An intervention to combat plant blindness in Life Sciences educators

by

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ABSTRACT

There is currently a strong consensus about the prevalence of plant blindness in educators as multiple studies have observed its effects both globally and in the South African context. During this study, a group of Life Sciences educators from the Gauteng province took part in an intervention which informed them about plant blindness and why it should matter to them, and then proceeded to give them a strategy to facilitate meaningful interactions with plants as part of their daily teaching. The proposed strategy involved the use of a mobile plant identification application called Pl@ntNet which allows educators to easily identify plants with their mobile devices and instantly gives them access to information, which could potentially increase their confidence in teaching about these plants. This was presented through an informative and practical workshop which included a treasure hunt for various plants. The influence of this intervention was assessed by collecting data through a preliminary online questionnaire, interviews with each participant, weekly diaries kept by the participants and a final reflection about their experiences. All interviews were transcribed verbatim, and data were analysed and interpreted by means of content analysis and thematic analysis through emergent coding. This study found that an educator-focused intervention could interrupt the positive feedback loop of negative perceptions which exists between educators and learners when botany is taught in classrooms, and kickstart a new positive feedback loop characterised by positive perceptions toward plants. This is a result of educators' increased confidence and positive perception regarding botany teaching.

KEY WORDS: Plant blindness; plant appreciation; Life Sciences education; educator perceptions; educator confidence; plant mentor; mobile learning; intervention; experiential learning; positive feedback loop.

ACRONYMS

CAPS	Curriculum Assessment Policy Statement
CT	Computerised Tomography
DBE	Department of Basic Education
FET	Further Education and Training
GPS	Global Positioning System
IEB	Independent Examinations Board
PCK	Pedagogical Content Knowledge
TSPCK	Topic Specific Pedagogical Content Knowledge
TTF	Task Technology Fit
UK	United Kingdom

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CHAPTER 1: ORIENTATION OF THE STUDY

1.1 CHAPTER OVERVIEW

This study probed into the phenomenon known a plant blindness, specifically in the context of the South African educational system. A simple intervention was developed by drawing on the existing local and international literature, after which it was presented to Life Sciences educators. I collected data to investigate whether such an intervention could have a meaningful impact on the educators and then situated the findings of this study as part of the broader global conversation about addressing plant blindness.

The purpose of this chapter is to introduce plant blindness as a legitimate problem, not just in education, but also to the rest of society and to then give a brief overview of how it has been addressed historically. This is followed by a description of the research problem statement, which is related to the challenges with regards to educators and their role in addressing plant blindness. Thereafter, the purpose and aims are elaborated on and the research questions are stated. A list of terms which are important in the context of this study, are defined and this is followed by the working assumptions and rationale for the study. Finally, a general outline of the organisation of the dissertation is included in the conclusion of this chapter.

1.2 INTRODUCTION

The idea that an imbalance exists between the amount of regard humans show to plants compared to animals was first seriously studied by Wandersee (1986), who found some evidence of a preference towards animal studies among junior high school students. In a later study, Wandersee & Schussler (2001) suggested the term ‘plant blindness’ as a means to refer to the phenomenon of people being seemingly blind to plants all around them. Subsequent studies have proposed various reasons that lie at the root of this widespread occurrence which alluded to the seemingly homogenous appearance and slow movement or change in appearance of most plants (Moscoe & Hanes, 2019). The prevailing belief used to be that plant blindness is a predisposition that humans are

biologically programmed to possess, but more contemporary research has begun to find that the extent to which humans are exposed to plants through meaningful interactions have just as much influence as the proposed visual perception limitations which humans have been found to possess toward plants (Wandersee & Schussler, 2001).

The state of affairs regarding the relationship between people and plants has been aptly summarised by Entwisle (2019) as two symptoms observable in many humans living in the 21st century. The first symptom is plant illiteracy which refers to the notion that people living in urban and suburban environments (which is an exponentially growing demographic) are blissfully ignorant about the critical role that plants play in much of their daily lives, and without which life, as we know, it will not even be able to exist. The perceptual limitation known as plant blindness is the second proposed symptom which has become especially relevant as living neighbourhoods become increasingly urbanised and plants are systematically being replaced by concrete jungles (DelSesto, 2020; Kueffer, 2020; Wandersee & Schussler, 2001). The result is that the role of plants is diminished as something resembling green wallpaper behind the 'really important' objects like humans, animals, and impressive feats of engineering and technological developments (Entwisle, 2019).

