull isn't?*

My understanding is that both teachers were aware of code-switching but they perceived it differently. Code switching helps learners to be engaged in a conversation, although it can be a limitation when learners do not speak the same home language (Sert, 2005).

#### **5.2.4 Use of analogies**

When Teacher 2 was observed he used an analogy to explain how temperature affects the transpiration rate. Instead of using an example that is unknown to learners, the analogy used was more an everyday aspect to learners as they wash even their own uniforms. The teacher said the following:

*TT2: Should I give you a very good example of washing?*

*TA2: Now, when you wash your clothes... (writes wash on the board). After you have washed your clothes you have to hang them on the line (draws line of hanging clothes on the board).*

*TT2: When you hang them on the line, the reason is for them to get dry. But if the temperature within the environment is not so high, don't expect your clothes to get dry. So, if there is no wind, don't expect your clothes to get dry. Therefore, I am saying, if the temperature is too low, your clothes will take so long to get dry. If there is no wind, your clothes will take long to get dry. Therefore, the higher the temperature, the higher the rate of transpiration and the lower the temperature...*

As I discussed in Chapter 2, analogies are important because when learners study new concepts, meaningful learning proceeds when they find and visualise connections between a newly taught context and what they already know (Harrison & Treagust, 2006). Ferreira (2011) explained that effective analogies can clarify thinking, help learners overcome misconceptions and create ways to enable learners to visualise abstract concepts. Analogies are used in science to develop insights into, hypotheses and questions about, and explanations of phenomena that are usually unobservable and need to be understood (Brown & Salter, 2010).

However, the limitation of using analogies is that, if the teacher does not carefully plan their use, learners might be left with ill-defined ideas (Brown & Salter, 2010). For example the analogy used by the teacher about higher temperature causing higher transpiration (see Section 4.4.2) might have confused some learners as higher temperature only cause stomata. Therefore, the teacher should clearly explain the analogy to ensure it is understood as intended and that misconceptions are minimised (Brown & Salter, 2010). The teacher could have explained that higher temperature causes the plant cells which control the stomata to open.

### **5.2.5 Practical work**

As discussed in Chapter 2, practical work is an inquiry and hands-on activity which makes it possible to transfer knowledge on higher order cognitive levels and create curiosity in learners (Ruparanganda, Rwodzi & Mukundu, 2013). In addition, practical work develops problem solving skills and a deeper understanding of the concepts and principles in biology for learners (ibid.).

Yip (2003) suggested strategies for helping learners develop a better understanding of the relationship between transpiration and water uptake in plants. He noted that a laboratory

activity using the Prediction-Observation-Explanation approach had been devised to engage learners to work in small groups of 3-4. The context of cut flower shoots helped learners to explore their existing understanding of the relationship between transpiration and water absorption of flower shoots (ibid.).

As discussed in Section 2.3.5.2, Yip (2003) proposed that learners should design an experiment on transpiration. Even if this is a very good strategy, it may not work for most teachers and learners in poor schools due to several reasons discussed below.

From observation of the two teachers, the practical work conducted was intended to measure how humidity affects transpiration rate. Both teachers made learners collect shoots that were tied in clear plastic bags, using old containers from the school ground. However, the Namibian Senior Secondary Certificate Ordinary level [NSSCO] biology syllabus suggests much more. As given in Section 4.2.1, the syllabus suggests amongst others, that learners use a potometer to compare transpiration rate under different environmental conditions; and use petroleum jelly to compare the relative number of stomata on the upper and lower epidermis of a leaf. Both teachers indicated in their interviews that they are faced with a shortage of equipment like a potometer and that this is a stumbling block to teaching transpiration effectively (see Section 4.3).

Kandjeo-Marenga (2011) maintained that most secondary schools in Namibia lack well maintained, modern laboratories and other resources. Some laboratories are too small, and some have inadequate student workstations. Because of these lacks, most secondary schools in Namibia offer teacher demonstrations rather than group-experiment activities.

As discussed in section 2.3.5.2, similarly, Rugaranganda, et al. (2013) noted that with a lack of practical work, learners are not able to put their learnt knowledge into practice to solve actual life problems (ibid.).

### **5.2.6 Scaffolding**

The two participating teachers gave different tasks to learners. Teacher 1 had prepared data on different factors affecting transpiration rate and learners had to plot them on graphs. Learners worked in three groups of ten, which might have been too big for learners. However she gave feedback which is necessary to let learners know when they have made a mistake so that they will learn from it and take corrective measures (Ip, 2005).

Teacher 2 gave the task to learners as homework and no feedback was given. Both activities given to learners had an aspect of graphs in them. In the next paragraphs, I discuss group work, homework and graphs.

### **5.2.7 Group work**

As discussed in Chapter 2, group work gives a chance for learners to work independently and in social settings without the teacher's overt guidance. Windschitl and Thompson (n.d) explain that if designed properly, group work gives learners many opportunities to engage in science talk, to learn from others and to develop social behaviour.

Furthermore, group work promotes opportunities for confronting different ideas, it helps learners develop ways of expressing own point of view, and develop the capacity of listening and understanding others (Wong, 2001). Moreover, learners who have done group work display their growth in tolerance, ability to listen to others, and respect each other's views, as well as becoming considerate and helpful towards others (Wong, 2001).

Similarly, group work improves learners' thinking and helps them to construct their own understanding of science content by strengthening and extending their knowledge of the topic (Lin, 2006).

During teacher 1's lesson observations it was noticed that work groups had too many members and some did not fully engage in the lesson (see Section 4.4.1). This limitation was also highlighted in Chapter 2 that, often learners think that they can disappear when working in groups or one learner may take over the work while the others sit back (Wong, 2001). Lin (2006) suggested three to six learners per group.

### **5.2.8 Homework**

As mentioned earlier in this section, Teacher 2 gave homework to learners. Carbone II (2009) considered that homework is necessary for the development of the learner and for the construction of his/ her knowledge. He added that homework is an important extension of in-school opportunities for learners to learn. However, others believe that homework creates stress Cooper (2008) added that learners do not always get homework done because they either do not understand as it may not have been explained enough. Again, parents do not always understand how to help learners (ibid.).

Homework may not be effective when learners end up copying each other's work in the morning because they did not get time to complete their homework at home. If the teacher does not control that, learners get marks that they did not work for. In this case, Marzano and Pickering (2007) suggested that learners get homework to interview parents about their experiences, instead of being given structured learning tasks.

### **5.2.9 Use of graphs**

As discussed in Chapter 2, a graph is used to clarify information that may be hidden in tabulated numbers. During observation of Teacher 1 she asked learners to work on graphs. However, they found it difficult to do the task as discussed in Section 5.5. During the stimulated recall interview, Teacher 1 indicated that:

*"Plotting graphs and use of units on the X and Y axis are some of the challenges learners face. They cannot differentiate between dependent and independent variables. Learners also fail to relate concepts to the situation on real life as humidity and temperature are observed in most weather situation"*

The teachers needed to spend more time explaining how learners can construct graphs. As Kali (2009) suggested and as discussed in Section 2.3.5.3, learners need to be taught the meanings of independent and the dependent variables. It seemed that learners struggled to construct graphs because they are not exposed to activities where they were required to do so. If learners can be taught about graphs, and given more activities, they would perform better and struggle less. So, it should be the responsibility of teachers to spend more time teaching learners on graphs construction.

### **5.3 Analytical Statement 2:**

#### **Teachers partially deal with challenges in mediating learning of the topic on transpiration**

The teachers participating in this study seemed helpless to conduct practical work with the learners. Because there was no equipment at their schools, they just taught theory and gave activities to learners to test for the paper 3 (practical paper) skills. It may be that transpiration is taught this way also because it is not regarded as important as other topics in biology. Hershey (1996) recognised that the neglect of botany in teaching appears to be a long standing problem which may be caused by teachers' lack of interest in botany, their botanical illiteracy, or the teaching methods. Another issue raised by Hershey was weaknesses of

botany teaching literature because literature is scattered in hundreds of books and journals. These are available only at university libraries, something which makes botany literature not accessible to most Biology teachers.

Another challenge the teachers faced is the language barrier. Ferreira (2011) noted that teaching Biology to English second language learners makes it difficult for teachers as teachers are faced with the double challenge of teaching a particular subject in English while learners are still learning the language. Although code-switch could be a solution (if learners speak the same mother tongue) it may not be used by many teachers; some teachers may regard code-switch as ‘smuggling the vernacular into the classroom’ (Probyn, 2009), this leaves the challenge of English as a second language be partially dealt with by some teachers.

Moreover, Kandjeo-Marenga (2011) noted that most secondary schools in Namibia lack well maintained, modern laboratories and other resources. She further commented that some laboratories are too small, and some have inadequate student workstations. Most secondary schools in Namibia offer teacher demonstrations rather than group-experiment activities because they lack laboratories and equipment (ibid.).

#### **5.4 Analytical Statement 3:**

##### **Learners are faced with challenges in making sense of concepts on transpiration**

Chapter 2, discussed that secondary school children have problems with drawing, annotating and scaling axes on graphs (Kali, 2005), who added that a related problem which is not widely documented was learners’ inability to assign variables to the correct axes. This problem was also evident from what Teacher 1 said during both the pre and stimulated recall interviews, the observed lessons, as well as the activity the learners worked on. In the stimulated recall interview, the teacher said the following:

*“Plotting graphs and use of units on the X and Y axis are some of the challenges learners face. They cannot differentiate between dependent and independent variables. Learners also fail to relate concepts to the situation on real life as humidity and temperature are observed in most weather situation” (see Appendix...SR1-T1).*

Teacher 2’s learners had similar difficulties in constructing graphs, although he did not highlight it (see Appendix D). He also expressed that his learners were shy and could not express themselves in English. This could be attributed to some teachers not allowing learners to code-switch. We all know that many learners cannot express themselves in

English but to keep quiet and do nothing about it will not help. Lewis (2010) suggested that learners should be involved in debates where they come to a resolution regarding ideas, concepts and theories. Debating can help learners improve their English, and overcome their shyness.

Another challenge that learners faced was their failure to define science concepts. This was expressed by Teacher 2 during the stimulated recall interview, when he highlighted that: *Learners couldn't define terminologies too such as, cuticles, water potential and xerophytic plants* (See Section 4.5).

Additionally, some learners (for teacher 2) were observed to not be given feedback, which might well be a stumbling block in making sense of the concepts on transpiration. As discussed in Section 5.2.6 above, feedback is necessary to let learners know when they have made a mistake so that they will learn from it and take corrective measures (Ip, 2005). While Teacher 1 gave feedback for almost the whole lesson, some teachers may not have time to give such feedback. But, to ensure that learners learn concepts in science, we need to constantly give feedback to our learners.

## **5.5 Analytical Statement 4:**

### **A reflection on lesson presentations and co-planning a lesson can improve mediating learning of transpiration**

#### **5.5.1 Reflecting on lesson presentations**

Reflective practice refers to the active process of examining one's own experiences to create opportunities for learning (Bracken & Bryan, 2010). The reflective practitioner model seeks to provide teachers with opportunities to capture their real life classroom experiences so that they can learn from them (ibid.). Farrell (2004) specified that a reflective teacher can look back on events, make judgements about them and alter his/her teaching behaviours in light of craft, research and ethical knowledge.

Although it was not easy to agree on the time of interviews, the two teachers had an opportunity to reflect on their lessons during the stimulated recall interviews (SRI). Reflecting on her lessons, Teacher 1 felt that she could have clarified and explained concepts better to her learners. She also commented that there had been too many learners working per group. To improve on her practice, she determined to divide learners in smaller groups, give

work to learners individually and to be more learner-centred by giving more practical work to her learners (See Section 4.5).

During the SRI, Teacher 2 expressed similar views. He indicated that there was a need to introduce the learner-centred approach. He also determined to move around the classroom rather than being stationed in front of the classroom. Also, Teacher 2 planned to make more use of the chalkboard to summarise main points, as well as to give feedback to learners for assigned tasks.

As a practical limitation, Farrell (2004) argued that even if teachers are aware that they need to reflect on their teaching, there is continued pressure to get through the curriculum, and they are overburdened with other work outside the classroom. He went on to argue that, as a result, teachers have no room to entertain the idea of reflecting on their teaching.

### **5.5.2 Co-planning a lesson**

Mallick (2012) considered that a lesson plan is an essential pre-requisite for good teaching of which the structure vary with different learning situations and with the needs of different groups of learners Furthermore, He argued that if a teacher has planned his/her lesson both wisely and well, he/she enters the classroom with confidence and with an easy conscience.

As discussed in Chapter four, the two teachers and I managed to develop a lesson plan as a way of improving on how to teach transpiration better. We looked at the errors the teachers made during the lessons and tried to improve on them. Although it took almost two days to have the lesson plan completed, we considered it worthwhile. There were a few aspects of the topic that one could not teach well, such as tackling the syllabus objective 2 (see Section 4.2.1). As a team, however, we were able to discuss how we could approach each syllabus objective. We also felt that the syllabus objectives failed to address the issue of graphs, and therefore the fourth lesson of the lesson plan was our own initiative of trying to improve learners' graphing skills. (see Appendix E). We also made sure that the lesson was accompanied by an activity. The activity given was adapted from Comet (2009), who provided a number of activities learners could work on in order to solve graphing problems. We also managed to plan other activities, and provided one topic task using previous examination question papers and textbooks.

## **5.6 Concluding remarks**

In this chapter, data generated from document analysis, interviews and observations was analysed, interpreted and discussed. From the analysed data sets, four analytical statements were generated. These analytical statements illuminated how the two biology teachers helped learners make sense of concepts, what challenges teachers face, how teachers deal with challenges faced by learners, and ways to improve mediating learning of transpiration.

It was found out that transpiration is a challenging topic to teach. Two major stumbling blocks in teaching transpiration effectively were identified as limited development of the Pedagogical Content Knowledge and lack of equipment for conducting practical work. Co-planning of the lesson was then implemented in order to help teachers improve the way they teach the topic on transpiration.

The next chapter summarise the main findings of the study, makes some recommendations and suggests areas for future research. I also discuss the limitations of the study and I finally reflect on my research journey to end with some concluding remarks to the study.

## **CHAPTER SIX: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSIONS**

*What the teacher does is important, as it enables learners to participate in activities that will help them to learn. However, the teacher cannot learn for the learners, the best the teacher can do is to provide guidance and assistance that makes it easy for students to learn (Fraser, 2006, p. 7).*

### **6.1 Introduction**

This chapter presents a summary of findings of my study, limitations, makes some recommendations and suggests areas for future research. I reflect on my research journey and offer conclusions from this study.

### **6.2 Summary of the findings**

The study reported on how selected grade 11 biology teachers mediate learning of the topic on transpiration. What triggered me to conduct this study was my personal experience as such a teacher, and knowing how learners perform poorly particularly in the practical Biology Paper 3. What triggered my interest were the NSSCO (2011-2012) Examiners' reports on transpiration which highlighted issues such as that, learners were not exposed to practical work, and could not spell concepts correctly. Hence, my motive to conduct this study was to investigate how teachers help learners make sense of concepts, the challenges they face and how they deal with them. Flowing from that I wanted to find out how teachers can improve mediating learning of transpiration. The findings of the study have helped me, together with the participating teachers and plan a lesson on transpiration as a way to improve teaching this topic.

The study was constituted as a case study of one school in Oshikoto region, which focused on two grade 11 Biology teachers. Qualitative methods were used to generate data, including document analysis, interviews and observations. In this study, a purposive sampling method was applied to select the school and the two participating teachers. Ethical issues were taken into consideration throughout the study.

It was found that the NSSCO Biology syllabus clearly outlines what the teachers need to teach learners, although it places little emphasis on teaching graphs. The textbooks used by

the teachers, Biology for Namibia (1<sup>st</sup> edition) and NAMCOL Biology Module 1, were both found to be useful although they present transpiration in different ways. Biology for Namibia provides clear notes while the NAMCOL Module 1 provides more activities.

The study further found that the participating teachers used a variety of teaching to help learners understand concepts on transpiration. Although both teachers gave activities to learners, one teacher did not provide feedback, which constrained meaningful learning. It also emerged that both teachers did not use a potometer, so that transpiration rate had to be mostly taught theoretically.

Group work was used but a bit ineffectively as too many learners were assigned per group. Three learners per group would allow for all learners to fully participate on the task assigned to them. Some learners who were given homework got undeserved as their task was a structured one, and was supposed to be completed in class.

Although the two participating teachers worked at the same school, they presented their lessons on transpiration differently, with each teacher using strategies of his or her choice. This compromised the quality of lessons taught to these learners. Mallick (2012) argued that if a teacher has planned his/her lesson both wisely and well, he/she enters the classroom with confidence and with an easy conscience. Therefore, teachers need to plan lessons together in order to ensure that they discuss and help each other on which are the best methods to use.

The study confirmed Kali's (2005) identification of a problem which is not widely documented in learners' inability to assign variables to the correct axes. It was observed that learners had difficulty in constructing graphs. Teachers need to make use of Comet's (2009) ideas on how to teach graphing to improve this skill.

Another challenge found to face learners was that they could not express themselves well in English. Probyn (2009) advocated code-switching in situations where learners speak the same home language. Learners and one teacher were observed to use code-switched and this brought about conversations in the classroom.

As alluded to in the epigraph, the important thing a teacher does is enable learners to participate in activities that will help them to learn. Therefore, this study concluded that co-planning, practical work, assessment with feedback, as well as at least two lessons on graphing, are some of the strategies teachers can implement in order to improve the way they mediate learning of transpiration.

This study therefore provided some insightful answers to the research questions. As indicated earlier and to a certain extent, teachers tried to use a variety of teaching strategies in order to mediate learning on transpiration, but their limited knowledge of Social Constructivism (Vygotsky, 1978) and Pedagogical Content Knowledge (Shulman, 1986/1987) proved to be a barrier to their efforts. This study implies that curriculum developers and Biology advisory teachers should come up with appropriate equipment and train teachers so that the teaching and learning of transpiration could be improved.

### **6.3 Recommendations**

Based on this study's findings, the following are recommended:

- Teachers need to co-plan lessons so that they can support one another. If there are two teachers at the school teaching the same subject to the same grade, it would be beneficial to them in terms of teaching strategies and assessment activities. This would also avoid gaps in the ways the lessons are presented to learners;
- The Ministry of Education should ensure that there is enough science equipment in schools so that teachers conduct practical work together with the learners. Most importantly, teachers need to be properly trained on how to use such science equipment;
- Teachers also need to be trained on the use of locally available material (especially a potometer) in order to conduct practical work and to improve their Pedagogical Content Knowledge;
- For every assessment activities assigned to learners, teachers should provide feedback; and
- The curriculum planners should also ensure that the syllabus includes graphing as a topic.

### **6.4 Areas for future research**

Further research could be done and I suggest the following:

- A similar study could be conducted, but with an increased number of sample schools, in a different region, and it should include both teachers and learners;

- Further research could be done on how practical work affects learning of biological concepts;
- A study on how feedback affects performance in Biology could also be conducted;
- A further study could be carried out on how co-planning affects mediation of biological topics and concepts;
- Further research could also be conducted on how graphing constraints and/or enhances learning in Biology;
- A further study could be conducted on how teachers use group work to help learners learn biological concepts; and
- Finally, a further study could be conducted on how homework constraints or enhances learning in biology.

## **6.5 Limitations of the study**

This study investigated how grade 11 Biology teachers mediate learning on transpiration. Although considerable data was generated, this was a case study that focused on only two teachers at one school, and the findings of this study cannot be generalised for all Biology teachers in Namibia. However, it provides some insights on how grade 11 Biology teachers mediate learning on transpiration. Furthermore, this study focused only on teachers and omitted learners' voices on how they had been helped to learn transpiration. Yet, this could have generated some more insights.

## **6.6 A reflection on my research journey**

In this section, I have presented how my research journey went academically. I have provided an overview of the course and my experience throughout the research journey.

### **6.6.1 Overview of the Masters in Science Education Course**

When I joined the course at NIED, I thought I had already been exposed to academic life, having done the Honours Course. I thought I knew a lot but when I started with the course that is when I realised that a Masters Course was at a new advanced level.

Through the coursework in my first year, I learned a lot through readings we were given. That is when I got an opportunity to learn about gender issues, the science curriculum, every day prior knowledge, and social constructivism.

Through the gender and science contextual profiling task, I analysed a number of documents including the National Gender Policy, the Constitution of the Republic of Namibia (1999), the National Curriculum for Basic Education (2010), The Millennium Development Goals [MDGs] report (2013), and a video- Roadmap to equality of The SADC Protocol on Gender and Development. All these enabled me to learn how to analyse documents. And most of all, these documents were designed to provide guidance for stakeholders and institutions (including the Ministry of Education) at all levels and to ensure that they always consider a gender perspective in their planning and programming processes. In addition, the task helped me to look at girls differently. Girls need to be motivated, to be active and take up science courses.

I found that every day prior knowledge may be divided into two, Indigenous Knowledge [IK] and Scientific Knowledge. IK is defined by Kibirige and Van Rooyen (2006) as a legacy of knowledge and skills unique to a particular indigenous culture and involving wisdom that has been developed and passed on over generations usually by word of mouth. Scientific knowledge is the science we learn at school and learners believe and respect because it is well documented. Through a task on cultural beliefs on lightning, I learned that we need to document IK, and to incorporate it in our teaching as it brings about active participation in the classroom.

This is in line with social constructivism. A social constructivist believes that when teaching, a teacher should start teaching by building on what a learner knows. Central to constructivism is that a child is capable of constructing new knowledge with the help of more knowledgeable others (Moll, 2002, p.17). A more knowledgeable other can be a teacher or a peer who uses language (English) to communicate to the learner. However, English as a medium of instruction is a challenge to some teachers and learners as their English proficiency is low. This in turn hampers science learning.

### **6.6.2 My experience throughout the entire research journey**

The introduction to the research course that I received at the university campus in Grahamstown exposed me to a number of issues around research. I learned about tools

needed to gather data and how one can handle them, theoretical frameworks that underpin research studies, as well as about the importance of cross-referencing. I also had an opportunity to listen to other students' research stories which gave me courage to work on my research proposal.

The research proposal was not an easy task as I submitted seven drafts before the final proposal. That exercise helped me choose theoretical framework that underpin my study. Although I did not understand the theoretical framework fully at that stage, while later working with the selected teachers I appreciated that the framework was needed to guide me to understand how teachers help learners construct knowledge; how they planned lessons, how they assessed work, and the importance of their content knowledge of the subject (see Sections 2.4.1 & 2.4.2).

Conducting research was one of the most challenging, yet good exercises. Triangulation is quite crucial in research but it was not a walk in the park. After pre-interviews, the selected teachers were observed and stimulated interviews were conducted. I had to transcribe and type all interviews and video lessons and this improved my listening and typing skills. Writing up Chapter 5 involved the challenging task of making sense of gathered data and referring it to literature I had reviewed in Chapter 2.

### **6.6.3 Lessons learned**

Through this systematic process of research, I gained skills of writing academic essays. I learned that whenever I am writing research, I always need to have back up storage devices just in case a computer experiences a problem.

Personally, I learned that if one wants to walk fast one walks alone, but if one wants to walk far one walks together (African Proverb). Fellow students and my lecturers helped in shaping my research through presentations, sharing sources and through guidance.

### **6.7 Conclusion**

This study focused on how biology teachers mediate learning of transpiration. This was worth studying as learners perform poorly in their paper 3 practical exams and some find it boring. The study established that the participant teachers have limited Pedagogical Content Knowledge (PCK) and also face a shortage of equipment for conducting practical work. These prevented them from effectively teaching transpiration.

The study suggests co-planning when there is more than one teacher teaching Biology at a school. It also suggests provision of science equipment at all schools by the government and training of teachers to improve their PCK. This study further suggests that there is a need for effective assessment practices so that learners can get feedback that can lead to them learning meaningfully. Finally, this study suggests that a graphing topic be included in the biology syllabus.

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## APPENDICES

### APPENDIX A: REQUISITION AND PERMISSION LETTER FROM THE CIRCUIT INSPECTOR

Rhodes University  
Marian K.N Frans  
Student number 11F7109  
Cell no: 0812356703, e-mail: kaunamn@yahoo.com

16 April 2014

Addressed to: The Inspector of Education  
circuit

**Re: Requisition for permission to conduct research at \_\_\_\_\_ Senior Secondary School**

Dear Sir

I, Marian Kauna Frans, a student at Rhodes University am hereby humbly asking for permission to conduct research at \_\_\_\_\_ SSS in June 2014. This study intends to investigate how biology teachers mediate learning of the topic on transpiration.

Research has indicated that many learners find plant studies boring and that plant functions are a difficult topic for the students, partly because they are characterised by a number of concepts that usually make the teaching of these concepts inadequate. In addition, most schools lack laboratory equipment and teachers find it difficult to present scientific concepts to learners practically, hence conducting research on transpiration.

This research will be done by interviewing and observing Grade 11 A- C Biology teachers presenting the topic to learners. Data gathered in this study may help novice Biology teachers and those who struggle to present this topic on transpiration to learners. This study will also inform other stakeholders involved in the development of Biology materials. The study will also provide useful insights to the Biology Advisory teachers and curriculum developers. Most of all, this study will inform my own practice on strategies that I can use to make the topic on transpiration interesting to my learners.

Thank you very much for your understanding.

Yours Truly,

.....  
M.K. Frans (Rhodes University student)

**Permission granted (please tick in the correct brackets)**

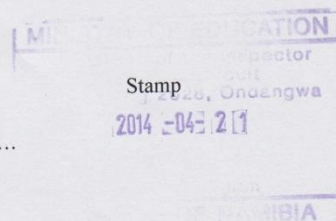
Yes () No ( )

Inspector's signature

.....

Date

..... 01.04.2014 .....



**APPENDIX B: REQUISITION AND PERMISSION LETTER FROM THE SCHOOL PRINCIPAL**

Rhodes University  
Marian K.N Frans  
Student number 11F7109  
Cell no: 0812356703, e-mail: kaunamn@yahoo.com

16 April 2014

Addressed to: The School Principal  
[redacted] SSS  
[redacted] circuit

**Re: Requisition for permission to conduct research at [redacted] Senior Secondary School**

Dear Sir

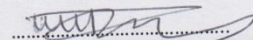
I, Marian Kauna Frans, a student at Rhodes University am hereby humbly asking for permission to conduct research at [redacted] SSS in June 2014. This study intends to investigate how biology teachers mediate learning of the topic on transpiration.

Research has indicated that many learners find plant studies boring and that plant functions are a difficult topic for the students, partly because they are characterised by a number of concepts that usually make the teaching of these concepts inadequate. In addition, most schools lack laboratory equipment and teachers find it difficult to present scientific concepts to learners practically, hence conducting research on transpiration.

This research will be done by interviewing and observing Grade 11 A-C Biology teachers presenting the topic to learners. Data gathered in this study may help novice Biology teachers and those who struggle to present this topic on transpiration to learners. This study will also inform other stakeholders involved in the development of Biology materials. The study will also provide useful insights to the Biology Advisory teachers and curriculum developers. Most of all, this study will inform my own practice on strategies that I can use to make the topic on transpiration interesting to my learners.

Thank you very much for your understanding.

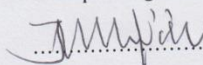
Yours Truly,

  
M.K. Frans (Rhodes University student)

**Permission granted (please tick in the correct brackets)**

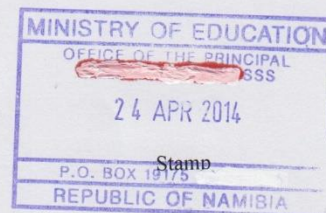
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Principal's signature



Date

24/04/2014



## APPENDIX C: INTERVIEW TRANSCRIPTS OF TEACHER 1 (T1) AND TEACHER 2 (T2)

### Teacher 1 Interview Transcript (I-T1)

**Time: 20 minutes, 38 seconds**

**Date: 04/07/2014**

R: Good R: Good morning X....?

T1: Yes, morning madam?

R: As I said, the purpose of this interview is to find out how you teach the topic on transpiration to your learners and I want to find out how you teach this topic to inform my own practice, ee... like how I am going to teach it better and also to help other teachers who find it challenging to teach.

Now, the first question is, how long have you been teaching this Biology Grade 11?

T1: Mmm... I have taught Biology for a quite number of years, now.... I can say aa.. it is now six years of teaching Biology to Grade 11s.

R: Okay... now, if you are to start with the lesson, teaching transpiration, how would you introduce this topic to your learners?

T1: Mmm... It starts with the up-taking of the water by the plants, so you really have to start ...why do plants need water {*prior knowledge*}, and how water gets into all parts of the plant, and then, you can proceed with how transpiration happen to the plant. They can learn from roots, through the stem by the xylem vessels and through that process and how they lose water. You can also involve evaporation, how they lose water. You can also involve evaporation, how it is important to the plants. They can understand if you describe concepts at the beginning of the lesson.

R: Okay, uhmm... now going to real teaching. How would you help your learners to make sense of the concept transpiration?

T1: Uhmm... You can even ask them to run, they start sweating, then you explain to them that, same applies to plants, but for plants it's not because they exercise or they run, but because of higher temperature [*analogy/Prior Everyday Knowledge*].

R: Uhmm..., uhmmm... now, there are other issues, like the water up-take. How would you present the concept water uptake to your learners?

R: And, aa...,mmm...the water uptake now, how would you demonstrate that to your learners?

T1: The water up-take by the plant, now, you can always start with a closer example, osmosis, if you put a potato tube in water, you will find out that the tube become turgid, so now you can see that the potato gained some water. Now, when you put it in sugar solution, then you can see that at the end of the day, that potato tube loses water. It will become more shrinking and you can see that it has lost more water. That applies to plants, so in dry conditions like summer time, they really need a lot of water, then you can say, take up more water because the temperature is also high.

R: But, do you perhaps carry out a certain practical activity, especially to demonstrate this, mmm..., water up-take using a plant?

T1: Yes, you can even come up with a potometer is one example to demonstrate transpiration to see how the plants up-take water [demonstration] and again it shows you how the plants lose water. And you can also, mmm... I think you can just take a plant, although it is not in a potometer. You can just take a branch of the tree, then you put it in pure water, then you cover it with a plastic again, there you are measuring the rate of transpiration [Use of locally available material to demonstrate transpiration], how do plants take up water and can also indicate the rate of transpiration, because it is the volume or amount of water being lost by the plant, which is more equally to the amount of water being up-taken by the plants.

R: Uhmm... okey, uhmm..., now, are you now, which one do you now use? Do you have a potometer at school or which one do you exactly use to demonstrate the water up-take by plants?

T1: No, no, you cannot use a potometer because we don't have it, but you can simply use an open can, then we put pure water, and take a branch of a plant, that I prefer to use to measure the rate of transpiration, by means of oo..., just any type of material that can be found in the environment instead of using potometer.

R: Okay, uhmm... moving on to the next question, what problems do you experience when teaching this topic transpiration to your learners?

T1: Uhmm... It is quite challenging, the problem is based on the learners. Sometimes, they can't define the concepts well [challenge], knowing that it is a loss of water from the plant leaves to the atmosphere in the form of water vapour, but they don't really get where the water comes from, they don't detect aa..., and how do the plants get water until such a process, until to the end where they lose water. I think that is one of the problem, they just know how to define it, and they can see that the plant is losing water, but where does the water come from, I think that is quite challenging when it comes to the learners. Because I don't know they think the water is coming from.

R: Uhmm...uhmm... maybe, perhaps we need to get to the textbook.

T1: Uhmm...

R: How do you find the content of transpiration presented in the textbook?

T1: Uhhh... It is aa... In terms of the textbook I can say, aa..., it is well explained, well presented. I think it is only the teacher who needs to clarify the concept to the learners, to make sense of how transpiration happens in real life situation.

R: Uhhh..., uhmmm...but again, do you perhaps, maybe in the same textbook that you are talking about, do we have practical activities well demonstrated, like...how you should go about it, or maybe are there...Iyaa...

T1: Yes, we do have like modules that we are currently using now, we can a quite number of practical activities on how to carry out transpiration [how content is presented].

R: Uhhh..., and...in the same textbook, do we have activities, maybe for the learners to test their knowledge?

T1: Yes, you can find activities and that activity you can give them to learners, during that moment [Strategy] because, aa... they do have answer booklets. So, if you let them go home, they might be tempted to copy answers from the booklet, from the answer book, but it is better to give them as a class work, immediately after you finish demonstrating or explaining what is all about transpiration.

R: Uhhh... now, the diagrams... in the textbook again, maybe... I have... There was a time, when went through the examiner's report and learners really have a challenge working on graphs. Uhm...now... we have this issue of the water up-take, I think it also focuses on graphs.

T1: Uhhh...

R: Do you find learners having a problem with graphs?

T1: Yes, they do have a problem working on the graphs, in terms of working out, we call it a scale on the X-axis, to present the scale on the X-axis and also on the Y-axis, and it is quite challenging, also when it comes to plotting [challenge].

R: Uhhh...

T1: I really don't know what is so difficult, if they do not acquire the concept mathematically, or... I really, I don't know what is the problem with that. Most of them, you can find them skipping, they did not do anything on the graph part [Challenge-graphs].

R: Uhhh... Now, what do you do there to.. to make sure you have solved that problem around the graphs?

T1: I think they can just be given more practical work[solution to challenge].

R: Uhhh...

T1: They can work on that, aa... it can be in terms of mathematics wise and also Biology wise, you can give as many work to measure the rate of what...what and every time you ask them to plot their results on the graph [solution]. I think they can improve there.

R: Uhhh... Iyaa..., the... another aspect... is the gender aspect.

T1: Uhhh...

R: Now, maybe when you have practical work with the learners, do you experience a problem, maybe there are more girls who are doing more work, or is it only boys doing the work? Do you experience a problem with regard to boys and girls participation?

T1: Uhhh... I... I can say yes...but that it does not all about when it comes to plotting graphs. I don't think there is gender issues, because everybody have to do it. But, when it comes to drawing is where mostly Biological drawing is where mostly I experience gender issues, where girls, they can't do much in terms of drawing, they always expect their male counterparts to do the drawings for them [challenge/ Gender and science].

R: Uhhh...

T1: But for graphs, plotting graphs, I think it is an individual work, and if they fail, it can be a boy or a girl who just don't understand how to go about plotting the graphs. So, there it is equally.

R: Okey... a...uhmm... apart from drawing the graphs where we have girls that have problems, now, what about, for example when you said you...take a can and a shoot from the plant to demonstrate the water up-take? Uhhh... Now, do you see boys and girls participating the same?

T1: Yes, in aa... improvising material, I have seen girls are more quite active compared to boys. I think boys are too, maybe ignorant or what [gender and science]...

R: Uhhh...

T1: But, girls, they like to come up with materials, but the problem with girls, they give to the male parts to fix them up. But it is their male counterpart to fix them [gender and science].

R: Okay...

T1: Uhhh...

R: Uhhh... now, since we know that it is an issue. The girls expecting the boys to boys to draw...Ho...how...what can be done to make girls to be also active when it comes to Biological drawings?

T1: It starts with when you make it that individual can come up with this, and it should be done under supervision [solution-gender], otherwise if it is not done under supervision of the teacher again, they can ignore fixing the part and come up with the model. And, but if you do

that and you make it an issue for each and everybody, under your supervision, I hope next time they would like to involve or to take part in such project.

R: okay...alright, now, another issue is the language issue. What have you experienced with regard to spelling of Biological concepts when teaching transpiration?

T1: Biological concepts, yes, it is always a concern, because what you usually, these learners express themselves, they are more in English, they ignore using Biological concepts, I think maybe Biological are too difficult for them to.. acquire them [spelling of scientific concepts] or I really don't know, really it is a big challenge. Instead they prefer using English and ignore Biological concepts, which again..

R: Ummm..

T1: It is not allowed in terms of Biology. So, they should be told they should be taught to use Biological concepts. And when you talk about spelling aaai... Spelling is aa...uhmm... I dnt know how can I say, they really cannot spell Biological concepts at all [spelling problem].

R: Uhhh...

T1: Yaaa...

R: now, what do you do to ensure spelling those, I mean that the learners get used to the concepts?

T1: I think it is always very helpful when you teach and you as a teacher, and you emphasise the use of Biological concepts and whatever you talk, that you can see that learners sometimes they can just hear you talking and the pronunciation it cannot be the same as writing. And the best thing is to write on the chalkboard, whatever. All the new concepts, for the new introduced topic should be written on the chalkboard and should be spelled out correctly and should be pronounced also correctly [solution to spelling].

R: Uhhh...

T1: Uhhh...

R: Okay, ummm... Is that the only way that you.. How about when for example, marking something like that? What do you do when you see that they, they have spelt the, the word or the concept in a wrong way?

T1: You underline where... what is wrong and I usually just initiate with 'sp', [solution to spelling] that I told them to see it is aa... meaning that, the spelling of the concept is incorrect.

R: Uhm...

T1: And for now, I train them, I always tell them, I will deduct marks for seeing an incorrect spelling, and that can enable them seriously to, to practice, and keep on writing so that they know how to spell out those concepts correctly.

R: Uhhmm...

T1: Uhhm...

R: Uhhm...ya... uhhm... the next question is... on the other teachers, including myself, who find this topic so a challenge to teach. I find it boring to teach because I prefer working with the animals than the plants, I don't know why I have that mentality. What do you think we need to do to make sure that when we present this topic, we do it aa... doing it the best?

T1: Uhhm... I think for that, for one to do it the best, aa... we are many Biology teachers.

R: Uhhm...

T1: It can be around our cluster centre. Then from **co-teaching** [*Way to improve presentation of transpiration*], **it is very important, seriously if you experience difficulty in the topic, you just need to go to your colleague and say, how can I do this? Or let me observe you, when you present this topic because I find it quite challenging. And then from there... Yes, it is boring, because you are just talking about plants, they can't see movement of water, it takes place inside, but... if you observe, if you read more books, if you do your preparations well and consult your colleagues** [*way to improve*], I hope you can get it. That is the way of improving.

R: Uhhm...

T1: that's why always when I find it so difficult, I go to anybody to discuss that how can I go about this. That's the only way I can get to elaborate much more during my teaching.

R: Okay...

T1: Uhhm...

R: Thank you so much, it was nice talking to you, and thank you so much for availing yourself.

T1: You are welcome

## **Teacher 2 Interview Transcript (I-T2)**

**Time: 34 minutes, 10 seconds**

**Date: 04/07/2014**

R: Many thanks for making time for me to interview you X...., as I said the purpose of this interview is to find out how you the topic on transpiration to your learners. I also want to find out how you teach this topic to inform my own practice, like how to do it better, and also to help other teachers who find it challenging to teach.

R: Okay, now, we are starting with the first question, for how long have you been teaching Biology to the Grade 11s?

T2: Aaaaa...., I have been teaching for about six years now.

R: Okay, now, if.. if, you are to start teaching this topic, how would you introduce this topic to your learners?

T2: Obvious, ee... about transpiration this topic is almost common in all natural science subject especially learners they normally meet this subject this topic either in Agriculture, or in Life science back to lower grades and even now in Biology. But, aa... For me to introduce this topic to them, they normally consider the parts of the plant that are involved in the absorption of water, either from the soil, and the other parts like the leaves that normally let water move out of the plant. By looking at their functions of those parts and then as a result [PK], we did also look at a... some diagrams of a certain apparatus known as potometer that is also used to measure the rate of transpiration in plants, and then I have to explain the function of Potometer to learners theoretically since some of those apparatus are not available in our school. So..., sometimes I have to improvise to make my own Potometers by using the available material and then, this in all it will convince learners and then they will believe that it is real plants normally lose water through their leaves.

R: Uhmmm...

T2: But then now, if learners combine my ideas, the current ideas in Biology, and previous ideas in the Agriculture and the Life science, aa... obvious they agree that, it is true, plants lose water through leaves and such a process is known as transpiration.

R: Uhmm...

T2: yes...

R: Aaa, I think you spoke about a few of the things, but I still want to find out more. Now, when you.. When you are teaching now, the actual teaching now, how do you make sure that the learners make sense of this water uptake, what do you really do?

T2: Aaaa.. when I am teaching this topic, so like what I told you before that I normally improvise to make the Potmeters, the Potometer is not normally constructed by me, but it has to be constructed by learners themselves [*improvisation and use of easily accessible resources*]. Aa...that means it has to be hands-on, minds-on by learners, not by teachers. So therefore, when learners are touching these materials that I have here on my table, aa... it is an advantage to learners that they will not forget whatever going to take place, aa...during the lesson presentation.

R: Uhmmm...

T2: And aa...uhmmm...aaaa...that is what the syllabus is saying that learners should touch, learners should see materials on their own, they should not just be taught theory [syllabus], but practical is more important than theory. So therefore, when learners are involved in

making Potometers on their own, that's the best way I can say, to bring the whole topic live to learners and then as a result, good results will be yield.

R: Uhmm...

T2: Yes...

R: Now, when you said learners make their own Potometers, so they make their own Potometers and then from there, what is next?

T2: Aa...after they have made their own Potometers, I have to decide which Potometers now to be used by the whole class...

R: Uhmmm...

T2: But before learners use that Potometer I have selected out of other Potometers, it is me who has to...aaa...make rehearsals for the learners a... that, first of all, the Potometer it is used like this, like this part of...like if I have to be specific for example, aa...when you are setting Potometer, we have to make sure that there is no air in the Potometer, aaa..that is why the Potometer is normally set under water, aaa.. to avoid bubbles. Because some of those bubbles may interfere with the experiment and you may not able to see or to get the results that you want to get [*How potometer is used*].

R: Uhmm...

T2: So, therefore, after I have made the rehearsals, then I have to appoint learners randomly..so just to avoid bias. So I have to appoint learners randomly, perhaps two learners just to come in front, and then aa... use Potometers and...while others are observing how Potometer normally works [*demonstration*].

R: Uhmm...

T2: Yes...

R: And now...apart from a Potometer, what else do you use? What other method do you use to make sure that learners really understand these water uptake on transpiration?

T2: Alright, After...or apart from Potometers, sometimes or immediately after the lesson, I also, ask questions, oral questions, aaa...and then apart from oral questions I also set questions basing on Potometers, just to see whether learners have understood or they did not [*strategy used to teach*]. And then, I also...set some very short questions, in other words I also set test s that are related to Potometer and then that test it has to be given to learners. Then, as a result, I am testing their knowledge. Whether they have understood the function of a Potometer, whether they have understood what transpiration is all about or what is that causing transpiration in plants and how can transpiration be stopped. In all those things I asked through oral questions, through class activities, and through test.

R: Uhmm

T2: Yes...

R: Okay, thank you for that, aa...we are moving on to the other question. What problem do you experience when you are trying, whenever you are presenting this topic to your learners?

T2: Right, there are many challenges there. Challenge number one it can be the language barrier [Challenge].

R: Uhmmm...

T2: Most of our learners are from rural areas and they have got a problem of English. And mind you that the language that we use in Biology is not really English, these are scientific words. And sometimes it's really difficult for me to translate them in their mother tongue [Challenge-code switching]. But I try by all means to simplify these scientific words for my learners to understand so therefore language communication is number one barrier. Another problem that I normally encountered here is..the availability of materials [Challenge]. Most of the things that we are doing here, when I am presenting my lessons, I normally do things theory instead of practicals due to lack of material. And then...another one is that ee..the parents or should I say the community, our school relationship together with the parents is not so hundred percent good [Challenge- teacher-parent-community relations], so most of the parents when they are being told that our school at least it needs this and this and this, can you please give us your hand?

R: Uhmm..

T2: The community sometimes does not look at our ideas as if perhaps we are trying to take money or rob, to take money out of their hands, it is not like that. We just want to teach our learners, to teach their children for, to become leaders of tomorrow, for example.

R: For example..., the example that you can give there, when maybe for example when you send the learners to go and get something and parents were not willing to help, what example can you give?

T2: I can remember something like, eee...like last time...

R: Uhmm...

T2: We... we were supposed to do a certain practical, a practical about...it was about food testing, but then when I sent my learners each one to bring just a type of food from their houses, most of the parents were refusing to give assistance and then this one has forced me to go and buy some items at an open market, eee...because learners did not come with anything because parents have failed me.

R: Iyaaa..

T2: Yes..

R: Now.., I want us to go back to the language issue. Do you think it's only a problem of you may be finding it hard to translate Biological terms to mother tongue, or what else is a challenge that maybe learners experience when it comes to this topic transpiration?