1.2.1 Broad context of the roots and status of research pertaining to plant blindness and the teaching of plant sciences

In the years following the coining of the phrase, academia has firmly established the concept of plant blindness as an indubitable factor to be considered in the context of Life Sciences education (Abrie, 2015; Allen, 2003; Pany, 2014). Amongst the plethora of studies inquiring into this phenomenon, the vast majority of researchers have concurred that plant blindness is apparent amongst educators and students alike and leads to widespread disinterest and even dislike of plant sciences (Abrie, 2016; Balding & Williams, 2016; Kinchin, 1999; Lombaard, 2015; Pany, 2014). Although plant blindness has been studied for quite some time, its significance as research subject has not been realised and there is still much potential for studies to inquire into ways that these wrongful

perceptions can be challenged and hopefully changed. Various leading research teams have found that, although it is now clear that plant blindness is widespread in schools and universities, it is becoming evident that this challenge can be addressed quite effectively with some careful thought and creativity (Goodwin, 2008; Krosnick, Baker, & Moore, 2018; Moscoe & Hanes, 2019; Nyberg & Sanders, 2014). This is good news and ample reason for researchers to investigate how ideas, which worked internationally, can be replicated and adapted for similar effect in the South African context.

1.2.2 Theory relating to plant blindness and its influence on education

Apart from the revelation that plant blindness is present throughout society, certain scientists have made a strong case in support of the assertion that an apparent inability to see plants is a default position in humans (Carrington et al., 2019; Wandersee & Schussler, 2000). When one considers how plant blindness manifests in practice, the influence of zoocentrism and zoochauvinism on perceptions of individuals should also be taken into account. Simply put, zoochauvinism refers to the notion that plants are less valuable and noteworthy compared to animals (Hershey, 1996), while zoocentrism is a term which is commonly used to describe the widespread practice of treating animal studies as central or paramount and thereby deeming plants as secondary and relatively unimportant, specifically in the context of Biology education (Balding & Williams, 2016).

A disproportionate focus on animals, vertebrates in particular, as compared to plants has been observed and confirmed by many researchers over the past two decades. Consequently, there is an abundance of literature pointing to the fact that this is especially true in educational spheres (Lindemann-Matthies, 2006; Yorek, Şahin, & Aydın, 2009). Some of the most recent literature regarding zoochauvinism has shown that learners prefer to learn about animals rather than plants and find it much easier to recall information relating to animals (Jose, Wu, & Kamoun, 2019). This notion has been echoed by many other studies with the general trend being that students simply do not perceive plants as interesting (Bozniak, 1994; Hershey, 1993; Nyberg, Hipkiss, & Sanders, 2019; Pany et al., 2019; Vujakovic, 2019; Yorek et al., 2009).

One of the reasons for this phenomenon, which has been proposed by multiple scholars, is that humans are evolutionarily programmed to be zoochauvinistic and therefore pay much more attention to animals than to plants (New, Cosmides, & Tooby, 2007). This premise is based on the fact that awareness of other animals was crucial for the survival of our ancestors, either to prevent being hunted by predators or to hunt other animals for food (New et al., 2007). Another line of reasoning which has received much more scholarly attention is the idea that the movement of an organism is closely linked to it being perceived by humans as a living being (Bardel, 1997; Jose et al., 2019; Kinchin, 1999; Wandersee, 1986; Yorek et al., 2009). Among the various studies probing this idea, is the main proposition that life cycles and general movement among plants are perceived to be very slow and dull (if not completely absent) at first glance, thus leading to the perception that plants are 'boring' and uninteresting (Jose et al., 2019; Koller, 2011; Sanders, 2019; Yorek et al., 2019). There is, however, a wide array of literature which suggests that this wrongful perception can be addressed quite successfully by getting people to take a proverbial second glance at the wonderfully complex and lively world of the plant kingdom.