T2: Aaa, not only language barriers, eee, do you know.. the thing is that eee.. when you are telling learners theory, that one is very difficult because learners they want to see things physically. Now, lack of those materials, obvious it will cause failure among our learners. Eee, now in terms of language communications, **I do not, I am not failing to translate or to translate these Biological words or scientific words to their mother tongue, I am trying**. But our learners.. to a certain extent, perhaps we need maybe someone to guide them in terms of a **career guidance** [*career guidance*]. That, if you are to go to Grade 11 for example, eee.. you must be good either in Physical Science, or in Life Science. Those two subjects, they are more of scientific and their words, the terminologies that are used there are not really English terminologies, or not really English words, therefore they are more of scientific. Therefore, our learners need guidance there in terms of ee..career guidance. Maybe we need either to employ someone either a Life Skills teacher, to come and help our learners that, for you to Grade 11, you must be good in these subjects, in these subjects.. maybe if you want to do science subjects. That in case... to avoid such a problem. But sometimes we cannot avoid that one, that is part of human beings. So as time goes on, I think they are going to improve on that one. Because so far by looking at their performance now, they are a bit better, they are convincing and I am happy about their improvement.

R: Okay. Because I..uhmmm...I still want to talk about the language issue. How is the spelling of scientific concepts with your learners??

T2: Aaa.. the **spelling is a problem to them** [*Spelling-challenge*], aaa..**most of them are failing to spell words in the right way**, but aaa..i normally try my best levels when I am marking their papers or their test books where learners have misspelled the word, I try to **correct it through marking and even during the corrections when I am giving feedback to them** [*solu.to spelling*]. Still I emphasise on the spelling of words, that this word is not spelled like that, but it is spelled in this way. Now in their papers, normally **I underline the word which is not well spelled, and then I put 'sp' stand for spelling**. And then most of the learners when they see that 'sp' they ask me, what does 'sp' stand for? I told them that it stands for spelling, that means you did not spell this word correctly. And aa..so far most of them, because I have been doing that since the beginning of the year, they are now in their right track, most of them they are improving. Especially girls, they are improving.

R: Now.. when you see that the learner has...apart from.. correcting them when you are you are marking, when you see that the learner has made, has written a Biological or scientific term in a wrong way or wrongly spelled, what do you do? Apart from again putting 'sp'?

T2: alright, aa..sometimes apart from putting 'sp', I also refer these learners to some teachers, because I am not the only teacher who teaches Biology in the school, we are actually two in the school.

R: Uhhmm..

T2: I normally refer them also to my co teacher, co Biology teacher in case maybe, because I normally think that maybe is it, is the problem with me or with the learners [sol-sp]? So I refer them to that particular teacher, perhaps for some assistance again, just to see whether they can improve or the problem is still continuing. But at the same time, my core teacher Biology is also helping them in terms of spelling words correctly, and she has also encountered that problem, whereby learners are misspelling words, and she do the same way, whereby she send her learners to me and I help them and I also do that to my learners, that I have to refer my learners to her and she also do assist them. So that means, we are both working together as a team.

R: Okay..

T2: Yes..

R: Okay. What do you do if you come across incorrect spelling while marking?

T2: Ee.., normally, I do not give marks if you give marks [sol-sp], to the learner who spelled the word wrongly, that particular learner will not improve. I don't give marks, to a wrong spelling. Aaa.. that one if you do not give marks, learners will totally improve. But if you give marks to a wrong spelling, your learners cannot improve because they thought, they will think that no, even though I spelled the word wrongly, still I have to get my marks. I never give marks to a wrong spelling.

R: Uhhh.. okay, moving away from the language issue, there is also the issue of diagrams. Aaaa.. we know that with transpiration, there is always graphs to measure, where learners have to present information maybe on the water uptake..iyaa .. Do, do you experience learners that have problems with the diagrams?

T2: Most of all, our learners do not know how to draw, drawing is a problem [challenge], aaa..esp..they lack Biological drawing, so therefore I try again by all means to teach them how to draw diagrams and I also present to them how diagrams are marked [solu-diagrams]. Because when you are marking diagram, we do not put ticks in the diagrams, but we use certain systems when we are marking diagrams, like L for labelling, D for details, P for proportion, S for size or shading. That is the system that we normally use when we are marking the diagrams. And I have presented to them clearly that this is how we mark graphs, so if you did not do it in the right way, you cannot score any mark here. But in terms of graphs now, because that one was diagrams, in terms of graphs, aaa.. still I normally explain to learners clearly the differences between the independent variable, or depended variable [sol-diagrams]. That means which one is to be placed on a horizontal line and which one is to be placed on the vertical line. I clearly tell my learners like that. E.g, for example, when you look at a time and temperature, now you can see that temperature is depending on time, that means temperature is dependent variable and time is independent variable. Therefore, temperature has to be on a vertical of the line, that is Y-axis time it has to be on the horizontal line, that is X-axis. That is how we normally make it clearly to our learners. Another good example, in terms of graphs is that if you give a table, with variable to learners.

R: Uhmmm

T2: Now we also tell them that the first data in the first column, that is dependent variable. And then the next data that is in the second column is, that is independent variable. That means, the first data in the first column, that is independent and second data in the second column, that is dependent variable. By looking at that, they will not struggle on which one to be placed on the horizontal or X-axis, and which one to be placed on the vertical or Y-axis. So by just looking at that graph, or the table, they could manipulate quickly. You say it's alright, this one is dependent the other one is independent.

R: Uhmmm....

T2: Yees...

R: Now, the other issue is the content presentation in the textbook. Which textbook do you use?

T2: We normally use modules, this NAMCOL modules but I have got also a certain book for Biology but this one is written by I...forgot the author now, but that one is also a Biology book but it is very nice and it is only used by the teachers but I tried my best levels to order some books but only that they are not yet here, I think by next week we might have those books that I have ordered. And then, once they come, I have to give them to my learners as supplementary books and that one means they have to read different books apart from the module that we have currently.

R: Uhmm...now, do you then, aaa..find the content in the textbook presented the way it is supposed to be, when it comes to transpiration?

T2: Aaa.. Alright, the content in the textbooks about transpiration, aaa.. it is somehow clear[content presentation], aa..therefore if you just give it to learners that, this content is all about or this part is all about transpiration, learners on their own may not be understanding or may not understand it, so therefore you have to come in as a teacher, and you try to explain in more details to learners[content pres.]. You try to define some problems, terminologies there, try to define them so that learners understand more clearly, then after you have explained it, you also try to summarise or to give a short summary on the chalk board whereby learners can copy it and put it down in their summary books[sol-content]. Now, together with that piece of summary that you have given to learners, and the textbook since things you have explained them clearly to them, it will be a bit better to them, ee.. when they are comparing their summary and then the textbook itself.

R: Hmmm...

T2: Yes....

R: Now..apart from the... the notes to the learners, do these textbooks provide a.. a.. clear activities for learners or how do you go about testing aa..this topic?

T2: Alright, some of the books, they have activities, but these activities in the books are of poor quality [challenge-activities]. I try set up my own activities based on the Syllabus [sol-activities]. Aaa..but even though these ones are of poor quality, I also try to give to my learners as aaa..as a beginners, just to look at those activities on their own and then apart from that, I then come in with my own activities that I set, but these ones are based on the syllabus, because if you are not setting activities basing on the syllabus, still your activities will be regarded as of poor quality. So therefore, I try my best to set my own activities but when I am setting these ones, normally I call my co Biology teacher to set them together so that we can combine our ideas [sol-activities], and a.. at least to merge our ideas with the levels of our learners.

R: Uhmmm....

T2: Yes..

R: Now, okay, I think we have exhausted that one. There is also an aspect of gender. The gender issue. Now, you spoke about improvising, aaa..so that you carry out practical work, ee..when you are teaching this transpiration to your learners. Now, em.. How do you find it, or maybe, how do learners perform when they are doing practical work, when it comes to boys and girls?

T2: Aaamm.. in terms of gender now, boys are more active than girls [gender and science]. Aa...because even when I am directing them or instructing them to construct their Potometers for example, boys are the first one to finish and the girls finish later [gender]. But if you compare these Potometers that are made by boys and those that are made by girls, obvious you can, you will be convinced that the Potometers that are made by boys are more accurate than those that are made by girls. Therefore now, when girls are comparing their Potometers with boys, most of the girls, they feel shy [gender], in the sense that perhaps they think that they may, we might laugh at them, but that is part of nature, we cannot laugh at them. No one is perfect, but what I am saying here is that boys are more active than girls, boys are more active than the girls, therefore aaa.. even it is like that, I also try to balance the situation whereby I sometimes tell my learners especially boys to say, do not laugh at others, even though their Potometers are not as good as yours. You are all one person, you are all my learners [sol-gender].

R: Okay...

T2: Yes..

R: Uhmm..the, the last question. Now, to some of us the teachers, I find transpiration so boring, because I prefer working more with the animals, and maybe other teachers who also find this topic challenging to teach, what advise are giving, what should they do, what should we do to make sure that when we teach this topic to our learners, we give our best?

T2: Alright, aaa... eee.. the best way, to improve with this topic of transpiration , number one, try to involve learners in your presentation [way to improve], that's the best one. Two, eee..try also to set your activities together with your co teachers in that particular subject [way

*to improve*], don't do things on isolation. And then, ee..three.. Aam, you should also **prepare before you teach***[to improve]*. That means you should **consult your syllabus***[way to improve]*, so otherwise aa..if you do not consult your syllabus, you are not going to do it in the right way. And then as a result, you end up saying the topic is too boring. And then, number four, **at least after you presented or during the presentations, try to give either class activities to learners and then after you have completed the topic, try to give a test to learners, just to see how far they have understood***[way to improve]*. And then, as a result ee.. you can see that there is an improvement in your teaching aa.. of transpiration.

R: Okay...

T2: Yees..

R: Thank you so much X.... thank you for availing yourself..

T2: You are welcome..

## APPENDIX D: VIDEO TRANSCRIPTS OF TEACHER 1(T1) AND TEACHER 2 (T2)

**Teacher 1**

**Key: TA1- First teacher action**

**Video transcript: Lesson 1-3**

**TT1- Teacher talk (first teacher)**

**Topic: Transpiration**

**L1- Learners, taught by teacher 1**

**LF1- Female learner, taught by teacher 1**

**LM1- Male learner, taught by teacher 1**

**X- Learner's name (withheld)**

The teacher sends a learner to go and get a shoot from a tree.

TA1: What we are going to do now is transpiration (writes it on the board. )

TT1: Okey, while we are waiting, she brings for us a nice shoot with a stalk, and now I require someone to fix it please. Now, what we need to do, only when we do it we can then define what transpiration is all about. Can you do it for me? I will tell you what to do. What you need to do, you take this plastic and that shoot, I want you to tie this plastic there, and I don't know where to place it, you look, maybe your colleague can tell you where to place it if you want to see how transpiration can take place. [Engagement during introduction of lesson, guidance during an activity]

LM1: Takes a shoot and tries to fix it. [Boys always want to fix]

TT1: You can direct him.

LL1: *Kutha oplastic eto yi manga...* (Take the plastic and tie it...)

TT1: okay, while you are tying that people, transpiration has to do with the movement of water, isn't? Now, I hope one can be able to define by looking at that experiment being set, how it is all about transpiration. Can I have a definition or someone who can define for me, maybe to start with, if you have an idea of what is all about transpiration. Can I have just somebody to define for me what transpiration is all about. Okay, who wants to tell us what is transpiration? [build on known]

LF1: Transpiration is the loss of water from the plant leaves.

TT1: Do you agree with the definition, is that a complete definition of what transpiration is?[Q & A]

LL1: Noooo!

TT1: Ahaa, thanks for trying...What is transpiration? [motivation]

LM1: Is the loss of water through stomata, from the plant's leaves.

TT1: is the loss of water through the stomata by the plant leaves. Okay, your definitions are close. Do you have another definition of what transpiration is all about? Do you have a different view of what transpiration is all about?

LF1: Is the loss of water from the plant leaves through the stomata and evaporate into the atmosphere as water vapour.

TT1: As water vapour... Okay, I think that is a complete definition of what transpiration is...

TA1: We can say is a loss(writes it on the board)...

TT1: Is that how we spell it?

L1: Yes...

TA1: The loss of water from the plant leaves into the atmosphere in the form of water vapour (writes on the board).

TT1: Now, where does the water come from? Where does the water come from, that the plant lose in the form of water vapour to the atmosphere? Where does that water come from?

L1: From the soil (chorus)

TT1: From the soil?

L1: Yes

TT1: Through the what?

L1: Through the roots

TT1: Okay, what you are going to see, let me put it (the constructed potometer) to stand here while we are coming to it. It means it should be there... I don't know why we have to put it there. Some suggested, place it outside but for the sake of us to see if there is something happened, let's just put it next to the window where we can receive light energy. Okay, now... we can say, this is all about what is transpiration.

TA1: Now, if I can draw for you a type of plant, it has got roots here you can see and then you can see the level here... this is underground what you can see now. Then you can see water entering the roots of the plant, then they move along the stem, then they reach the what? Then they reach the plant's leaves (draws a plant in the chalkboard, and shows the movement of water).

TT1: Now, which process is responsible for the up-taking of water in the soil?

L1: Osmosis

TT1: It is Osmosis. Why do you think it is Osmosis? Who can tell me, why you think it is Osmosis? Osmosis is responsible for the uptake of water as you said by the plants roots, why do you think it is the process that is suitable for it, to uptake water from the ground? Haaa...? Any idea? You don't have any idea? People now, what you see now, we define... how do we define Osmosis?

Learners page through the books.

TT1: Did you get for me a definition of what Osmosis is?

L1: Yes

TT1: Aaa... what is it? N wants to tell us, what is Osmosis?

LM1: Is the movement of water molecules from the region of higher concentration to the region of lower concentration through a permeable membrane.

TT1: Through a partial permeable membrane, do you agree with that definition?

L1: Yes

TT1: So, Osmosis...

TA1: If you talk about concentration (writes concentration on the board)

TT1: Is something that is concentrated, can water be concentrated? Aaaa...? So we define Osmosis as a movement of water molecules

TA1: ... from higher water potential to lower water potential (writes it on the board).

TT1: Example, when water are running in the rivers, along the rivers, that one is a good example of Osmosis, because you can see that water are running from where there is higher water potential to where there is lower water potential. But we cannot say they are concentrated, they are not concentrated at all. So we cannot define Osmosis in terms of concentration isn't it? So...but we define it in terms of movement of water molecules from there where there is higher water potential to where there is lower water potential. And means where there is more water, it can cause the force of attraction can move towards one direction isn't? From where there is higher water potential... then if you compare it with the plants, it is more the same because what happens is, when the plant is in need of water, is in need of more water, it can take more water at a fast rate, isn't? And that..., now you can see that by Osmosis, through the plant's roots... within the plant roots you can find what we call what? You can find what we call vessels. And this water are being transported along the vessels. Those are the tubes of the plant, that runs from the roots, up to the leaves of the plant, isn't?

L1: Yes

TT1: And now, the vessels... we have two vessels... what are those two vessels?

L1: Xylem vessels

TA1: Xylem and...? (writes xylem next to the plant drawn on the board)

L1: Phloem

TA1: ...we have the phloem and we have the Xylem (adds phloem).

TT1: And it is the Xylem that is responsible for transporting water from the plant's roots upward the plant's leaves. And then, once the plant has taken water, then along the stem it will reach now the roots. Now what will happen? How transpiration can happen? And at what time do you expect transpiration to take place? Okay, tell me... at what time do you transpiration to take place?

L1: During the day

TT1: Aaaaa? During the day? I think X has more idea than what we are saying, what are you saying?

L1: During the day because it is hot

TT1: Hot temperature... and what else.....? Transpiration happens mostly, we can say during day...yes as they said.

TA1: Day time, you can say day time, when it is hot, dry, and windy (writes on the board). That one you can compare it with yourself, what happen during the hot temperature? What observation can you see from your body? You start sweating isn't?

L1: yes (chorus)

TT1: Now, the same applies to the plants, but the plants we say, what is happening to the plant, we call it as transpiration. And this transpiration happens during the hot, dry and windy day. So is where you can see transpiration rate is taking place as faster as like that. Now, by knowing that it can happen during this time of the weather, what are the factors affecting the rate of transpiration? X....?

LF1: Humidity

TA1: Okay now, humidity (writes it on the board)... we talk of factors affecting the rate of transpiration (write the heading on the board).

TT1: What is the second one?

L1: temperature

TA1: temperature (writes it on the board), what else?

L1: Light intensity

TA1: light intensity (adds it to the list), yes..!

TT1: What else?

L1: Wind speed

TA1: We have also wind speed (adds it to the list)

TT1: Is that all?

L1: No!

TT1: Any addition to what is written or any suggestion... that you want to add on the factors that are affecting the rate of transpiration? Aaaaa...?: Okay, by knowing this factors now, how are they affecting the rate of transpiration? Uhhmm...? How humidity affects the rate of transpiration? First of all, is there anybody with an idea of what humidity is?

L1: Yes...

LF1: Humidity is the amount of water vapour in the atmosphere.

TT1: The amount of water vapour that is available in the atmosphere. So now, if we have...the amount of water vapour that is available in the atmosphere, and we say, transpiration is the loss of water from the plant's leaves in the form of water vapour into the atmosphere... What will happen to transpiration when we have more water vapour available in the atmosphere?

LM1: Transpiration will be lower

TT1: The rate of transpiration will be lower, why? Because there is already an amount of water vapour that is available in the atmosphere. And that... again, when those amount of water available in the atmosphere, meaning that the plants cannot lose more water. Okay, then, what about temperature? What about temperature? How does temperature affect the rate of transpiration?

LM1: When the temperature is higher..... I have no idea.

TT1: You have no idea, who can help him?

LM1: As the temperature increase, the rate of transpiration also increases. And during the hot day, transpiration increase.

TT1: Come on... you are just on the right track. What is that you want to tell us? During the day...

LM1: Plants lose more water vapour than cold day.

TT1: Rather than?

TT1: cold day... And one thing that you need to take note, as you say that transpiration happens during the day, why do you think it is during the day? When it is hot, dry and windy... and one thing that we need to notice is... during the day... the leaf consists of stomata, and stomata are only opening during the day. And that causes the plant to lose more water because of the opening of the stomata during the day. So... as water has to evaporate from the surface of the plant's leaves via the stomata, in the form of water vapour then it goes into the atmosphere. It is obvious that higher temperature increases the rate of transpiration. And when it is low temperature like today, what can you say about the rate of transpiration? Is it going to be very fast or is it going to be low?

L1: low

TT1: Why are you saying it is going to be low? Ha...? Why is it low today?

LM1: Because...

TT1: Because...?

LM1: The temperature is low.

TT1: Because the temperature is high?

L1: Low

TT1: Is very low, how can you describe it? Just describe it. So what you can see is...I can see that it is hot, but it is cold, but it is... aa... should we say windy? Or it is not windy?

L1: It is windy

TT1: It is windy... Okay, it should be low...the fact is that it is very cold, but you can see that it is also hot, cool and it is a little between there. That is why the rate of transpiration can be slow. In terms of light intensity, how does light intensity influence the rate of transpiration? Hmm... are you with me?

L1: Yes

TT1: Okay, how does it affect the rate of transpiration? Then from there out we can see if there is something going on there... is the set up practical that we want to see the rate of transpiration that we know it is happening during hot, dry and windy... How does light intensity affect the rate of transpiration? Aaa...? Aaaa...? You have no idea?

TT1: Oh, I have my boss here, please can you tell us how light intensity affect the rate of transpiration?

TT2: Okay, what is happening is that... Like now it's now during the day, that means if there is more light, obvious the rate of transpiration will be high. But if there is no enough light, the rate of transpiration will be low. For example, during the night yu don't expect high temperature, but if you look at the day like this time, the rate of transpiration is very high due to higher light intensity like what you wrote on the chalkboard. That means, during the day, more energy is being given to the plant, and this energy will increase the rate of transpiration. But during the night, there is no light intensity, that means aa... that is dim light and there is no enough light and you are expecting the rate of transpiration to be low.

TT1: Did you get it?

L1: Yes...

TT1: I hope you can be able to describe how does light intensity affect the rate of transpiration. Seems like he is a good teacher, can you tell us again how wind affects the rate of transpiration?

TT2: Alright, with wind...what is happening is, aa... you can even see that aaa... when there is wind, wind is likely to remove the excess moisture in the air. And aa... if more moisture is being rmoved by the wind from the air, we are expecting higher rate of transpiration. But if there is... during the calm day, it means there is no wind that day, isn't it?

L1: yes

TT2: We call it a calm day or still day. That means the rate of transpiration will be high. I am saying, when wind is blowing, it remove excess amount of water, the word excess means amount of water being removed by the wind from the air. And that means, if there is no moisture in the air, then the rate of transpiration will be high. But during the calm day, when there is no wind, that means the rate of transpiration, during the calm day will be less isn't? That means there is no wind, so we are expecting the rate of transpiration to less if there is no wind. That is what we call calm day, you get it aa...?

L1: Yes

TT1: But a... what you have said here with humidity and temperature, I think you are correct because here you are saying the more the temperature or the higher the temperature, the higher the rate of transpiration, and the lower the temperature, the lower the rate of transpiration. Same applies to humidity here, that if there is large amount of humidity in the air, we are expecting the rate of transpiration to be lower. But if we have less amount of humidity in the air, still the rate of transpiration will be high. You get it a...?

L1: Yes

TA2: So like what your container nearby the window is that, as you want the whole potometer to attract more heat, so there is more heat being attracted by the potometer, the rate of transpiration will be high. But if you just put it on the table like here now, which is a bit far from the light, so we are expecting the rate of transpiration to be lower. So the reason why it is put there, is for this container to absorb more heat. So that the rate of transpiration will be high (pointing and referring to the constructed potometer). Do you get it?

L1: Yes

TT2: I don't know why X...did not explain when you were fixing the part of the plant in the container, that here you can see that there was no air entering in the container. That means we do not want to have some bubbles inside the container. Let me say potometer, we do not want some bubbles in the potometer because those bubbles affect our results that we want to have at the end of the experiment. Therefore that means when you are setting it, you have to make sure that there is no bubbles. So the bubbles that are going to take place later, they must not be from the environment, but they must be from the plant itself. You get a...?

L1: Yes

TT2: So now, when you see bubbles are taking place, that means the rate of transpiration is now taking place.

TT1: Okay, do you have a question?

LF1: Yes X...

TT1: Okay, that is good!

LF1: It is like I am not understand the word still day. As it is that on a windy day the rate of transpiration is increase. Is means that when there is no wind, the rate of transpiration decrease?

TT2: Yes, it is. That is what you call calm day, the day is just calm, no wind, it is still day, no wind. The rate of transpiration will be lower. During the windy day, obvious the rate will be high.

TT1: Questions? Is it clear?

L1: Yes- motivation to ask questions

TT1: Okay, if it is clear, and there are no questions, tell me...

TA1: Like this one, I just take a... it is just a simple experiment, for us to see how does the rate of transpiration can take place (Takes the constructed potometer from the window to the table). Now, just from your observation as we did with this one, I think this practical is not fairly done, by the look of how they tied up this plastic... it was supposed to be too big and what can you tell, if the rate of transpiration is taking place? A...? What indicates that now, by setting this experiment, I need to have the shoot from the plant, I need to have water, and I need to have this big plastic. I will tie it around the shoot, then the stalk will be in the water... in the container of water.

TT1: Now, we said the rate of transpiration will be low, that's why it is difficult for us to see our results. But for you to tell that yes, it is taking place, in such a way, what can you tell, what observation can you make that yes, now the rate of transpiration is taking place? By just making a simple... should we call it a simple potometer? A potometer is not like this a... this one is just what

you take but it can also indicate for us that yes, the rate of transpiration can take place. What observation can you, you yourself expect to see here and then you can say nothing, no rate of transpiration is taking place? Or, now I can see that the rate of transpiration is taking place. Uhmmm...? You have no idea?

L1: No...

TT1: A...? First of all, X told you about the bubbles, that when you set your practical, please be careful, make sure that there is no air bubbles inside here. Those... What is happening here they start producing bubbles isn't? So when they start producing bubbles, it indicates the uptake of water by the plant. And then if the uptake of water, if the plant take up water, what will happen? What can you expect to see in this plastic container? What do you expect to see X...?

LF1: You are expecting to see the water in that plastic.

TT1: You expect to see drops of water in this plastic, then you can able to tell that the rate of transpiration is taking place. So now, if there is nothing here and no bubbles are being produced, like this, and there is nothing, no drops of water here, so there is nothing taking place here. So we expect is that to see some drops of water inside the plastic and to see bubbles that are being formed to indicate the uptake of water by the plant. Okay, is there any question? Maybe we can do it fairly, and you keep it on the sun every day, just next to the window, I hope you are going to get good results. If you want to see that yes, this is how the rate of transpiration takes place. There is no question in terms of transpiration, do you understand what is transpiration? Do you understand all the factors that are affecting the rate of transpiration, and you understand why there is supposed to be no bubbles in the container when setting an experiment, like you want to measure the rate of transpiration? And then, I think if there is no question, what can we do? Should I ask individuals to go and make this one? Or you can make it as a group?

L1: As a group

TT1: Just as a class a...? Bu I will advise for you, this plastic should be wider enough. And when you are always making an experiment, we are always having a control and the experiment. Isn't? Now, this is a what? This is the experiment, a...?

L1: Uhmm...

TT1: Now the controller, what you are going to do? You are going to set just two... just have two containers of water, then the two container of water, the you take... You look for two plant shoots, is that clear?

L1: Uhmm...

TT1: Then when you look fo the two plant shoot, one you put it in the container, you label your container A, and you label your container B. In container A, you place one plant shoot and in container B, you place one plant shoot. Then once you do that, only one container you are going to tie it with a plastic. The type of plastic I advise you to use, have you seen those ones, the soft one? A bread plastic isn't?

L1: Uhmm...

TT1: Yaa... those are the plastic, as long as you make sure that no holes to make your experiment fair and please make sure that there will be no bubbles, don't allow air to enter into your container, then please you all set them there on the sun every day, then you observe the results. So you cannot observe... This one, if today it was too hot, we can able to see the results today, but since the temperature is too low, we are unable to see that isn't?

L1: Yes

TT1: But if you put it there on the sun... it is very simple to set. Take a clear container, you want to see water, because you want to observe the movement of the bubbles as well, as that indicate the uptake of water by the plant, and in the plastic, we want to see drops of water. Okay, is that clear?

L1: Yes

TT1: Okay, I will only do it, I think two or one, as a class. One just, this group, yours is a controller, container B is yours. Container A, is for this group. They must be placed on the side at the same time. Then that is all for today, in the absence of any question.

The End!

## **Lesson2 Teacher1**

TT1: Before I start, I hope you can see... We are going to start with ours... Now I hope you can tell me the difference, as you know your level of water.... I hope you guys gained a better knowledge of how transpiration happens In real life situation. By just looking at your container, okay, the way it is aa..?

TA1: Okay, that is our topic (writes transpiration on the board).

TT1: Okay, today as I gave you homework aa... last time, coming up, setting up an experiment on how to measure the rate of transpiration, and you can say that, measuring the rate of transpiration... Do we need to define transpiration is?

LL1: Nooo!

TT1: So we still have that idea, that is a loss of water, so today we are going to look at...

TTA1: Measuring the rate of transpiration (writes it on the board).

TT1: But I want to hear from you, before we start... Usually, when you measure the rate of transpiration, people do that, with what we call a potometer. Have you seen how a potometer looks like?

LL1: Yes

TT1: Although we have tried to just elaborate on how to measure the rate of transpiration using a... using the simple transpiration experiment... I want to know the level of water, I don't know how full was it according to your experiment, and I can see a lot of water in that plastic, and now I want you

guys to tell me how was your level of water. Is the level of water remaining the same? Or you can see that it goes down?

LL1: It goes down!

TT1: Are you sure that it goes down? In which container? We have two containers here, which one do you want to tell me that the level of water goes down?

LL1: Container B...

TT1: Have you seen any movement in this container?

LL1: Yes...

TT1: The water also go down ee?

LL1: uhmm...

TT1: Okay, So now, what does that mean now?

LF1: Transpiration

TT1: That means that, the more the plant is losing water, the more it's taking up what?

LL1: Water

TT1: Water... through the process of what?

LL1: Transpiration

TT1: Osmosis, but it is losing water through which process?

LL1: Transpiration

TT1: Oka, now, looking at that... now we have... Behind this experiment that we did, there are factors that are affecting this isn't?

LL1: Yes

TT1: And those factors are... are what? Which factors affecting the rate of transpiration?

LL1: Humidity, temperature....., wind speed

TT1: Humidity, temperature, light intensity, wind speed, okay! It is those factors that affecting the rate of transpiration. And I hope if we can see it, in the morning, we cannot say it is the same situation as you compare it to that now. Isn't?

LL1: Yes

TT1: So because of those factors affecting the rate of...transpiration. People, as you mentioned those factors, now...is just that you don't have stopwatch, but I prepared a table for you. We measure the rate of transpiration in cubic metres, in cubic centimetres. The rate of transpiration can be measured in cubic centimetres, because it is dealing with what? Always volume...is a volume of water. And humidity can be measured in what?

LM1: Percentage

TT1: In percentage, exactly, thanks for knowing. Light intensity can be measured with what? Aa....?

LF1: Degree Celsius

TT1: Degree Celsius? Okay, light intensity...all those factors affecting the rate of transpiration

TA1: We have wind, and that we say humidity can always be measured in percentage, we talk of temperature... Temperature can be measured in what? (writes on the board)

LL1: Degree Celsius

TA1: Temperature can be measured in degree Celsius... that can.... Light intensity can be measured in...? ( writes light intensity on the board)

LM1: With our eyes

TA1: In cd (puts cd next in brackets)

TT1: Tell me what cd stands for. While the wind, aaa... wind speed can be measured in....

LM1: Kilometre per hour

LFM1: Cup anemometer

TT1: It can be wind velocity, it can be measured in what? In...?

LF1: Knots

TA1: It can be measured... wind speed or you can put wind velocity, it can be measured in kilometre per hour (writes km/h on the board).

TT1: Okay, now these are the units to measure all the factors affecting the rate of transpiration. For now, I prepared data for you. Now, I want you to plot this data according to the experiment. I had mine that you did not see and it is where I gathered this data, and now I want you to plot them on the graph. And once you plot them on the graph paper, each and every one will explain to me your what ... you will plot the...those who are going to plot the graph for humidity, you plot it and from there you describe the possible curve or straight line that you get from your results. Once you plot them, you explain the possible curve. Either you get a straight line, please explain to us what that mean. And then the second thing..., describe the shape.

TA1: If you happen to get may be your graph happen to be like this, or it happens to be a straight line (draws a curve and a straight line on the board), this one you explain the shape, and the other one you draw the best possible curve of your results.

TT1: Then in terms of diffusion gradient, did you know that there is diffusion taking place? What is that diffusing out of the plant leaves?

LL1: Gases

TT1: It can be gases, it can be water in the form of water vapour, then we are saying they are evaporating from the surface of the leaves. Again in terms of diffusion gradient, you explain the shape of the graph. Then use your graph to estimate the transpiration rate in terms of 45%, in terms of 75%.

And those are the groups that are going to do humidity. The first group, group A, you can do humidity, take a graph paper from that book, then you plot your humidity information. The second one, group B, you are going to plot wind velocity or wind speed and at the same time plot the graph for temperature or for wind velocity. Here you choose temperature or velocity and once you do that, draw the possible curve. We have to it quickly now, as long as we have seen our results, what is happening and that is what our graph can tell us, according to the results we get here. Then from there, describe the shape of the curve and explain the shape of the curve linking to diffusion gradient and also to the action of the stomata and you provide a reason as to why. Just form up a group and you do it then you finish, I want the explanation immediately... now. The last one here, you do for me, record for me the light intensity as one of the factors affecting the rate of transpiration. Your information, you plot them in the space of light intensity and please your description is here. I have level one for group A, two for group B, and three, group C.

### Learners moving into different groups to work on the task

Okay, you plot them in your graph, we want to see to see your curve in terms of light intensity, I want to see your curve in terms of temperature or win speed, I want to see your curve in terms of humidity. Please do it, take a paper quickly.

LL1: *Kapuna ngu ena opena a shange?* [Is there no one with a pen to write? ]

TT1: One thing that you need to do, what do they say? Transpiration rate should be on which one? Transpiration rate once you are drawing your graph...transpiration rate, once you are drawing your graph, it should be on which side? Now, assume you draw your graph, where can you put transpiration rate? On the vertical axis.

TA1: This is your vertical axis, this is your Y-axis, is where you put the rate of transpiration. And on the X-axis is where you are going to put your temperature, your light intensity and your humidity. May you please do that [explaining by drawing the Y and X- axes on the board].

TT1: somebody can have a sharp pencil and you do that immediately please, before the bell rings. I want to hear the explanation of the curve or the shape of the graph. And I am telling you, if you get that, it is the same as you describe the experiment that you have done. It will give you the same answers, okay.

LG3: Do we write here? *Mpano itapu shangwa* (We can't write here )...temperature...

LG3: Let us explain it...

TT3: If you are sitting far, may be the papers are few, get the papers there...and try to contribute.

LG3: *Tetii, ninga, shangaa* (Okay, do, write)... one is eight... to tameke pombanda kokatable (you start at the top of the table).

TT3: May you quickly finish, get to your work and try to plot them.

LG3: *Ninga nee... kutyaa* (Do it... that...), the light intensity, on x...

TT1: Yes, remember... biologically, when you draw graphs, what do you do? You put a dot and you circle it (while moving to group one).

TT1: How are you? What is so difficult here?

LG1: This humidity...

TT1: Uhhh...you are okay... (while moving to group two, and learners continued on their own).

LG1: *Itale oku* (Bring it here), to tameke pevi (You start at the bottom)... zero with 26.

LG1: To tameke pombanda (You start at the top)... (another suggestion from a different girl). 100 with zero...

LG2: oonumba ndhono odhina ngaa omahala gethike pamwe? (Do those numbers have the same spaces between?)

TT1: Are you doing something? (Teacher approaching Group 2)

LG2: Yes

TT1: Are you doubting your scale? (moving closer to the drawn graph paper)

TT1: What is this? Please label your x-axis and your y-axis, if you want me to help you. Know I don't know what you are doing.

LG2: This is X..., this is Y... (putting labels on the graph paper drawn)

TT1: then I will be back to you (moving to group three).

LG2: Let's not forget the units (while he labels units on different axis).

LG3: Ngele owa pewaa... (If you are given...)

LG3: Ahawe, hasho ngaaka (No, it's not like that).

TT1: What is that you are arguing on? You are doing light intensity (pointing to the worksheet), then if your scale is set like that, you go where there is what? Transpiration, you read 2.3, and you move where there is 2.3 on your y-axis, and on your x-axis you plot...they meet at zero???. That is why I was asking, your scale... one unit represent what on your y-axis?

LG3: *Ngaashi ngeyi* (Like this), one, two.. one, two...

TT1: let me see... If you have now, if you want to find out your scale, you say five divided by ten, then you get what?

LG3: zero point five

TT1: now, this is half, one, one point five, two, two point five,... that's how you do it (moving to group 1)

LG3: Okay, zero point zero ... (group continuing on their own).

TT1: Continue... Your units here represents what on the Y... on the X-axis?

LG1: Temperature (chorus)

TT1: Aa...? Your units...

LG1: Degree Celsius

TT1: How many Degrees Celsius now?

LG1: Hmm...

TT1: Here you need to find out, if you counted that these lines are five, then ten divided by five is...? so each of this line now represent what?

LG1: Two

TT1: Alright, that is how we say... one unit on the x-axis represents two units... and on the Y-axis?

LG1: each unit represent half

TT1: Half...okey (moving away from the group)

TT1: Okay, there is only four minutes left. Work as as a group, your views can always be taken. Some people are almost done. If you are done plotting, try to suggest answers on that paper. Now I want you to describe the possible curve, then d, in terms of diffusion gradient... ask if you don't know. At e, you use your curve (giving direction to group 3).

LG1: Draw the possible curve...this is the y-axis and this is the x-axis (pointing at the graph paper).

LG3: *Kashili fair oshima shono kaa...* (That is not a fair thing)

LG3: *Tegelela ashike* (Just wait)

LG3: *Ano ngwiya okuli pungapi?* (And that one is at what number?)

LG3: *Tegelela... five oye ngu.* (just wait, five is here.) okay, 5 is here, 5.1, *mpano opena two mpa* (here is 2).

LG3: *Ano okwa tiwa 5 point ngapi?* (It says 5 point what?)

LG3: 5,3

LG3: *Sho wa plota mpano kasha li mondjila kaa.* (What you have plotted here is incorrect.)

LG3: *Okay, Tameka oku yalula sigo okomulongo.* (Okay, you start counting up to ten)

LG3: One, two, three, four, five, six, seven...

LG3: Okay, 5.3 is here.

Moving to Group 2

LG2: *Kandi wete wa plota mondjila kaa, taamba okadhimitho* (I don't think you have plotted correctly, here is an errasor.)

LG2: *Ano ngwiya okuli pungapi?* (So this one is at number what?)

LG2: 12.9

LG2: 12.9, *oompa* (here).

Teacher approaching Group 1

LG1: Miss, at point three... look at our graph.

TT1: You must at least come up with a correct unit on the x-axis, the correct unit on the y-axis. When you are done, please submit the papers, then I can provide you with the feedback probably, graph papers that you were working on, may I please have them?

Learners collected their papers and handed them to the teacher.

The End!

### **Lesson 3 Teacher 1**

Teacher handed marked papers back to learners.

TT1: Yesterday we looked at different factors affecting the rate of transpiration. We were just busy with the practical of all the factors affecting the rate of transpiration. I gave you to plot...this group one, I gave you to plot which factor?

LG1: Humidity

TT1: Humidity as a factor that affects the rate of transpiration. How does it affect the rate of transpiration. And that you can get it from the curve, or from the straight line that is being formed. And this group, I gave them to draw a graph on which one?

LG2: Temperature

TT1: Temperature, and the last group they did what?

LG3: Light intensity

TT1: Light intensity. What we did not do is just with wind velocity, which is more likely like temperature. Okay, now, if you look at their curve (pointing at Group 1)... Let me check your curve, in terms of humidity. Now, this is the curve of how humidity affects the rate of transpiration. (Teacher showing Group one's graph paper to the whole class). Now, by seeing such a line, what conclusion can you make? Describe that, is it a curve or a straight line?

LF1: Straight line

TT1: Now, what does that mean? Describe it in terms of humidity and the rate of transpiration. Okay, say something please. You just say what you know, what you understand about the line. It seems like the group members did not describe their curve, they are failing to describe their curve or their straight line. What does it mean by looking at it like this?

LF1: As the rate of humidity is increasing, the rate of transpiration is decreasing.

TT1: As the rate of humidity increases, what will happen to the rate of transpiration?

L1: Decrease

TT1: The rate of transpiration decrease. Can you see that? (Teacher pointing at Group one's curve). That means, if there is a lot of amount of water vapour in the atmosphere, that tells us that... transpiration rate will decrease. But why didn't you put it on paper? Okay, that is just how one can describe a curve. What I found is... People you were supposed to choose a good topic. Whenever you

are given such a thing, you are always having a title on top of your graph, you were supposed to create that. Then from there, as you can see, transpiration is measured in what? In cubic centimetres and there is per hour. Because what you need to use, to measure the rate of transpiration, it requires you to have a stop watch and then you can see how transpiration is happening by seeing drops or by seeing a reduction in water. So now, that is why it should be written here on the Y-axis, transpiration rate, then you put in brackets the unit for transpiration, in which it can be measured. Then from there what you need in terms of humidity, yes humidity, they have put percentage in brackets (Pointing at the graph).

TA1: So meaning that, you draw your graph like this...and this is your Y-axis, and this is your X-axis. If here you write relative humidity, the units for humidity in which it can be measured should be written in bracket. Then you indicate percentage, and then one can read. Then on this side, is where you write transpiration rate and the unit is, because is the amount of water vapour...centimetre cubes, hour... like that as it is given to you (Teacher draws a graph on the board and puts all labels on x and y- axes.). And on top here, were should always have a title. Although I gave you marks, people when you are plotting biologically, any point that I plot like this, it should be circled, it should be enclosed with a circle. Only that I am drawing on the board, don't draw it like this, have a smooth curve encircled. If I show you mine, although it is not 100% accurate (teacher showing own curve to the class), this curve is for light intensity. This is what I expected from you guys. You draw and make sure that all units are here and all points should be enclosed in the circle, and always you put a title on top. Then from there, you described your curve well (referring to Group one), by saying as humidity increase, the rate of transpiration decrease. That is the shape. In terms of the diffusion gradient, describe the shape of the graph. Ask if you don't understand what humidity is. What explanation can you give in terms of humidity? In terms of diffusion gradient, in terms of humidity...? In terms of humidity what will happen is, as humidity increase, it reduces the rate as diffusion gradient are less steep. Do you understand?

L1: No

TT1: That as humidity increases, it reduces the rate of transpiration, what is the reason there? The diffusion gradient is less steep. Is that clear...?

L1: Yes (chorus)

TT1: It is not...

TA1: Because when you talk about diffusion gradient, we expect a steep curve to be like this (drawing a steep curve on the board). But for us now, we can say, as humidity increase, it reduces the rate at which transpiration takes place. Then the diffusion gradient, according to the their graph it looks like more or less steep, it is not straight, it goes down. This is just what you need to know, that, as humidity increase, it reduces the rate of transpiration, the reason is, the diffusion gradient is less steep. It is not a steady, constant, it is just less steep. Then I will move to what I have seen, I want group 3, what was your topic?

LG3: Light intensity

TT1: Light intensity. May I have your graph paper?

LG3: Handing the graph paper to the teacher

TA1: This is their curve, I hope you can see, that connects the rate of transpiration in terms of light intensity. By the look of the curve, can anyone explain to us this curve? Look at it and explain, what is the curve trying to tell us? (pointing at Group 3's curve)

TT1: In terms of light intensity... It is one of the factors affecting the rate of transpiration, that means if there is no enough light, the rate of transpiration will not take place or it will be much slower. But in the presence of light, the transpiration rate will be much faster. So now, what is the curve trying to tell us? You need to explain this. What does it mean, group members please, may I hear something from you guys? Hmmm... Is it only X...? Is it written X's group? X say something, then I want to hear from Y, then I want to hear from Z...

LG3: It shows that, as the light intensity increases, the rate of transpiration which is the loss of water from the plant's leaves, the rate of transpiration also increases. As the light decrease, the rate of transpiration also decreases.

TA1: Is that what your curve describes? Did you really observe your curve?(Showing the curve to the group) But your curve has started this way (drawing and showing how Group 3's curve look like). Group members, your curve started like this and it shows something like this. Here there are points, here there are points where there is a turning point (adding points on the graph).

TT1: Your curve is more or likely like that. Does that describe that as light intensity increases, there is also an increase in the rate of transpiration? Eeee...? Seeing a curve like that, does that mean there is an increase in light intensity, same apply to transpiration rate? Class, do you agree? Do you agree with that curve? Now, if that one is what it means?

TA1: What about if the curve could be like this? What about if the curve could be a straight line like this? How could you describe such a straight line like this in terms of light intensity? (drawing graphs on the board).

TT1: if the curve was a straight line like this, I can agree with X statement by saying, as the light intensity increases, there is also an increase in the rate of transpiration. But for now, the curve is that way, what does that tell us?

Learner s quite for a long time.

TT1: X...

LF1: By looking at this curve, where transpiration is high, the rate of transpiration is decreasing. I mean when transpiration is low, the rate of intensity is decreasing.

TT1: When the transpiration rate is low, the rate of intensity is...decreasing. Do you agree with that? Aaa...? Aaa...?

When no learner gave an answer

TA1: People when you see a curve like this, you can see at the beginning it was like this, then from there you can see how it goes, so a bit steeper like this (pointing at the graph on the board).

TT1: Now you can say that, initially, at the beginning, as light intensity increases, there is a slow rate of transpiration. But once, they reach a maximum point, for example, 30, let me say this one is no more humidity, but this one is light intensity, and is measured in cd. Now, if it happen to reach a

specific point, or like you can start with this point, probably you can reach 30 cd, and 30 cd stands for? What is the unit for measuring light intensity?

L1: Candela

TA1: Candela, so now, if it reaches 30 candela, then what will happen? You can see a steep increase, but at the beginning of your curve you can see that as the light intensity increases, there is a slower, can you see how the curve look like? There is a slower increase in the rate of transpiration. But, when it reaches here, then it starts to be more faster, isn't it? (Teacher explains using the graph that was used to explain the humidity curve on the board.)