The influences of such misguided conceptions with regards to plants have been found to be detrimental to education as these wrongful perceptions held by many educators are carried over to their learners (some of whom will eventually become the next generation of educators) and thus creating an ongoing cycle of misrepresentation (Abrie, 2016; Allen, 2003; Hershey, 1996; Pany, 2014). Simply put, there is a good chance that educators will teach about topics as they were taught by their educators, often perpetuating the same negative attitudes through the examples they use and the pedagogy which they implement in their own classrooms (Borko & Putnam, 1996; Luera & Otto, 2005). This assertion is supported by the multiplicity of scholars who have noted an unequivocal correlation between learner disinterest in subjects relating to plants and the way it is taught in the classroom (Allen, 2003; Hershey, 1996; Pany, 2014). One of the cardinal ways in which this plays out in the classroom is to be found in the types of examples educators use to explain phenomena in botany lessons. Various studies have found that

when educators are required to explain a concept with examples, they lean disproportionally toward using examples from the animal kingdom (Hershey, 1996; Lampert, Scheuch, Pany, Müllner, & Kiehn, 2019; Pany et al., 2019).

It should, however, be noted that the abovementioned behaviour is not indicative of all educators and that there is a minority of educators who defy the status quo with unbridled enthusiasm about plant-related topics. They venture to teach in ways that inspire their students to develop plant appreciation. Various studies have found that these educators have two important traits in common. The first important trait is having hands-on experience with growing, caring for, or merely interacting with plants (Balding & Williams, 2016; Margulies et al., 2019; Wandersee & Schussler, 2001). The importance of this factor is supported by the intriguing fact that the few societies across the world which do not yet exhibit plant blindness, are precisely those who live in such a way that they have continual meaningful interactions with plants (Balding & Williams, 2016; Margulies et al., 2019). The second factor that plays a determining role in fostering plant awareness and appreciation is the presence of a knowledgeable adult, or what Hersey (2002) referred to as plant mentors, who can facilitate such meaningful interactions with plants. The impact of these two factors have been attested to by many educators and plant scientists who shared their stories of becoming interested in plants in a recent twitter poll lead by Jose et al. (2019)

A concept which has become synonymous with discussions about teaching effectiveness is that of pedagogical content knowledge (PCK), as suggested by Shulman (1986), and even more specifically, topic specific pedagogical content knowledge (TSPCK), as described by Rollnick & Mavhunga (2013). Topic specific PCK, which refers to knowledge about effective pedagogy within a specified subject area, is one way in which educators of Life Sciences might address the deficit created by plant blindness, zoochauvinism and zoocentrism (Coetzer, 2019; Lombaard, 2015). In recent years, there has been quite a deficit in the literature with regards to the relationship between plant blindness and TSPCK, with the exception of a few researchers (Abrie, 2016; Coetzer, 2019; Lombaard, 2015).

Recent unpublished exploratory research investigated whether an experienced Life Sciences educator showed any signs of TSPCK, specifically with regards to alleviating the effects of plant blindness on secondary school learners (Coetzer, 2019). The study found that the educator did not know about plant blindness as a characteristic which is inherently found in most students and that the educator was oblivious regarding the effects that this phenomenon might have on pedagogical effectiveness (Coetzer, 2019). Evidently, if educators are not aware of a problem and its serious repercussions, it easily slips under the radar and is thus unknowingly perpetuated.

1.2.3 Previous endeavours aimed at combatting plant blindness and developing plant appreciation

Based on the abovementioned research, there are two important premises to be considered regarding plant blindness in the educational context. Firstly, it is important to note the implications of Life Sciences educators being unaware of the existence of this phenomenon. This presumably plays out in classrooms around the world and indeed even in the South African educational system, possibly because educators also have some level of plant blindness. Although the idea of plant blindness has been studied extensively for decades and is established among scholars and academics, the research is only able to effectuate real reform if it is carried over to grassroots level where educators are physically teaching content to their students. It is at this level that interventions become very relevant and necessary.