TT1: Is that clear? So now, you can describe it this way. As intensity increases, there is a slower increase in the rate of transpiration, then intensity increase up to a certain level, then the rate of transpiration will be more steeply. As you can see here, as from here, it increases so steep until it reaches a maximum point. Then, there after, there is again a reduction because it goes it decreases beyond that. Okay, now, in terms of diffusion gradient, temperature, time of the day, action of the stomata, explain the shape of the curve, in terms of light intensity. There, you link diffusion gradient, you link temperature, you link time of the day, and you link the action of the stomata. Did you read those question?

After a long silence in class, the teacher approaches one boy.

TT1: To which group do you belong? Okay, now look at this curve for me. Now, in terms of light intensity, what happens to diffusion gradient, the action of the stomata, and the time of the day?

Learners not responding.

TT1: Everything that you know about light intensity, we have discussed what will happen to the light intensity? How did it become a factor that is affecting the rate of transpiration? People, it is in our books. Aaa...? (19:35).

Learners paging through the books.

TT1: Aaa...? Tell the whole class (pointing a boy and giving him the graph paper to comment on)...

LM1: Light intensity increase due to the rate of transpiration.

TT1: Due to the rate of transpiration?

LM1: Yes

TT1: Why? What makes it to increase... It can increase because transpiration is less? Aaa...? Who can help? People, you just need to look at your graph. You don't need to come up with anything, anything that you are going to answer is based on your curve. To explain, how does your curve tell us the light intensity in terms of the transpiration rate.

TA1: And I have said, when I described this curve for you, I said, at the beginning here, you can see that the light intensity increases, but the rate of transpiration should be very slow (pointing at the graph on the board that was used first). The fact that, you cannot see this one, it is a bit curved, not so steep enough to say, the rate of transpiration is also increasing. But as it reaches the certain point here, now you can see there is a drastic increase in the rate of transpiration as light intensity reach a maximum, probably of 30 Candela. Is that clear?

L1: Yes

TT1: Now, what is so difficult to link the diffusion gradient, the stomata and the time of the day? What will happen as the light intensity begins to increase here? And it is during the day, then the stomata begins to open. People, you have learned that during the day stomata are open so that diffusion of gases can take place, the rate of photosynthesis takes place, water in the form of water vapour is diffusing out of the leaves and evaporate from the surface of the leaves, and that is what we call what?

L1: Transpiration

TT1: Transpiration... So now, when you link that, you just need to say, as intensity increases, stomata begins to open, allowing transpiration to take place. Then as intensity increases, stomata open fully, only higher transpiration rate will take place.

TA1: Here as it begins to increase, then also the stomata start to open. When the intensity increase more, like 30 or 40, then it allow the rate of transpiration to take place faster because now all the stomata are open (Explaining using the graph on the board). And that is what time? It is only during the day. People you know that theory that, photosynthesis cannot take place during the night, why?

L1: No Carbon dioxide

TT1: Because there is no diffusion of gases, stomata are closed, and there there is no light that can enable the stomata to open. And remember, what will happen to the stomata? When it reaches a maximum, probably let me say, at 50 candelas, what will happen? Aaa..., what will happen to the stomata? When the light intensity reaches the maximum, people you know, everything works based on the enzymes. You know that higher temperature can denature our enzyme, and that there will be no reaction that can take place. But now, if it goes beyond that, when it works properly, it is within the optimum temperature during the day. Now, what if it goes beyond that? If it goes beyond that, because of higher light intensity up to 50 candelas, what will happen is that, we will have higher transpiration rate. And as a result, the stomata will be closed. Why do you think the stomata has to close when the light intensity increase drastically? Tell me, why? When the light intensity increase drastically, let me say, 50/90, the stomata will be closed. What is the reason behind?

L1: They will close to prevent loss of water vapour.

TT1: They will close to prevent excess loss of water. And that is why, now we can see, our curve if we draw it nicely, it comes down here at a point of 100 Candelas, isn't it? That means, that the rate of transpiration decreases as a result of higher light intensity, and all the stomata close to reduce excess loss of...

L1: Water (chorus)

TT1: And remember, higher light intensity increases temperature and it is a result for it to close the stomata to reduce that. Now the last thing we need to talk about temperature. And I don't have a specific curve for the temperature. For the light intensity, it is here that I have drawn, yes you can see how it increases, it reaches its maximum point and then then it decrease down drastically. Provided that here, the light intensity increase more and it closes the stomata then it reduce the transpiration rate was reduced. That is why you can see the line goes straight downward. There is a decrease in the rate of transpiration.

TA1: For temperature, for lazy people, this is the curve that I was expecting in terms the rate of transpiration in connection with temperature. Can't you see that it is more similar to the light intensity curve? Can you see that they are more similar? ( teacher showing the curve that was expected from Group 2).

TT1: Because I have said, the light intensity also increases and causes an increase in the temperature. And now, if you do understand the curve of light intensity as we have explained it, then you can build your explanation here. Who can describe this curve quickly? Temperature in connection with the rate of transpiration... Open your mind people, you want to say something, aa..? Okay, tell us, what is it? I will show you the curve, yours is just to tell me what will happen.

LF1: As temperature increase, the rate of transpiration will also increase.

TT1: Uhmm?

LF1: Resulting in more loss of water through the stomata.

TT1: Resulting in more loss of water from the stomata, yes, I agree. That is one point, but she forget again one point. See on this curve here, that one need to explain. What is that is missing right now? As the temperature increases, the rate of transpiration also increases. And then thereafter, what will happen? Aaa...?

Teacher explains when no learner gave a response.

TT1: And thereafter, above which temperature probably? Can't you see my line? What will happen at 40 Degree Celsius?

LM1: Stomata will close.

TT1: As the temperature increases above 40 Degree Celsius, the rate of transpiration decreases so that stomata closes to reduce the loss of excess water that can evaporate from the surface of the leaves. Okay, we can end here.

The End!

### **Stimulated recall interview (SRI)**

**I:** Alright, by reflecting on your lesson, what do you think went well and where do you need to improve?

**TT1:** I think the lesson presentation went well. But there is a need to clarify the concepts to the learners. The unit of light intensity measurement was not clarified well, at first learners failed to get what (cd) as a unit stand for. The use of real life situation should be included in the explanation to make it easy for learners to understand. Learners sang while giving answers. There were too many learners per group work and some were too relaxed and not fully involved during the lesson.

**I:** Did you notice any challenge that learners faced, which made them experience difficulties in making sense of the topic on transpiration?

**TT1:** Plotting graphs and use of units on the X and Y axis are some of the challenges learners face. They cannot differentiate between dependent and independent variable. Learners also fail to relate concepts to the situation on real life as humidity and temperature are observed in most weather situation.

**I:** Okay, having observed how you taught the lesson, in your opinion, what are the challenges that you faced while presenting transpiration to your learners?

**TT1:** Practical work is the most challenging issue when it comes to teaching this topic. Learners need to observe the rate of transpiration, how it happen in real life situation, yet materials are the obstacle and a teacher need to improvise them. To come up with a potometer as seen as the best measure for the rate of transpiration is quite challenging.

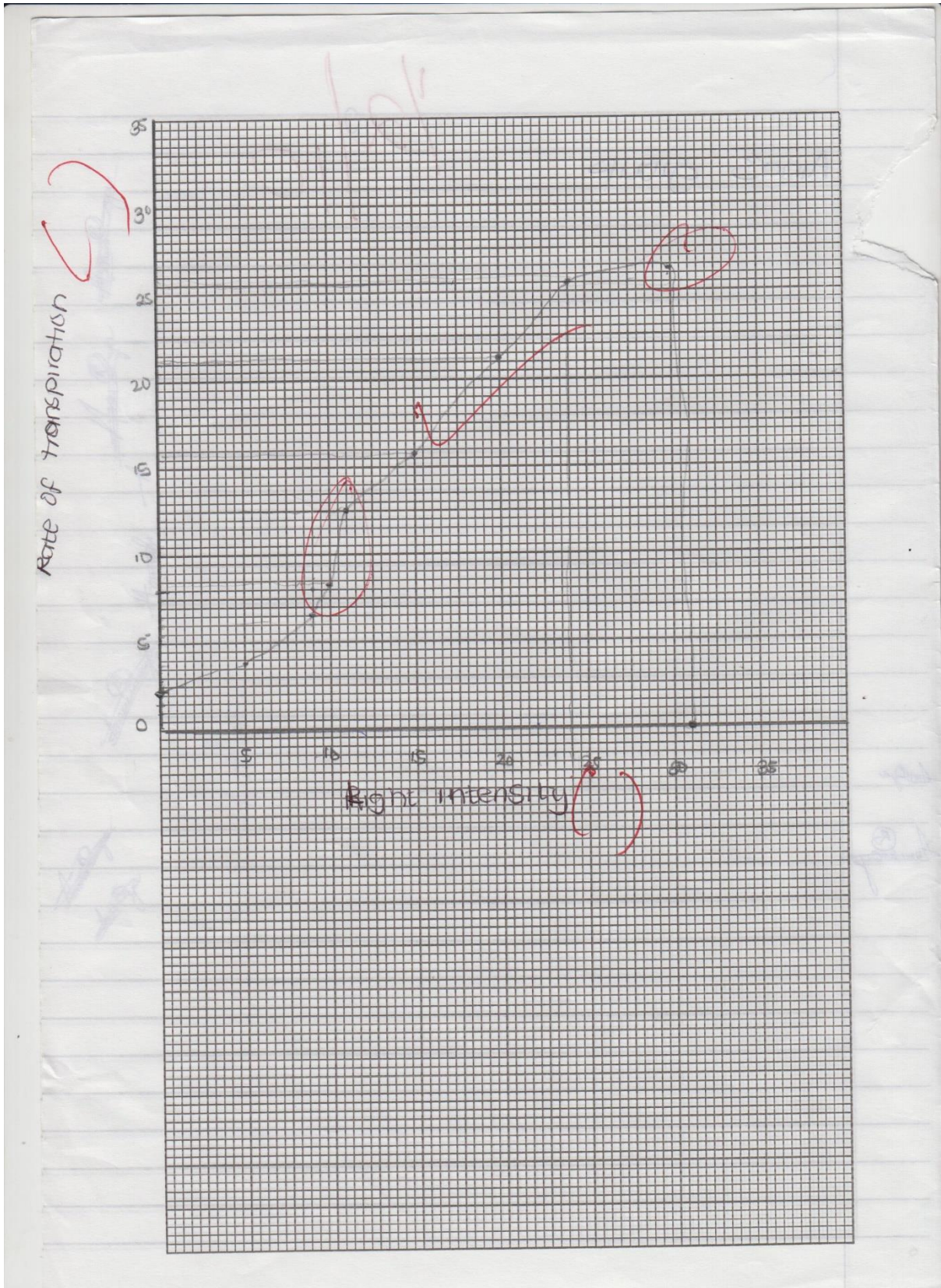
**I:** Suggest any strategy that you may use in future to help learners understand this topic on transpiration.

**TT1:** Next time, I will make sure that I minimise the number of learners working in a group. I will also give individual work to learners. And I will also use a learner-centred approach by giving more practical work to my learners, to ensure they understand transpiration better.

Thank you so much madam for your time, for watching long videos and for the time to answer these questions.

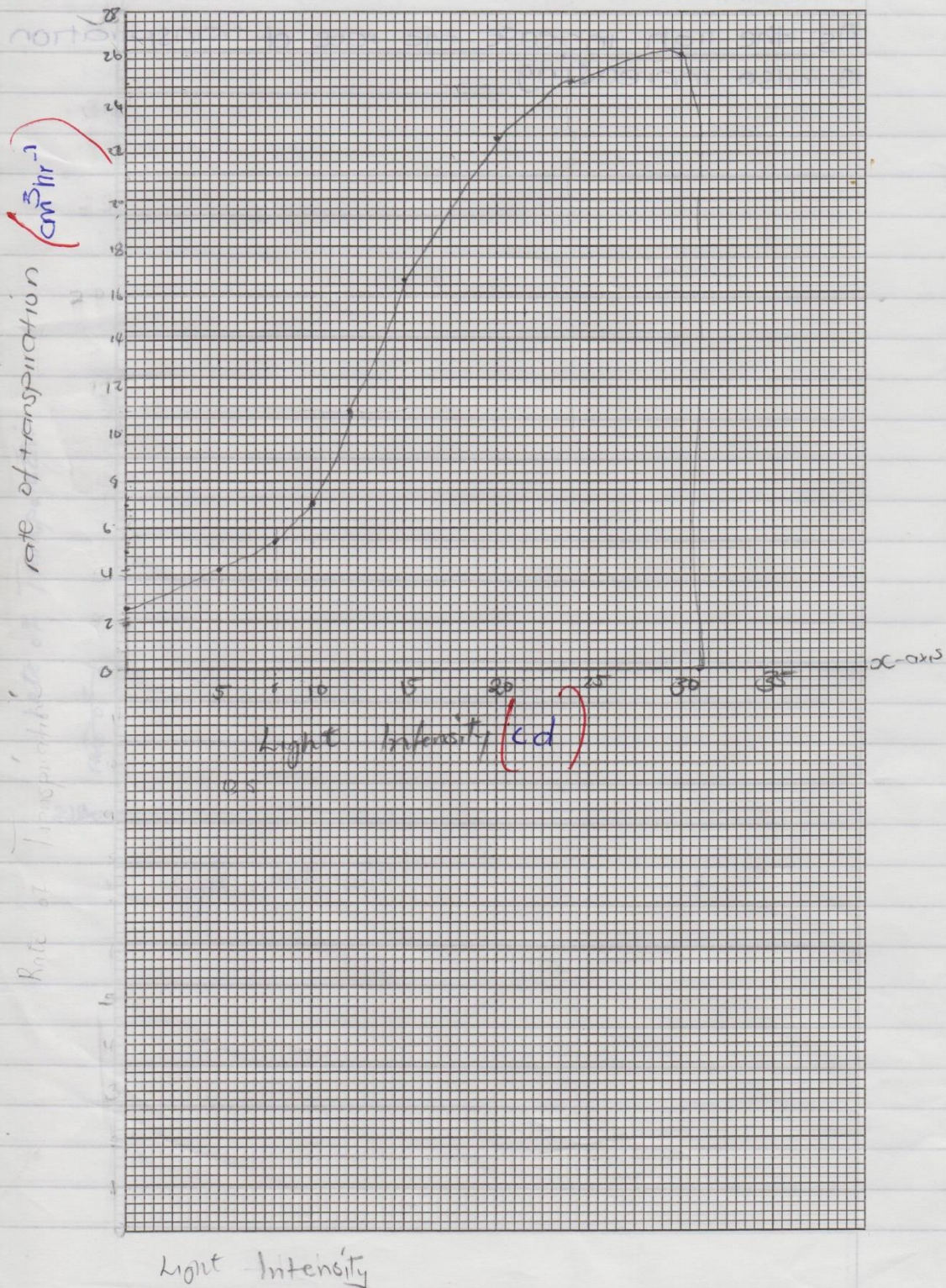
TT1: You are welcome

**Group work activity sample 1 (T1)**



Group work activity sample 2 (T1)

The rate of transpiration affected by light intensity



**Video transcripts: Lessons 1-2**

**TT2- Teacher talk (Second teacher)**

**Topic: Transpiration**

**L2- Learners, taught by teacher 2**

**LF2- Female learner, taught by teacher 2**

**LM2- Male learner, taught by teacher 2**

**X- Name of learner**

TT2: Today, we are going to look at a new topic, that is transpiration.

TA2: With transpiration, for you to understand it better, I have got some material here in front of the class. And aa....This is a bottle of water, this is a plastic and this is a branch of the plant. [showing material one by one].

TA2: Now, what I want to do with the material here , I want to construct a potometer.

TT2: Have you ever heard that word before?

L2: No

TT2: I am going to construct a potometer, but this potometer is not me who is going to construct it. But I have to direct someone to construct it. A potometer is actually an apparatus that is used to measure the rate of transpiration. Perhaps someone is him/herself that, what is transpiration? So you are going to hear that definition. You have already done transpiration in grade 8,9 &10, I think even in agriculture you have done transpiration. I want either a boy or girl to come and construct a potometer (a first girl stands up).

TT2: Open the bottle, (teacher explains while learner do action), make a hole on the lid of that bottle, take a branch, put it in the hole, now put it in the bottle and close it.

LF2: Make a hole on the lid (of a bottle of coke), put a branch in the bottle and close it as instructed.

Teacher touches the bottle and explains

TT2: You can see that that there is no air bubbles, in our simple potometer. That means, when you are setting a potometer, make sure that there are no bubbles in the Potometer, because the bubbles interfere with results. But later, at a certain stage, bubbles may be appearing in the potometer and those bubbles are going to be coming from the plant and when you see bubbles there, it is an indication that transpiration is taking place.

Teacher continues to explain while learner is doing action.

TT2: Take the plastic; put it on top of the branch. Alright...not like that. And then you tie it here.

Learner ties the plastic at the bottom of the lid as instructed by the teacher.

TT2: Now, what do you think is the reason of putting a plastic on top of this branch?

L2: To prevent transpiration (whole group answer).

TT2: The reason of putting this plastic on top of the branch is that, when water is coming from the plant, in other words when this part of the plant is transpiring, the water will be...? Will be where?

LL2: In the plastic

TT2: Yes, in the plastic. And when you see some droplets in the plastic that is an indication that transpiration has taken place. Now, we have to put it here, which means we have to wait for it, for a short period of time.

Teacher starts to write on the board.

TT2: For now, we are going to look at transpiration in details, and later we are going to observe our potometer. What I am saying is that, plants normally get waters from where? From the soil, isn't it?

L2: Yes

TT2: Plants use their roots to absorb water from the soil (while writing on the board). But to be specific here, the type of roots that are used by the plant to absorb water from the soil is...

L2: The root hair

TT: Yes, root hair or root hair cells but remember these parts are normally containing some ions, or should I say some minerals that have dissolved in water isn't? (While drawing on the circle board to put mineral examples) These mineral can be? Nitrates...

L2: Magnesium, Phosphorus (continue to finish listing minerals).

Teacher draws a structure of a plant on the chalkboard and shows roots, soil level, water table or water in the soil.

TA2: When the root hairs have absorbed water from the soil, they pass water from the soil, they pass water to the xylem in the roots (labelling where xylem vessels are supposed to be on the plant structure). And these xylem vessels can still continue to transport water along the cells to the...?

L2: To the leaves

TA2: To the branches and then later to the leaves. Once this water reaches the leaves, some of the water will be used for photosynthesis for the plants to make their own food. (Teacher explains while writing on the board).

TT2: But not all the water will be used for photosynthesis, but where will it go?

Teacher pauses and gives a chance to learners to answer.

LM2: Evaporate

LF2: In the atmosphere

TT2: Very good, some of the water will be lost by the plant leaves into the air, through what...through which structure?

L2: Stomata

TA2: Stomata openings (while labelling stomata on the leaves drawing on the board)

TT2: Stomata are certain openings in the leaves whereby plants normally lose their water in the plant. Now, such a process whereby plants are losing water through stomata, that's what we call?

L2: Transpiration

TA2: Yes, very good! (Teacher writes an arrow on stomata and writes transpiration on the board)

TT2: That is what we call transpiration. Now, can we define transpiration this time?

L2: The process... the loss of... (Chorus)

TT2: No, one person at a time please.

LF2: The loss of water through the stomata into the atmosphere.

TT2: Is that water in the form of what? Is that water visible?

L2: No (chorus)

TT2: Uhhh... why is it not visible?

L2: Because it is in the form of water vapour

TA2: It is in the form of vapour (Writes vapour on the chalkboard)

TT2: That means transpiration, is just a process whereby plants are losing water through stomata in the form of vapour. Now, this Potometer that we have constructed now, you can see that the plant is now dipped in the container of water. And then this plant is now trying to absorb water from the container. That means, the water is now being dragged through the xylem vessels up to the leaves, isn't it? (Teacher using a hand to indicate direction)

L2: Yes

TT2: And, as water goes in the leaves, some of the water will be used for the process of photosynthesis and some of them will not be used for the process of photosynthesis but rather goes into the atmosphere. Now, if we are going to see some droplets of water in this plastic,

that means transpiration has taken place (pointing and looking at the plastic covered around the bottle). But if we do not see some water droplets there, then there are some reasons why you may not see some droplets there. It can be perhaps, like you are in class, that means it is a bit humid. You understand?

L2: Yes

TT2: That means there is not enough sunlight, in other words, if the temperature is not too high, transpiration may not take place. Understand?

L2: Yes

TT2: But if you take this apparatus... Potometer outside, and then you can stay there for some few hours, you may be able to see some droplets of water in that plastic. If you come closer, those who are nearby... (Looking at the plastic closely)

Learners seated next to the where the container is move closer to the plastic.

LF2: There is some drops here (pointing to the plastic)

TT2: If you just see any droplet there, that means transpiration has taken place.

A boy touches the plastic and the teacher moves closer.

TT2: Now, like what I told you before at the beginning, that when you are setting this Potometer, make sure that there is no bubbles of the air, otherwise you'll not get what you want to see.

TA2: Erases the board and writes factors that can affect the rate of transpiration.

TT2: These factors can be...

L2: Temperature

TT2: Can be temperature, very good. What else?

LM2: Wind, humidity...

TA2: Teacher writes the three factors on the board

TT2: Now, if these are the factors, we are going to look at each, one by one. How temperature affect the rate of transpiration, how humidity can affect the rate of transpiration and wind, how it can affect the rate of transpiration.

LM2: What about light intensity?

TT2: Light... should we put it in the same line as temperature?

L2: Yes

TA2: Writes light intensity closer to temperature and puts it in brackets.

TT2: I am going to give you an example of temperature and you can try the rest.

L2: Yes

TT2: Should I give you a very good example of washing?

TA2: Now, when you wash your clothes... (writes wash on the board). After you have washed your clothes you have to hang them on the line (draws line of hanging clothes on the board).

TT2: When you hang them on the line, the reason is for them to get dry. But if the temperature within the environment is not so high, don't expect your clothes to get dry. So, if there is no wind, don't expect your clothes to get dry. Therefore, I am saying, if the temperature is too low, your clothes will take so long to get dry. If there is no wind, your clothes will take long to get dry. Therefore, the higher the temperature, the higher the rate of transpiration and the lower the temperature...

L2: The lower the rate of transpiration.

TT2: That means, if the temperature is high, more heat is provided and then as a result, transpiration will be higher. If the temperature is too low, transpiration will be low, there will be no transpiration during low temperature. How can humidity affect the rate of transpiration?

L2: High humidity, low trans...

TT2: One person, one person...

A boy raises a hand and stands

LM2: If the humidity is higher, the transpiration will be low, due to the moisture in the atmosphere.

TT2: What if humidity is low?

LM2: The rate of transpiration will be high (same boy)

TT2: The rate of transpiration will be high, in low humidity?

L2: Yes

TT2: Good, very good! What is humidity? I don't know what humidity is.

L2: Is the amount... (chorus)

TT2: You like to talk together (points a boy)

LM2: Is the amount of water vapour in the atmosphere

TT2: The amount of water vapour in the atmosphere... How is wind normally affect the rate of transpiration?

L2: Wind, wind... (chorus)

TT2: How is wind affect the rate of transpiration? (repeats when learners remained silent).  
Anyone brave enough to stand up and tell us? Uhhh...?

LM2: When wind blows, remove the excess water in leaves' surface which slow down the rate of transpiration.

TT2: Pardon...?

LM2: When the wind blows, remove the excess water on the surface of the leaves and low down the rate of transpiration (boy repeats).

TT2: **And lower down the rate of transpiration.** Very good aa... that means... That means when the wind is blowing, obvious it removes the excess amount of vapour or amount of humidity in the air, isn't it?

L2: Yes

TT2: And as a result, transpiration will be higher. It will be higher if humidity is removed from the air, the rate of transpiration will be higher. Do you understand? But when there is no wind, that means during the calm day, the rate of transpiration will be higher, isn't it? That means there is no...

L2: it will be higher (chorus)

TT2: **Not high, it will be low.** Isn't it? When there is no wind, the rate of transpiration will be low. Now, these are the factors that affect the rate of transpiration. In examination sometimes, or even in the test I can just ask you a question to say, aa... There are about three or two factors that may affect the rate of transpiration, describe how temperature or humidity affect the rate of transpiration, 4 marks. Understand, aa..., so that means, when you are going to describe that, so I have to look at the spelling, I have to look at the flow of your ideas, how did you express yourself, understand, aaa...? I can look at all these aspects. But if you spell any word wrongly there, no marks.

L2: What?

TT2: Yes, no marks. That means you are wrong. Obvious when you spell any word wrongly there will be no...

L2: Marks... (chorus)

Teacher moving towards the Potometer

TT2: It is taking so long. Can you suggest why this branch is taking so long to transpire?

LF2: No enough light (shouts)

TT2: One person, who has to raise up her hand or his hand. Why do you think this plant is taking so long to transpire?

LM2: I think it is because of the sunlight which is limited.

TT2: The amount of sunlight is limited aaa...? The temperature is...?

L2: Low (chorus)

TT2: Is it high or low?

L2: Low

TT2: That means, if the temperature is lower, obvious that means that it can affect the rate of transpiration. What else do you think, apart from temperature? What else...?

LF2: Because there is no enough...

TT2: There is enough wind?

L2: Noo...! (chorus)

TT2: I did not get you, what did you say?

LF2: There is no wind blowing

TT2: Very good! There is no enough wind, that means that this is the calm day, isn't it?

L2: Yes

TT2: The calm day, when there is no wind, lack of wind can also delay the rate of transpiration on this Potometer. Apart from wind and temperature, what else do you think? Another reason...?

LM2: Humidity, because now we are in the class, just like that. There is no, there is higher amount of water vapour, because you know... this... just like that... humidity is higher.

L2: Whole class laughs

TT2: Oh, very good! That's good! That means we are in the shade, isn't it? We are in the shade and that is why the rate of transpiration is very low, not as high as you wanted.

LF2: Sir, it can only take place when there is no roots here?

TT2: Yes, what is happening is, on this part of the plant or on that branch, there is xylem vessels, look on the chalkboard. Alright, xylem vessels are found in the stem, in the branch, even in the leaves. So, their main function is to absorb water. Understand aaa...?

L2: Yes

TT2: Now that plant is absorbing water slowly by slowly. Where is this water going to go? It means it's going in the leaves, and the reason why this plant is absorbing water is that, now, pressure in the leaves of the plant is reduced. I is just like, when you are sucking, either when you are drinking a cool drink with a straw, you have to suck, isn't it?

L2: Yes

TT2: That means when you are sucking the drink from the container, you are now reducing the pressure from the top of the straw. And the pressure in the container is higher. So therefore, the solution is coming from the region where there is high pressure, to the region where there is...?

L2: Low pressure (chorus)

TT2: That means, the pressure here is being reduced by transpiration and the pressure in the container is higher (points to the plastic cover around the plant). That is why the water is now being absorbed by the plant through xylem vessels, understand?

L2: Yes sir

TT2: And that continuous absorption of water from the container by that particular plant, that is what we call transpiration stream or transpiration stream or transpiration pull. Understand?

L2: Yes

TT2: That means transpiration is pulling water out of the container, through the plant. Get it aa...? Alright, perhaps another question...?

LM2: Sir, transpiration, transpiration needed by plants? Is important?

TT2: Yes, it is important to some plants, not some plants but to all plants. It is important in the sense that when plants are transpiring like that, they are also cooling themselves, aa...? Plants normally cool themselves through transpiration. But to a certain extent, transpiration is a problem to some plants, especially plants that do not store water in their body. Those that are not called succulent. Sometimes, it has got disadvantage to the plant. What else?

LM2: On the xylem vessel, is it permeable or impermeable to water?

TT2: Very good! Do you think xylem vessel is permeable or impermeable to water?

L2: Permeable (chorus)

TT2: What does the word permeable mean? One person, who wants to try?

LF2: Permeable means can allow some substances to enter.

TT2: No, refer to water

LF2: It allows some water to enter and some to leave the surface (continuing to explain)

TT2: Very good! That means xylem vessel is permeable to water, that means it allow water to pass through it. Is your question answered?

LM2: Yes

TT2: I see only boys are participating, boys are the only ones asking questions, what about girls?

LF2: When will be the humidity high?

L2: Laugh

TT2: When do you think the rate of humidity will be high?

L2: During...

TT2: Is it during the day or during the night? Is that your question?

LF2: On cloudy day or rainy day? (same girl asking again)

TT2: Can someone try to assist her?

LM2: I think it is during the wet season

TT2: During the wet season, transpiration will be high?

L2: Humidity will be high

TT2: It will be high? The question is, when the rate of transpiration will be high?

L2: Humidity

TT2: Humidity?

L2: yes

TT2: When the rate of humidity will be high? Right?

L2: Yes

TT2: During the rainy time, like what was said. Someone else...?

LM2: You said that plant cannot die? Due to the amount of water in the container?

The whole class laughed

TT2: Alright, that is the question to the class, who can try to provide an answer? Who can try to provide the answer to the question? (teacher repeats when learners were silent). Can you repeat the question?

LM2: I was asking, that plant cannot die, due to those amount of water?

TT2: Very good, that's the question.

LF2: I think the plant cannot die because it needs to absorb the... water so that respiration can take place.

L2: Laughter

TT2: Alright, X wants to add.

LF2: It cannot die because plants need water for many functions.

TT2: Like...?

LF2: Like, for it to survive, for...the process of photosynthesis to occur, and transpiration also.

TT2: Alright, there was a hand there (pointing to the back). Who's hand was up here?

LM2: The plant cannot die because, there is low water concentration.

TT2: Come on again

LM2: The plant has low water concentration (lowered voice)

TT2: The plant has low water concentration?

LM2: Yes

TT2: It will not die?

LM2: Yes

TT2: That means more water are entering the plant?

LM2: Yes

TT2: Very good! What were you saying? (Pointing to another boy)

LM2: The plant cannot die because the xylem vessel is permeable to water, it will let some water to enter inside...

TT2: That means more water is getting in the plant?

LM2: Yes

TT2: Very good!

LM2: And... will not slow transpiration

TT2: Ahaa... and the last one?

LM2: I think it will not die because it will absorb the right amount of water it needs.

TT2: Alright, it will not die because it will absorb the right amount of water that it need, aaa... As from now, I will not dismantle this Potometer, it will be like that, and then we will come and observe it from break.

Otherwise, if there is no other questions, then this is the end of our lesson.

**The end!**

## **Lesson 2 Teacher 2**

TA: Last time we looked at definition of transpiration (writes transpiration on the board)

TT2: And I completely forgot what transpiration is all about. Can someone try to remind us what transpiration is all about?

LF2: The loss of water vapour from the plant leaves through stomata into the atmosphere.

TT2: Very good! That is excellent, perfect explanation. That aa... the process whereby plants are losing their water, in a form of vapour, through leaves, specifically through the leaves' stomata, into the atmosphere, that is what we call...

L2: Transpiration (chorus)

TT2: We were done with explaining transpiration, with an experiment, but that experiment did not work, it failed us due to certain problems. That experiment was aa... in other words, what we were trying to construct there, it was a Potometer. We were trying to construct a Potometer. And a Potometer, is one of the instruments that is used to measure the rate of transpiration. It is used to measure the rate of what?

L2: Transpiration (chorus)

TT2: Now, when we were trying to observe that aa... Potometer, whether we will see some droplets of water in the plastic or not, aa... our conclusion was like, we did not see any drop of water in that plastic. Isn't it?

L2: Yes

TT2: Because of certain reasons, that means, there were factors that were affecting our rate of transpiration on the Potometer. Those factors we said that they were... What are the factors that are affecting the rate of...?

L2: Humidity, wind...

TA: Humidity, temperature, light intensity (teacher writes the list on the board)

TT2: You have to say light intensity, isn't it?

L2: Yes (chorus)

TT2: Now, remember we are not outside the classroom, we are inside the classroom. Therefore, we rather say... Here we are in the shade, there is low humidity. No, humidity is passed already. We can say light intensity, we are in the shade (writes shade in brackets).

Alright, that's why we do not have enough light because our classroom is covered with this roof and obvious they create shade. And then, in the shade is one of the factor that is affecting the rate of transpiration. Maybe, transpiration was trying to take place, in the Potometer there in the plastic, but aa... because there was no enough light, obvious, transpiration was too slow, and it was unable to be detected. You get it aa...?

L2: Yes (chorus)

TT2: You look at wind again, there was no enough wind isn't it?

L2: Yes

TT2: That means, it was a calm day. That means, if there was no wind, if there is no wind, no transpiration. If transpiration is taking place, not as much as when there is wind. I have talked about two things, calm day and...?

L2: Windy day

TA2: Windy day, (teacher explains while writing on the board). Yes... This are full different days, understand? So, if you are to compare these two days, calm day and windy day, we are saying, here (points at calm day), the rate of transpiration will be higher or low?

L2: Low

TA2: Here, the rate of transpiration will be... lower ( writes lower in calm day column). What about here? (Points at windy day)

L2: It will be higher (chorus)

TA2: It will be higher, you get it aa..? (then writes higher on the board in windy day column).

TT2: That's why on our Potometer, when we were trying to observe it, we did not see much water. Maybe there were drops, but we were unable to see those droplets, isn't it? Because it was a calm day, there was no wind. You get aa...?

L2: Yes

TT2: But if there was wind, perhaps if we were to conduct that experiment outside, then obvious we could see some droplets of water, isn't it? Because wind will be enough. And as a result, if wind is there, it will remove excessive moisture in the air, obvious it will lead to transpiration to take place. What about temperature? Still we are in the classroom, isn't it? That means the rate of temperature is reduced by the shade. You get it aa...?

L2: Yes

TT2: The temperature was not so high, and it was not so lower, but it was moderate. Do you get it aa...?

L2: Yes

TT2: so it was moderate in the sense that...transpiration was reduced. That's why we were not able to see some droplets in our experiment. And then you look at humidity again, aa... Still we are saying, perhaps there was high humidity. There must be high humidity, that's why you did not see the results that you want to see. Isn't it?

L2: Yes

TT2: Alright, that's is all about transpiration aa... That's why, those are the factors that are affecting the rate of transpiration. But if we go further to say, since we have talked about transpiration. Now, I am saying, sometimes you look at...

TA2: Let's start at the first diagram. I am just giving a few examples, aa...? (draws a circle on the board). So these are the soil particles remember? Plants have got very beautiful structures that looks like this (teacher draws the structure between soil particles).

TT2: Can you see?

L2: Yes

TT2: So if I ask somebody that, what do you think this structure is all about, someone will be able to tell me, isn't it?

L2: Yes (chorus)

TT2: What do you think this structure is?

L2: A root hair cell

TA2: Now, apart from the root hair cell, you can see that this structure (pointing at the tip of root hair), it is called what? An extension, a thin extension, if somebody says thin extension, excellent (And writes thin extension on the board).

TT2: Now, we are saying, this is part of the plant that is penetrating the soil particles isn't it? These are soil particles (writes soil particles on the board). The thin extension is now penetrating the soil particles, why? To absorb what?

L2: To absorb water

TT2: To absorb water from the soil. Now, once water has entered the root hair cell, where is this root hair taking water to?

L2: To the xylem vessels

TT2: To the Xylem vessels. And where is this xylem vessel found?

TA2: In the roots (writes xylem next to xylem vessels on the board)

TT2: Now, as the water passes from the root hair cell, into the xylem vessels in the roots, this water continues going upward the plant. But, before it reach stems of the plant, there is a certain structure which is called cortex (Teacher writes cortex on the board). Cortex is not

**cortex for girls**, do not confuse with the cortex that you use during menstruation. Plants have got a structure which is called a cortex also in their roots. That means water moves right from the soil into the root hair cell, to the xylem which is found in the roots, across the cortex in the root again.

TA2: And then (draws arrow next to cortex) from the cortex, water will then move into the xylem vessels again (writes xylem after the arrow). This xylem vessel is not in the root anymore, this one is now in the stem (writes stem in brackets above in xylem of the plant). Then from this stem (adds another arrow from stem), the water continue to move up the plant, where?

L2: To the branch

TA2: in the branches of the plant and eventually to the leaves. Now what will happen to this water in the leaves? There are two main functions of water in the leaves and are as follows: One, this water may be used for food production, that means water may be used during the process of photosynthesis. Two, this water may also be used for cooling the plant, and may be lost to the air but you may not be able to see it, is in the form of gas (teacher writes the functions on the board while explaining).

TT2: If you look at these notes that I have drawn on the chalkboard, it is in the form of a chain, that means water is continuously moving from the plant to the leaves. So, if this is like that, then that is what we call transpiration pull. That means transpiration is pulling water from the soil.

TA2: Now, what we are saying is that aa... this water which is coming from the soil into the plant, water is passing from cell to cell, I believe you know how cells look like (drawing cells on the board). Now, if water is passing from this cell to the next cell but through cytoplasm, from cytoplasm of the first cell into the cytoplasm of the next cell. Then, that's what we call apoplast movement of water (teacher writes apoplast on the board). But if water is still passing from cell to cell but this time is passing through vacuole (writes vacuole on the board), this is not called apoplast, but is called symplast (writes symplast on the board too).

TT2: Now, the movement of water from the soil to the body of the plant and eventually the leaves, water normally passes from cell to cell until water reaches the leaves of the plant. How exactly water passes or moves from the soil, now water passes from cell to cell or through cell to cell isn't it?

L2: Yes

TT2: Now, when this plant parts are absorbing water, like root hair cell, xylem, cortex, stem, and branches are absorbing water from the soil, the process that is involved there is osmosis.

TA2: That means, here there is water, and here in the leaves there is also water, isn't it? (pointing to soil particles drawn on the board)

L2: Yes

TT2: But the availability of water in the leaves and in the soil, is not the same. That means in the soil, there is higher availability of water in the soil, but I don't want to say higher availability of water because that one is English.

TA2: **I want you to say in the soil, there is higher water potential** (writes higher water potential on the board).

TT2: And then in the leaves, there is lower water potential. Now, by looking at these two cycles, higher water potential, lower water potential, we can deduce the definition of the word osmosis. How do we define osmosis?

L2: The movement of... (chorus)

TT2: One person at a time please. Who is brave enough to define for us osmosis?

L2: Learners paging through the books.

LM2: Is the movement of water from the region of their water potential to the region of their lower water potential.

TT2: Very good! Someone else?

LF2: Is the passage of water only, from the region of their higher water potential to the low region of their... (Learner sits)

TT2: It is the same, very good! Someone else?

LM2: Is the passage of water molecules only, from the region of higher water concentration to the region of lower water concentration through a permeable membrane.

TT2: Very good, that is what I wanted, through partial permeable membrane. These ones you forgot partial permeable membrane (teacher pointing to the other learners who gave the definitions first).

TT2: Let me make it clear, much clearer, but I am just repeating what you have said. Osmosis is the movement of water molecules only... can you see... From the region of higher water potential, to the region of lower water potential, through partially permeable membrane. **But back to your previous school, some of your teachers have told you that, instead of saying, through partial permeable membrane, they have said, through semi permeable membrane.** It is the same, semi and partial is the same. But then you are defining osmosis now. I want to see ...er on the word high, ...er at low, because we are comparing two parts. Higher water potential and lower water potential. These are comparable words. That is how I want it to be like. Do you get it?

L2: Yes

TT2: Is there anything before I go ahead?

L2: No

TT2: Alright, since transpiration is a problem here, we are saying, some of the plants, they have got certain mechanisms that they use to prevent or reduce the rate of transpiration. I repeat, some plants or should I say almost all the plants, they have their natural mechanisms that they use to reduce the rate of transpiration.

TA2: Mechanisms that plants use to reduce the rate of transpiration (writing the heading while explaining).

TT2: There are some mechanisms that are found on plants, that allows the plant to reduce the rate transpiration. Otherwise if plants are not using those mechanisms, most of the plants will lose water, and will wilt and die. What are these mechanisms we are talking about? What are they?

Teacher pauses

TT2: In other words, I am saying... let me simplify this one. What are the aspects or what are the characteristics plants have to reduce the rate of transpiration?

Silence in class

TT2: Hmm... What is it?

LF2: The opening in the leaves...

TT2: Opening in the leaves? What happens to opening in the leaves?

LM2: The stomata in the leaves

TT2: Come again...

LM2: The stomata in the leaves

TT2: Ahaa... Is it on the upper surface or lower?

LM2: Lower surface of the leaf

TT2: Very good, we are saying, number one mechanism, one characteristic, plants have to reduce the rate of transpiration... the distribution of stomata. You get it aa...? That most stomata in plants are found on the underside of the leaf.

TA2: Should I say, my hand is now representing the leaf of the plant. Now, this is the upper surface, this is a lower surface, can you see? Now, most stomata are found on the lower surface or the underside of the leaf. Here there are also stomata, but not as much as like the stomata that we get on the underside of the leaf (teacher showing both upper and lower part of the hand while explaining).

TT2: Now, why...? This part is always... Why most stomata are found here? Before you give the reasons, I don't want to hear anyone saying stomatas. No, there is no word stomatas, there

is only stomata or stoma. Stoma is singular word and stomata is plural. Can you see? No stomatas aa... Why is that more stomata are found on the underside of the leaf?

L2: To reduce the rate of transpiration (chorus)

TT2: Very good! To reduce the rate transpiration. The reason why not this part (showing upper part of hand), is that this part is always exposed to the sun and if this one was to contain more stomata, then obvious more plant will lose water and obvious it is likely to cause wilting in plants. Because...perhaps more water is lost than the plant is absorbing from the soil. Now... Therefore, number one mechanism here is distribution of stomata.

TT2: Now, which else?

TA2: I can remember that we said, more stomata are found on the underside of the leaves (writes underside of the leaves in brackets next to distribution of stomata). Leaves...that is, they are many isn't it? What about this one? (teacher writes the word leaf on the board)

L2: One leaf

TT2: Alright, apart from distribution of stomata, what else?

LM2: The size...

TT2: The size of leaves aa...? Very good

TA2: The size of the leaves (the teacher repeats and writes it on the board)

TT2: What happen to the size of leaves? How is the size of the leaves playing a role in reducing the rate of transpiration?

LF2: When the leaf is small... aa... then the plant is not going to lose more water.

TT2: Very good! That means, the smaller the surface area. If the leaf is too small, it means, its surface area is also... small isn't it? That means there is very few chances for that leaf to lose much water, because it has got small surface area. What I am saying here is that, if you look at the leaves of those thorn trees... Look at their leaves.

The teacher points at the thorn tress outside

TT2: The leaves of those thorn trees are too small. But if you look at some of the leaves like those ones, those trees, those ones they have bigger leaves.

The teacher points at the other trees next to the class.

TT2: That means those plants' leaves are likely to lose more water than the thorn trees, isn't it?

L2: Yes

TT2: That's why sometimes most of the plants that are dying are the ones that have got bigger leaves than those with smaller leaves, isn't it?

L2: Yes

TT2: That means, those with bigger leaves are losing much water

TA2: Smaller leaves we say, have spiny leaves (writes spiny on the board)

TT2: That means they have smaller leaves. Someone is saying, what about the bigger leaves? How do we call them?

LM2: Yes

TT2: How do we call bigger leaves?

LM2: Bigger leaves

TT2: They are just big leaves?

LM2: Broad leaves

TT2: Very good! Somebody here has just his vocabulary.

TA2: Broad leaves (while writing on the board)

TT2: That means broad leaves is opposite to this one, spine leaves. Someone here is saying narrower, these ones are narrower (pointing at the words spine leaves). These ones are big... isn't it? What else? Another mechanism that plants use to reduce the rate of transpiration?

Silence in class

TT2: Have you ever... observed those leaves very well?

L2: Yes (chorus)

TT2: Sometimes if you look at the leaves... X, do you want to add?

LM2: Yes... **The leaves have wax cuticle**

TA2: Very good! **They have a waxy cuticle** (teacher writes waxy cuticle next to other mechanism on the board).

TT2: Alright, leaves have waxy cuticle. Waxy cuticle, that one is a plastic-like substance isn't it? That is always on the surface of the leaves. Now, if that plastic is there, it reflects the light back. It do what?

L2: Reflects the light back

TA2: Reflects light back (write it on the board). That means, as it reflects light back, it reduced the rate of transpiration. Apart from those waxy cuticles, what else do you think?

LF2: Plants have leaves that fall off during the dry season.

TT2: Can you see! That aa... during the dry season when there is no enough water for the plant to conserve water in their body, they use this mechanism of dropping off their leaves. Do you understand?