Since Wandersee & Schussler discovered the pervasiveness of plant blindness, many efforts have been made to combat it through various interventions, of which Wandersee & Schussler (1999; 2000) once again played a pioneering role with the development of an educational poster and picture book. Subsequent efforts toward creating interventions were based on increasing the amount of time learners spend investigating plants in their immediate surroundings and interacting with plants by learning about their respective names, history and common traits. The vast majority of these projects produced positive results as they were able to address plant blindness in meaningful ways (Brewer, 2002;

Frisch, Unwin, & Saunders, 2010; Goodwin, 2008; Lindemann-Matthies, 2006; Wandersee & Schussler, 1999).

Exploration of the literature regarding interventions which have been aimed at addressing plant blindness, have yielded two clear trends with respect to implementation. The first trend is based on informing school-attending learners and university students about plants in various creative ways to trigger and grow an appreciation for these seemingly inconspicuous organisms. Some notable examples of this approach involve providing learners with information about plants and some of their interesting properties (Lampert et al., 2019; Strgar, 2007), using plants that are useful to human endeavours (Pany & Heidinger, 2015) and even using educational theatre to evoke a positive attitude towards plants (Stagg & Verde, 2019). Some researchers have even proceeded to use fruits and flowers along with discussions and teaching about plant reproduction to increase the aesthetic value of plants among their participants (Prokop & Fančovičová, 2012; 2014).

The second trend among previous interventions is based on encouraging meaningful interactions with plants as research has shown that it is a good predictor of favourable perceptions toward plants. Many research projects have partnered with botanical gardens and educational centres to facilitate educational programmes that encourage learners to interact with plant life and learn about them through these interactions (Fančovičová & Prokop, 2011; Knapp, 2019; Nyberg & Sanders, 2014; Sanders, 2007; Tunnicliffe, 2001). The idea of letting learners grow plants themselves, whether inside the classroom or outside in school gardens and flower boxes has also been used in many interventions to the benefit of the majority of the participants who reported a nearly unanimous increase in plant appreciation or plant awareness at the very least (Jose et al., 2019; Knapp, 2019; Nyberg & Sanders, 2014).

Perusal of the relevant literature has proven that very few interventions have been designed specifically for the context of the South African educational system and therefore, most Life Sciences educators remain ignorant about plant blindness and what could be done to remedy its effects (Goodwin, 2008). It is disquieting to note that the vast

majority of interventions are focused on learners and neglect to consider the crucial role of educators in addressing plant blindness. This study proposed to address this shortfall by means of an intervention for educators which drew on the existing literature about the importance of interesting information and meaningful interactions with plants. In addition, this study aimed to establish whether such an intervention could aid educators in combatting plant blindness in themselves as well as amongst their learners.

1.2.4 Constructivist learning and mobile technology

One of the more recent lines of thinking about intervention design, which seems promising, focuses on the use of mobile technology to facilitate interactions with plants in meaningful and engaging ways (Kissi & Dreesmann, 2018). The fundamental premise behind such a direction of thinking is based on the theory of constructivism in relation to learning (Uzunboylu, Cavus, & Ercag, 2009; Vygotsky, 1978). The basic premise of this theory of learning is that humans construct meaning (learn) by socio-cultural interactions and integrate new knowledge into pre-existing models through meaningful interactions with content and phenomena (Luera & Otto, 2005; Richardson, 1997; Uzunboylu et al., 2009). This theory of learning has been implemented with great success since its conceptualisation and has recently sparked the idea of using active and experiential learning like treasure hunts to enhance the way in which plant sciences is taught (Freeman et al., 2014; Hartman, Lydon, & Rasmussen, 2019).