L2: Yes

TA2: That means plants drop off their leaves (writes it on the board)

TT2: That means when leaves are dropped, obvious the rate of transpiration will be reduced. But sometimes, even though the leaves are reduced, **if you just stand under the tree, sometimes you may have drops of water on your body**, isn't it? And then you end up looking up saying maybe there is a snake here, what are these drops for? Have you ever experienced that?

L2: Yes

TT2: Alright, that is also water coming from the... or being dropped from the branch of the plant. And such form of water when they are coming from the branch to your body... we call it gutation (teacher writes gutation on the board). We call it what?

L2: Gutation (chorus)

TT2: Apart from drop off the leaves, another mechanism?

Silence

TT2: Look at the leaves of the plant for example, there are small hairs there on the leaves. Did you not see that?

L2: We have

TT2: Those hairs on the leaves, they also trap a thick layer of air. Now, if those layers have trapped a thick layer of air, nearby the leaves, it is very difficult now for the leaves to lose water. Do you understand?

L2: Yes

TT2: That means, most of the leaves are hairy leaves. They are what?

L2: Hairy leaves

TA2: Hairy leaves (writes hairy leaves on the board)

TT2: Therefore, these hairs, they are trapping thick layer of air nearby the surface of the leaves to reduce the rate of transpiration. But on the other hand, if you look at some of these plants again, if you look at how their stomata appear... Their stomata sometimes are not exposed to the surface, they are a bit inside the leaf. That means that their stomata are sunken. Sunken stomata (and the teacher writes it n the board).

L2: What does it mean by sunken?

TT2: Let me put it in Oshiwambo, aa... Okay... *Omafo amwe...ou weteko, eestomata dimwe kiimeno, eshi to tale oya fa ya ninginamo lelalela. Omwa mona omunhu nande ngeno oho tala omunhu fimbo limwe e to mu tala momesho, oho mono kutya oku na omesho e li mwii, miikololo hashoo?* Translated: Some of the leaves... you see, some of the stomata on plants, It appears sunken when you look at it. **Have you seen that sometimes when you look at a person in his or her eyes, you see that the eyes appear dipped, within the skull isn't?**

Laughter in the class

TT2: Sunken eyes... Omesho omaninginamo, keeli kombanda, hasho? Maara opuna ngoo omunhu u mwe e na omesho matunhumana. **Translated: Eyes that appear dipped, are not raised, isn't? But there are those with eyes that appear raised.**

Laughter in the class

TT2: Now, the stomata are appearing in that form, that are a bit inside the leaves, not so outside the leaves, not so on the surface of the leaves, they are called sunken leaves. Therefore, if stomata are sunken like that, they are all reducing the rate of what?

L2: Transpiration

TT2: Look at this one, some of the plants do it in this way that if it is too hot... If it is too hot, extremely hot, what plants do is that...

TA2: Plants close their stomata (writes it on the board)

TT2: They just close their stomata, isn't it? That's also another method of reducing what?

L2: Transpiration

TT2: The rate of transpiration... So these are some of the mechanisms that plants use, aa... it is also that some plants... Some of these plants, the reason why they are dropping their leaves that way, they want to conserve water within their body for so long. So if the plant can store its water, this time or it just make sure that this water will not be finished until the rain comes, again, therefore these are called succulents (writes the word succulents on the board). These are succulent plants, that means all plants that store water either in their leaves or in their stem, they are succulent plants. What are the examples of those succulent plants?

L2: Euphorbia

TA2: Euphorbia, very good! (writes Euphorbia on the board)

L2: Welwitchia

TT2: How do we spell it?

Loud noise in the class

TT2: Alright, alright, we know it! Welwitchia Mirabilis. Listen here, Welwitchia Mirabilis is one of the succulent plants.

LF2: Amoeba

TT2: Amoeba?

L2: !Naras

TA2: Alright, we have !Naras, is it like that? (while writing the word !Naras on the board)

L2: Yes

TA2: This exclamation mark is here (teacher putting the exclamation mark before the word Naras)

L2: And S?

TA2: Okay... And then, there is also another species of trees that is also known as succulent... Baobab (And the teacher writes Baobab on the board). There are also some trees that look a bit bigger... They are also like Baobab tree like this, they are in the form of aa... pear.... These are Quiver trees (while writing Quiver on the board).

TT2: Quiver tree is also one of the...succulent plants. Generally I am saying, plants take... a certain plant... Let's say all plants absorb water from the soil by using the root hairs whereby the thin extension penetrates between the soil particles and then it absorbs water. These water are transported in the xylem vessels where?

L2: In the roots (chorus)

TT2: Then this water in the xylem vessels will then be carried in the cortex and then from the cortex, into the xylem vessels into the... stem and then...

L2: Branches

TT2: And then...?

L2: To the leaves

TT2: Now, when the water are in the leaves, they are usually for two functions. Function number one, for photosynthesis, two for cooling the plant. But some of the water that are not used for cooling the plant, they will be lost into the air in the form of?

L2: Transpiration

TT2: Now, we are saying, the process whereby plants are absorbing water from the soil we call it?

L2: Osmosis

TT2: Osmosis, how do we define osmosis? The movement of water molecules only...

L2: From the region of higher...(chorus)

TT2: This is not Grade 1... from the region of higher water potential to the region of lower water potential...

L2: Through a partially permeable membrane.

TT2: Very good! Alright, now look at this one (points to the root hair cell drawing). Water is now being absorbed from the soil, they passes into... or they passes by using two forms. Form number one is apoplast, form number two is...

L2: Sympoplast

TT2: Apoplast is when water are moving through cytoplasm to the cytoplasm of the next cell, or through cell wall to cell wall. That is apoplast. Then if water is moving through the vacuole to the next vacuole, then that is...

L2: Sympoplast

TT2: Sympoplast, can you see?

L2: Yes

TT2: And then we have also looked at mechanisms that plants use to reduce what? The rate of...?

L2: Transpiration

TT2: And these are mechanisms, isn't it? Don't forget the factors that we have discussed at the beginning, especially the ones that are affecting the rate of transpiration. Before you go out, is there any question?

LM2: What causes the stomata of the plant to open and close?

TT2: Very good, that is a good question. What causes the stomata of the plant to open and close? Let me just look at this one. Why the stomata of the plant have to open?

Loud noise

TT2: For what?

Loud noise in the class again

TT2: Remember plants need to make their own food. Carbon dioxide is taken from the air diffuse in the leaves of the plant through the stomata. This is why stomata has to be open. But while stomata are open, more water are lost. You get it aa...?

L2: Yes!

TT2: Now, if stomata are closed, what is causing stomata to be closed? When what? When the temperature is high... If the temperature is too high, obvious stomata have to be closed to

reduce the rate of transpiration. So generally I am saying, the opening and closing of stomata is controlled by special cells called guard cells. This is the end of our lesson, I will come and give you your worksheet during study time. You will have to submit your work tomorrow morning so that I mark it.

The End!

### **Stimulated recall interview (SRI)**

I: Thank you for making time to watch this video so that we reflect on the lesson.

TT2: You are welcome

I: Reflecting on your two lessons, what do you think went well and where do you need to improve?

TT2: The voice projection was good and learners were actively participating. Where I need to improve is aa... I need to introduce a learner-centred approach rather than being teacher centred. I need to move around the classroom and monitor all learners in the classroom instead of being stationed at the front of the class when teaching. The chalkboard was also under-utilised and I need to use it to highlight all necessary point next time.

I: Okay, thank you sir, after your lesson presentation you gave an activity. Don't you think you needed to provide feedback to the learners instead of just handing back the activities?

TT2: Oh, yes, I didn't have enough time but next time I will make sure that I give my learners proper feedback. Time was just too limited, but I need to improve on this.

I: Alright, did you notice any challenge that learners faced, and which made learners experience difficulties in making sense of the topic on transpiration?

TT2: Yes., some learners are shy and that leads them to be unable to express themselves and make up follow-up questions. Learners couldn't define terminologies too such as, cuticles, water potential and xerophytic plants.

I: What do you think makes learners to be shy?

TT2: I think aa..., it is the language. They are afraid of making mistakes while asking questions and of others who may laugh at them, English... But I always encourage them to speak and discourage those who laugh at others.

I: In your opinion, what are the challenges that you are facing when teaching the topic on transpiration to your learners?

TT2: Our department lack apparatus such as potometers and a laboratory. Sometimes one wants to show learners how to measure the rate of transpiration, but there is no exact apparatus, one has to teach theory.

I: Lastly, by reflecting on the lesson, suggest some strategies you may use to help learners understand this topic on transpiration.

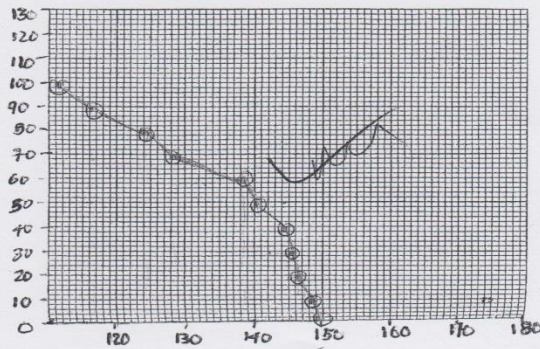
TT2: I will give more class activities to the learners and the feedback. I will also ensure hands-on and minds-on strategy so that learners understand better instead of just theory.

I: Okay, thank you again sir for availing yourself to watch the videos and to respond to questions.

TT2: You are welcome madam

**Teacher 2- Learners activity sample 1 (T2)**

When the experiment was complete, **tube B** was also weighed and its mass found to be 138g.  
 (a) Use graph paper to plot a graph of the results for **tube A**. Select suitable scales to make the best use of the graph paper.



(3)

(b) Name one important factor, which would account for the change that took place when the experiment was taken outdoors. Explain how this factor would cause the observed effect.

*Summ. temp. sunlight as outside is hot the plant with more use of water faster than in shade. (2)*

(c) Name the process which would account for most of the loss of mass from **tube A**.

*the water is taken up through transpiration. (1)*

(d) What was the purpose of **tube B**?

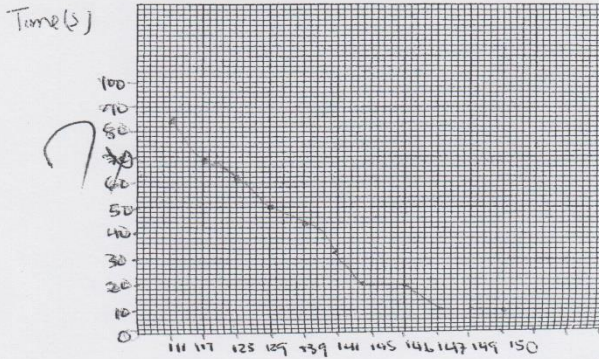
*to compare the water loss in tube A and tube B where there is no plant. (2)*

Which vessels are the main water conducting cells inside a plant and what are their functions?

*xylem vessel transport water from the roots to the rest of the plant  
 phloem tube transport synthesized food. (2)*

End of Biology Topic task

When the experiment was complete, **tube B** was also weighed and its mass found to be 138g.  
 (a) Use graph paper to plot a graph of the results for **tube A**. Select suitable scales to make the best use of the graph paper.



(3)

(b) Name one important factor, which would account for the change that took place when the experiment was taken outdoors. Explain how this factor would cause the observed effect.

light intensity, as the light and heat from the sun increases, the rate of photosynthesis will not increase because the plant have the light to use. (2)

(c) Name the process which would account for most of the loss of mass from **tube A**.

Transpiration (1)

(d) What was the purpose of **tube B**?

To see if transpiration can occur in plant. plant product of a fair experiment. (2)

Which vessels are the main water conducting cells inside a plant and what are their functions?  
 xylem vessel (apoplast transport of water from through chloroplasts of the plant. (symplast transport water through vacuole of the plant. (3)

End of Biology Topic task

## Lesson 1

Syllabus objectives: Learners should be able to:

- Define transpiration as the loss of water vapour from a plant (mostly through the leaves).
- Describe how the loss of water vapour is related to cell surfaces, air spaces and stomata
- Describe the effects of variation of temperature, humidity and light intensity on transpiration rate

### Introduction

The teacher tests for learners' prior knowledge by asking them to define transpiration.

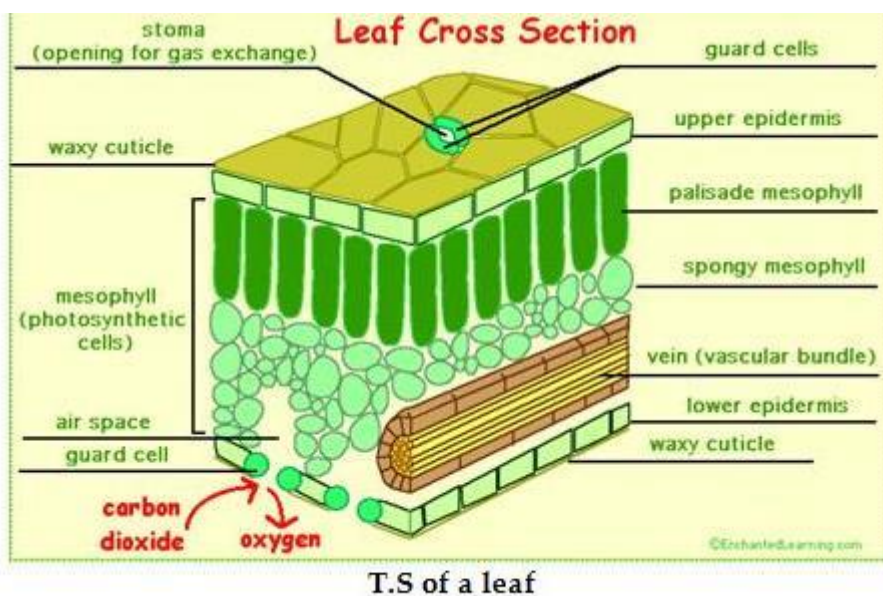
- Transpiration is the loss of water vapour from the plant leaves, through stomata.

Teacher asks what are stomata and where do we find most of them?

- Are pores on the plant leaves through which  $\text{CO}_2$  and  $\text{O}_2$  diffuses in and out of the leaf during photosynthesis and water vapour to leave during transpiration. There are more stomata on the lower epidermis than the upper epidermis.

### Main part of the lesson

The teacher asks learners to refer back to the internal and external structures of the leaf. After the listing is complete, the teacher will show the transverse section of the leaf, using power point.



**How the loss of water vapour is related to cell surfaces, air spaces, and stomata.**

Using the chalkboard and the leaf section, the teacher explains the following:

- Water in the mesophyll cells form a thin layer on their surfaces.
- The water evaporates into the air spaces in the spongy mesophyll
- This creates a high concentration of water molecules in the air spaces of the leaf than in the atmosphere outside.
- Water diffuses out of the leaf into the surrounding air through the stomata, by diffusion.

Learners copy down notes

The effects of variation of temperature, humidity, and light intensity on transpiration rate

Teacher asks learners to explain how low/ high (variation of) temperature, humidity, and light intensity affects the rate.

After learners have explained, the teacher writes the following information on the chalkboard and explains.

<b>Transpiration speeded up by</b>	<b>Transpiration slowed down by</b>
Dry air	Humid air
High temperature	Low temperature
Moving air	Still air
Bright light	Dim light

### **Consolidation**

- What is transpiration?
- One should be able to label the transverse structure of the leaf, esp. stomata, air spaces and the mesophyll layer (palisade, spongy).
- How water loss is related to cell surfaces, air spaces, and stoma.
- Conditions affecting transpiration rate.

### **Activity 1**

3. (a) Name the biological process by which a plant loses water to the air. (1)  
(b) State two other processes which are involved in the movement of water from the roots to the leaves (2)

4. Figure 1 shows the rate of water uptake by a plant over a period of three days.

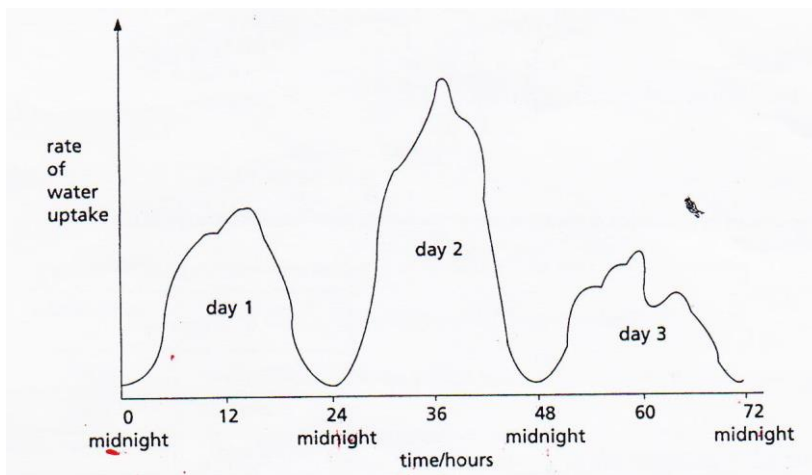


Figure 1

- (ii) Using information in Figure 1:
- (c) Account for the rate of water uptake at midnight (2)
- (d) Suggest reasons for the differences between the rates of water uptake on days 2 and 3 compared with day 1 (3)

**Total [8]**

### Homework

Learners should do the following:

- Define Xerophytes
- Identify examples of xerophytes in their communities and their names in Oshiwambo.
- Prepare for presentation in the classroom during the next lesson

## **Lesson 2**

Syllabus objectives, learners should be able to:

- Describe methods by which xerophytic plants can reduce transpiration rate, with reference to two named examples (e.g. Aloe, Euphorbia, Quiver tree )
- Describe how wilting occurs
- Discuss the adaptations of the leaf, stem, and root to different environments, with emphasis on local examples.

### **Introduction**

Recap on previous lesson- define transpiration, how loss of water vapour is related to cell surfaces, air spaces and stomata, and conditions affecting the transpiration rate.

### **Main part of the lesson**

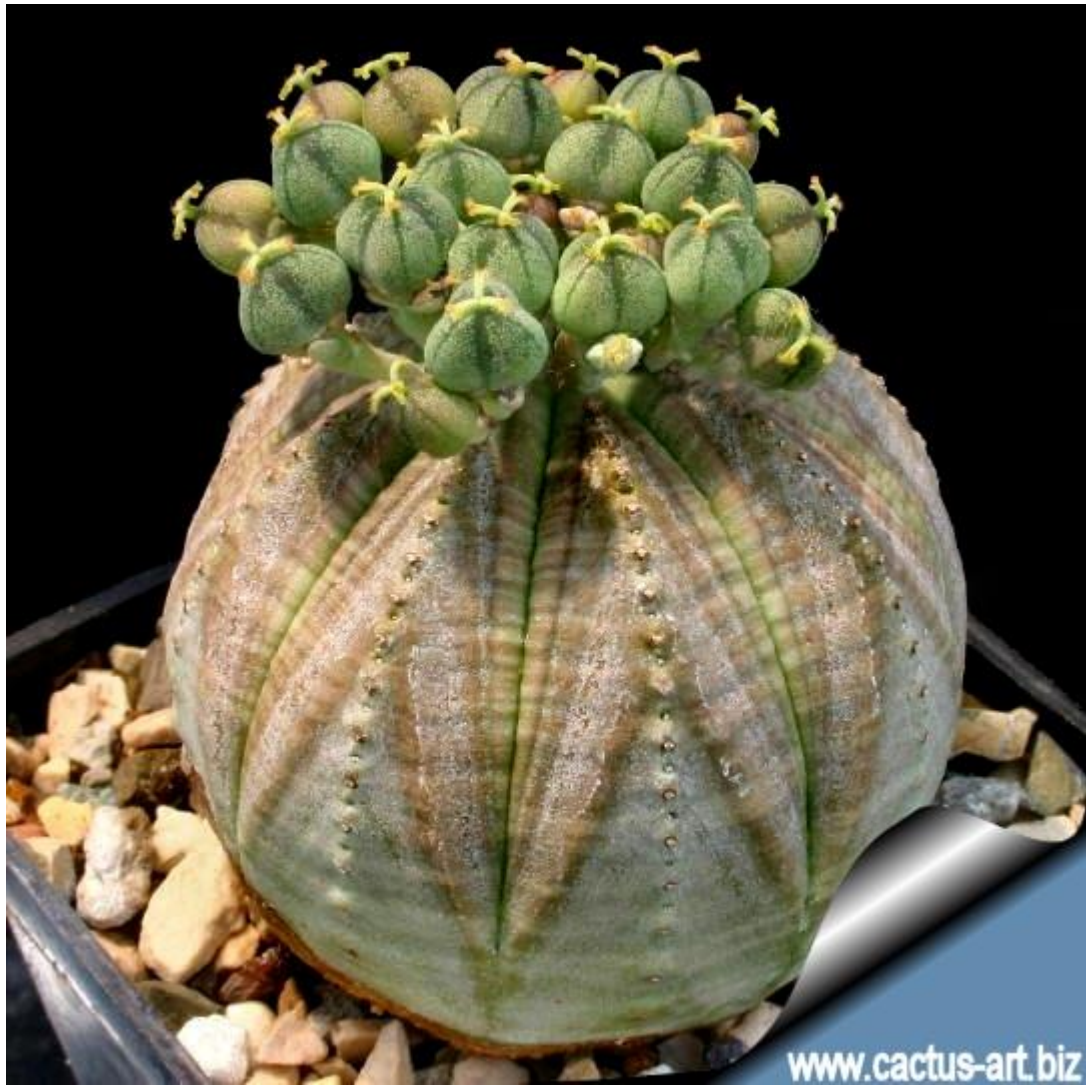
Two learners to present their findings and the teacher summarises that on the board.

- Xerophytic plants are plants that are adapted to survive in dry, arid regions. The teacher uses power point to show images of Aloe, Euphorbia and Quiver tree.





What are these (above)?







And the ones above...?



And again the name of the trees above...?

## **How aloe plants minimise the water loss:**

### **Roots**

Shallow roots which spread out near the surface of the soil to absorb overnight condensation (water). Any water from light rain and dew is also absorbed.

### **Stem**

- Thick stem which stores water
- Covered by cuticles to prevent water loss
- Protected from further water loss by old leaf bases
- Grows upright to prevent exposure to sunlight.

### **Leaves**

- Large succulent leaves
- Thick wall cuticle to reduce water loss
- Leaves arranged to provide shade for each other
- Shiny cuticle to reflect sunlight
- Sunken stomata to reduce water loss

## **Euphorbia**

- Small surface area
- Plant short and close to the ground
- Not exposed to dry winds
- Roots have many fibrous roots to absorb surface water
- Fleshy and succulent
- Shiny surface to reflect sunlight.

## **Quiver**

- Have water storing succulent leaves
- Shallow root system that:
  - Absorb water following rare rainfall events
  - Absorb water when condensed ocean fog drips from their own branches and leaves

## **Learners' activity**

- Explain how other plants (apart from Aloe, Euphorbia, Quiver) survive in dry/cool conditions. (5)

## **How wilting occurs**

The teacher asks learners to explain how wilting occurs

## **Notes**

- Wilting refers to the loss of turgidity of non-woody parts of plants
- Wilting occurs when the turgor pressure in non-lignified plant cells falls toward zero. The cells lose their turgidity (shape) and become flaccid and eventually the whole plant hangs over.
- Wilting occurs when a plant loses more water through the leaves and stems than is being absorbed.

### Lesson 3

#### Syllabus objectives

- Use a simple potometer to compare the rate of transpiration under different environmental conditions
- Carry out an investigation to compare the relative number of stomata on the upper and lower epidermis of a leaf, using petroleum jelly.

#### Introduction

The teacher writes the word potometer on the board and asks if learners know of that instrument.

The learners are shown the diagrams of a simple potometer

The teacher then explain **how a simple potometer is used to measure the transpiration rate under different environmental conditions**

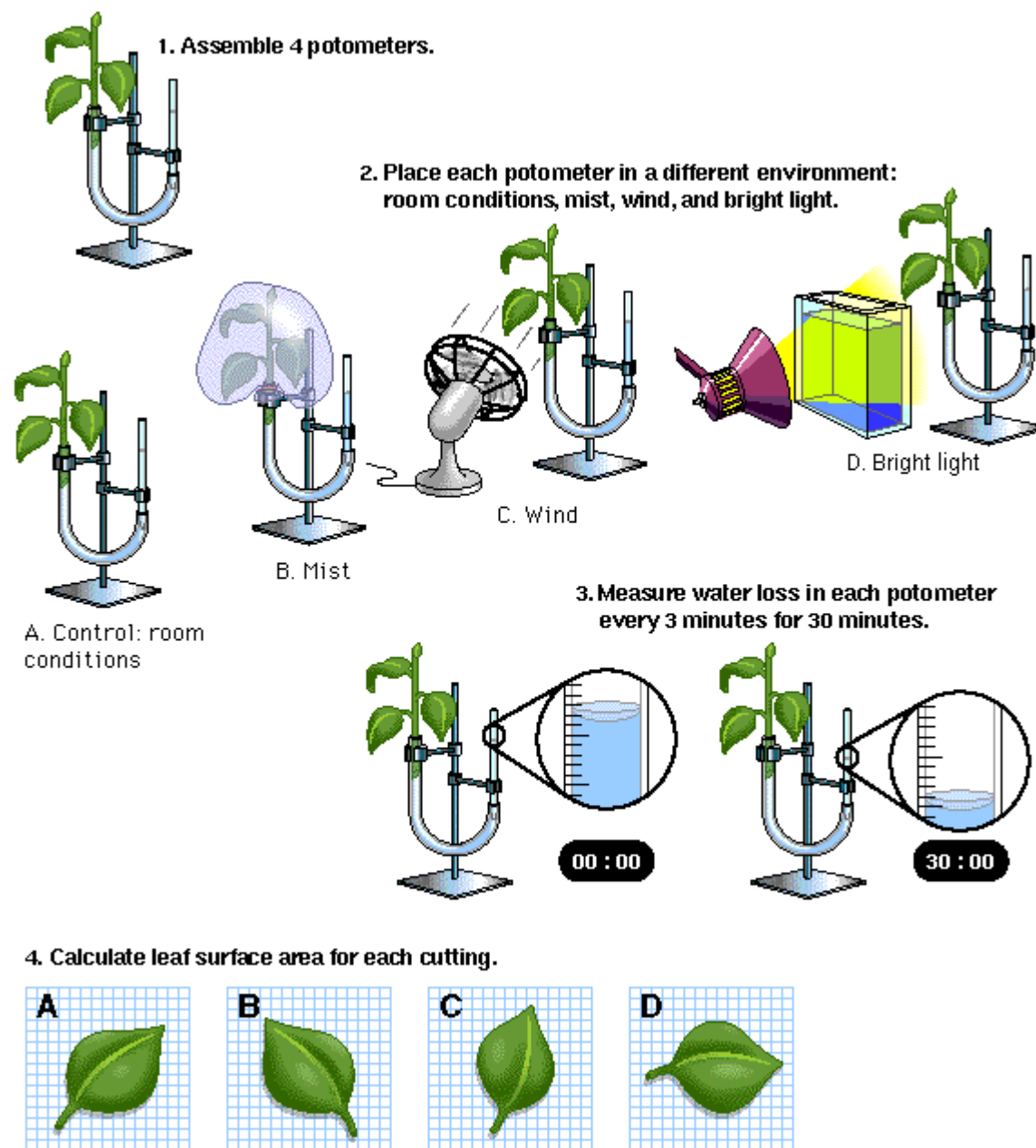
- The more the water is lost during transpiration, the faster the uptake of water occurs.
- The potometer measures the rate of water uptake of a shoot(transpiration rate)
- A little water taken up can be used or photosynthesis and other metabolic processes, but the most is transpired.

#### Precautions when setting up a potometer

- Use a healthy, undamaged, non-wilted shoot.
- Allow the shoot to acclimate and become adjusted to the factor being investigated
- Keep the environmental conditions constant
- Cut the shoot under water to make sure no air goes into the xylem.
- Insert the shoot into the potometer under water.
- Make sure the entire apparatus is full of water- no airlocks or bubbles.
- Cut the shoot at a slant(sloping/at an angle)
- Dry the leaves
- Ensure air/water tight joints (one can use a rubber bung).
- Measure the distance travelled by the bubble in the calibrated tube in the given time
- Move the air bubble back to the beginning by opening the tap.

Learners copy down notes before they are shown the pictures on a potometer.

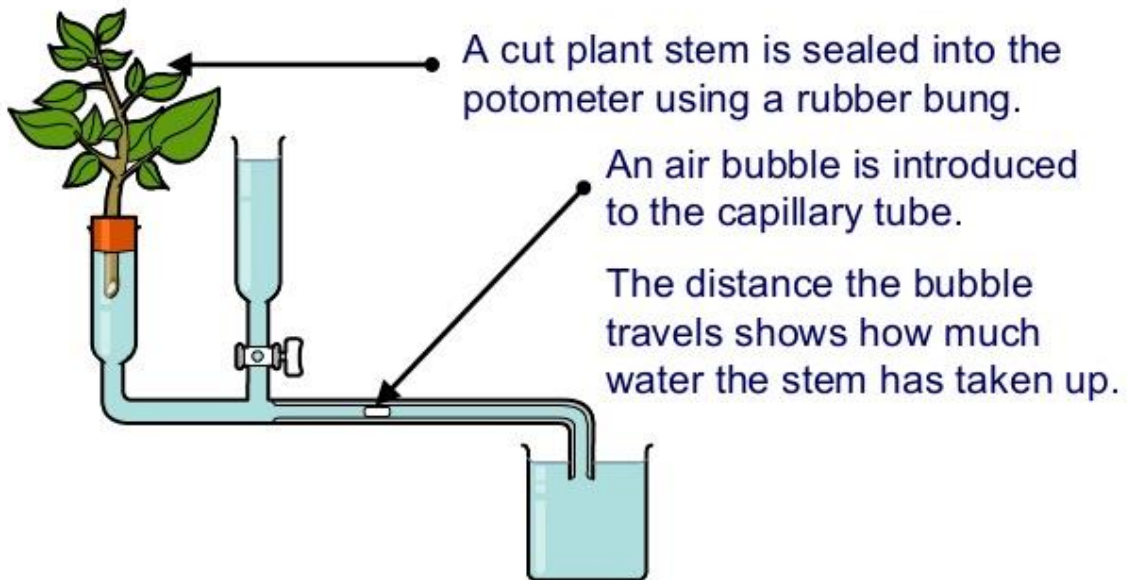
In order to measure some different rates of transpiration, follow the four steps outlined in the graphic below. For a review on assembling a potometer, see [Design of the Experiment](#).



- Use a fan directed towards the shoot to investigate wind
- Use a heater to investigate temperature
- Use a light bulb to investigate light intensity
- Cover the shoot with a transparent plastic bag to investigate humidity.

# Transpiration

Transpiration can be measured using a **potometer**.



## Objective

- **Learners should be able to construct a graph by labelling the x and y axes, as well as plotting.**

1. The teacher asks learners why graphs are needed

Why graphing- write on the board and explain

- best ways to communicate the results of a scientific investigation
- can clarify how two measured variables affect each other

2. The teacher asks learners to write on pieces of papers the differences between the independent and dependent variables.

### Feedback to learners

#### Independent variable

- The variable that can be controlled by the experimenter OR
- The quantity whose values are decided and fixed by the experimenter.
- It usually includes time (dates, minutes, hours,), depth (feet, metres), and temperature. It is always placed on the X-axis (horizontal axis).

#### Dependent variable

- The variable that is directly affected by the independent variable. It is the result of what happens because of the independent variable. It is always placed on the Y-axis (vertical axis) OR
- The unknown quantity whose values are being measured

**Question to learners:** What is the independent and the independent variable if one carries out the experiment on: **The effect of temperature on transpiration rate in plants?**

### Feedback

- Independent: The temperature at which the investigation is carried out
- Dependent: The transpiration rate

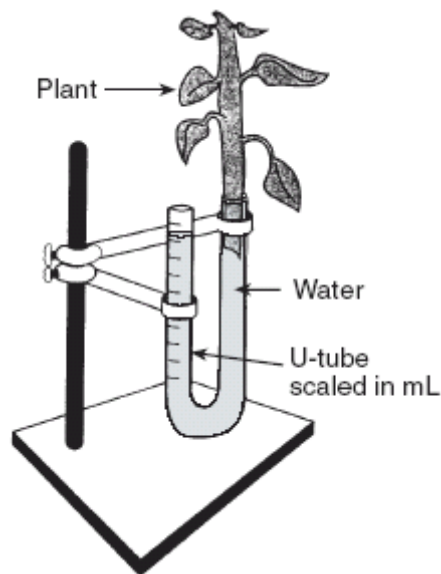
## Activity 2

Name \_\_\_\_\_ Date \_\_\_\_\_

**Directions:** Using the directions included below to complete the graph and the related questions. Point values are listed as appropriate.

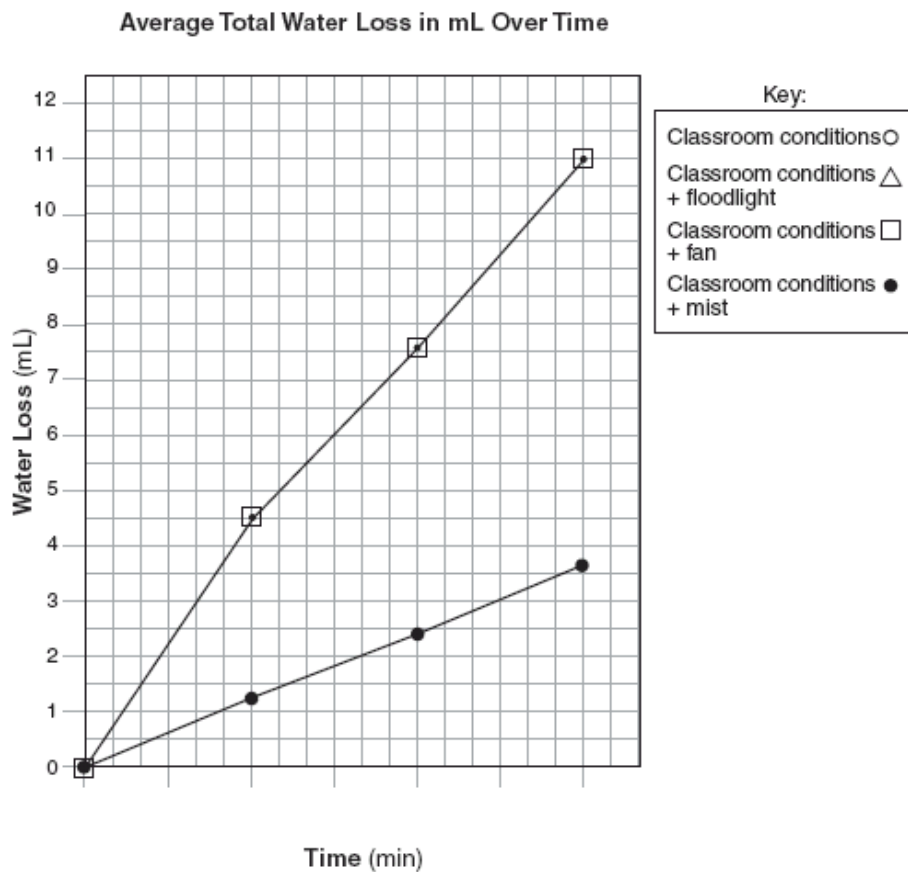
Base your answers to questions 1 through 5 on the information, diagram, and data table below and on your knowledge of biology.

A student conducted an investigation to determine the effect of various environmental factors on the rate of transpiration (water loss through the leaves) in plants. The student prepared 4 groups of plants. Each group contained 10 plants of the same species and leaf area. Each group was exposed to different environmental factors. The apparatus shown in the diagram was constructed to measure water loss by the plants over time in 10-minute intervals for 30 minutes. The results are shown in the data table.



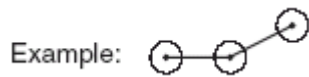
Environmental Factors	Average Total Water Loss in mL Over Time			
	0 min	10 min	20 min	30 min
Classroom Conditions	0.0	2.2	4.6	6.6
Classroom Conditions + Floodlight	0.0	4.2	7.6	11.7
Classroom Conditions + Fan	0.0	4.5	7.6	11.0
Classroom Conditions + Mist	0.0	1.3	2.4	3.7

Directions (1–3): Using the information in the data table, construct a line graph on the grid, following the directions below. The data for fan and mist conditions have been plotted for you.



1. Mark an appropriate scale on the axis labeled “Time (min).” [1]
2. Plot the data for the classroom conditions from the data table. Surround each point

with a small circle and connect the points. [1]



3. Plot the data for classroom conditions + floodlight from the data table. Surround each point with a small triangle and connect the points. [1]



4. Identify the environmental factor that resulted in the lowest rate of transpiration. [1]

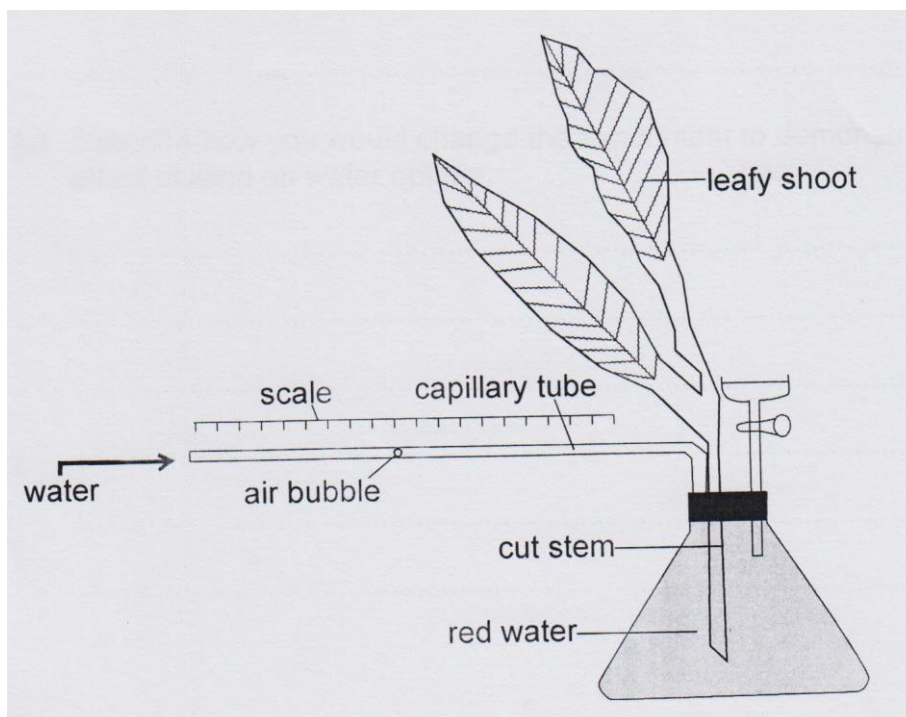
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5. Identify the control group of plants in this experiment. [1]

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### Activity 3

A learner set up the apparatus shown in below. The learner also set up a similar piece of apparatus without a leafy shoot and left both for 30 hours.



At the end of this time, the leaves of the shoot had become red.

(a) Suggest an explanation for this result.

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..... [4]

(b) Explain the purpose of setting up the apparatus without a leafy shoot

..... [1]

(c) Describe how you would change the experiment to demonstrate the effect of wind on water uptake.

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..... [5]

**Topic task: Tranpiration**

**Learner's name.....**

**Grades 11 A-C**

**Grade.....**

1. Circle the correct answer below

(i) When a plant loses more water than it absorbs it results in:

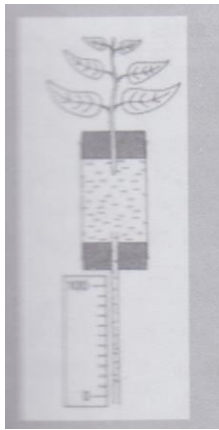
**A** transpiration

**B** translocation

**C** osmosis

**D** wilting

(ii) What name is given to the apparatus below



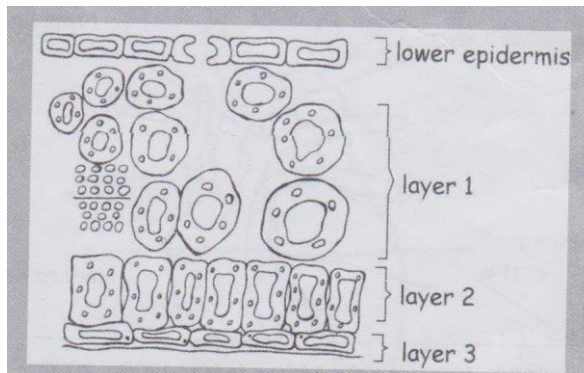
**A** scale

**B** barometer

**C** potometer

**D** photometer

(iii) The diagram below presents layers in a leaf



In which layer would you find vascular bundles?

**A** layer 1

**B** layer 2

**C** layer 3

**D** lower epidermis

- (iv) If a plant with the leaf above was found in the Namib desert, which adaptation feature would you expect the leaf to have?
- A long roots to reach underground
  - B fleshy stems to store water
  - C thick cuticle above layer 3
  - D many fibrous roots

- (v) Which of the following is **not** a xerophytic?
- A aloe
  - B tomato
  - C quiver tree
  - D euphorbia

[5]

2. Name the two factors that affect the rate of water loss and describe their effects.

.....

.....

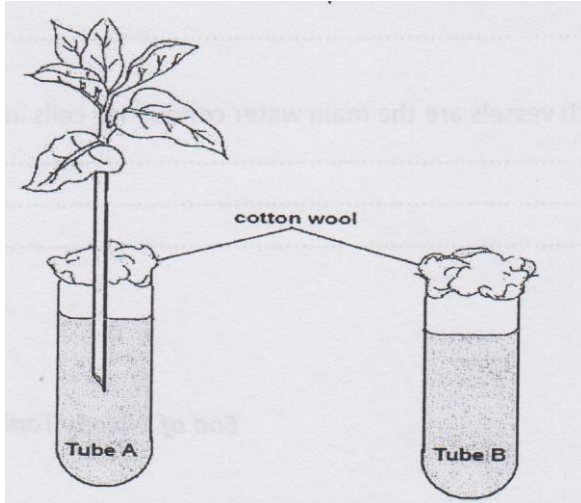
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[4]

3. Two tubes of the same size were partly filled with water. In the first tube a leafy shoot was placed and held in position with a piece of cotton wool. A similar piece of cotton wool was put in a second tube, but without a plant.

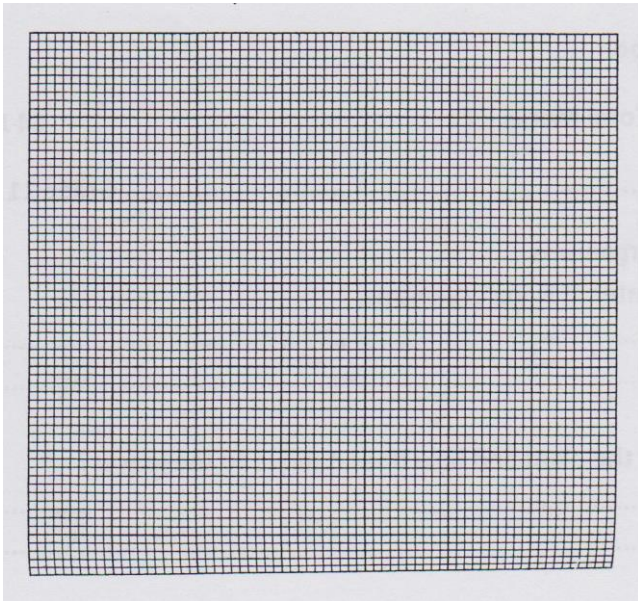


The total mass of tube A at this stage was found to be 150g while tube B had a mass of 140g. Tube A, standing in a laboratory, was then weighed at 10 minutes intervals over the next 50 minutes. After 50 minutes both tubes were taken outdoors and the weighing continued for tube A. the results obtained for tube A are as follows:

Time/minutes	0	10	20	30	40	50	60	70	80	90	100
Mass of tube A in grams (g)	150	149	147	146	145	141	139	129	125	117	111

When the experiment was complete, tube B was weighed and its mass found to be 138g.

- (a) Use a graph paper to plot a graph of the results for tube A. Select a suitable scale to make the best use of the graph paper.



[3]

- (b) Name one important factor, which would account for the change that took place when the experiment was taken outdoors. Explain how this factor would cause the observed effect.

.....  
.....  
.....  
.....[2]

- (c) Name the process by which would account for the loss of mass from tube A.

..... [1]

- (d) What was the purpose of tube B?

..... [1]

- (e) Describe precautions one need to take while setting up an instrument we use to measure the transpiration rate.

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.....[4]

**Total [20]**