The tremendously popular mobile game, Pokémon GO, which was launched in 2016 made it clear that the technological revolution, which has mobile devices at its forefront, holds much potential to assist in efforts to enhance learning about plant sciences (Hartman et al., 2019). The game was reminiscent of a treasure hunt, requiring users to seek out certain creatures with the help of the Global Positioning System (GPS) and camera on their mobile devices (Carter & Velloso, 2016; Hartman et al., 2019). Some researchers picked up on this trend and experimented with using a similar approach to facilitate meaningful constructive learning about plants through the help of a mobile application and a treasure hunt with very promising results (Hartman et al., 2019). From

their initial attempt at presenting a plant treasure hunt to university students, Hartman et al. (2019) found that participants reported an increased ability to link lecture content with real world context, in addition to a greater understanding of some of the plant-related topics about which they were learning in class. Other studies which inquired into active learning strategies, such as those used by Hartman et al. (2019), have demonstrated that it can improve student performance across multiple domains including science and mathematics with as little as 10-15% of class time devoted to such learning (Freeman et al., 2014). It is however worth noting that the vast majority of these types of interventions are focused on the learners and therefore raise the question of what the influence could be if educators were to buy in to the process and start implementing them in their own contexts. This study attempted to address this question through research.

1.2.5 Plant appreciation and plant love

The term plant blindness, first proposed by Wandersee & Schussler in 1999, has been the unanimously-accepted term when referring to peoples' inability to notice and appreciate plants. There has, however, not been a shortage of alternative terminology to describe the same type of phenomena. As this study focused fundamentally on the presence of plant blindness and ways to combat it, it is useful to consider whether or not there might be a more appropriate term to use which is reflective of the current state of research on this topic. One of the criticisms of the term plant blindness is that, although very useful, it could be problematic as it might be interpreted as merely a deficit model or a medical model of a condition for which we need to find a cure (McDonough MacKenzie et al., 2019; Sanders, 2019). Historically there have been two approaches to the subject. The first approach is to use terms phrased in the negative to indicate the deficit, as was the case with plant blindness. Examples include terms such as plant neglect (Hershey, 1993), plant illiteracy (Entwistle, 2019) and more generally, biology blindness (Flannery, 2019). The second approach is to use words phrased in the positive which rather focuses on a behaviour or awareness that needs to be fostered and instilled into people who have not yet acquired it. Examples of such terms include plant awareness (Sachdev, 2019) and flora appreciation (Balding & Williams, 2016). The general trend among academics

seems to gravitate towards positively-phrased terminology as this carries a stronger message of hopefulness and empowerment (McDonough MacKenzie et al., 2019, Sanders, 2019) It is for this reason that this study made use of terms such as plant awareness and plant appreciation. The purpose of this approach is to draw on the suggestions and criticism of the abovementioned scholars to encompass the most important aspects with regard to what was intended since the conceptualisation of the term plant blindness. Plant appreciation, as used in this study, refers to both the physical awareness of plants in the world around us and an appreciation for its novelty and importance to all life on earth.

1.3 RATIONALE

This study relates to the researcher in terms of an academic and scholastic career as well as his professional capacity. As a Life Sciences educator, I am well acquainted with the challenges and problems in the current educational system, especially relating to what makes a Life Sciences educator's job difficult in the South African context. The majority of Life Sciences educators who have been asked about this topic have confirmed that evidence of plant blindness is widespread in their classes (although not specifically using the term) and many educators are not afraid to admit that they themselves detest the parts of the curriculum where they are expected to teach about plants. This notion of favouring certain parts of a curriculum has been found all the way down to elementary school level (Luera & Otto, 2005). The current state of plant blindness research seems to be at an exciting turning point in the South African context as it has been established that it is a matter worthy of attention and effort. The next obvious step seems to be to start working on finding feasible ways whereby plant blindness can be addressed in South African schools and universities. One of the fundamental premises for this study is that educators play a crucial role in learner perceptions about plants. It is therefore clear that helping educators to interact more with plants and develop plant appreciation is a logical first step to ultimately formulating a long-term strategy to address plant blindness and banish it from South African schools. One of the main challenges for educators with regards to the types of teaching that such a strategy would necessitate, is a lack of

adequate knowledge about plants and confidence in themselves to teach in ways that foster plant appreciation. I believe that a simple intervention such as what is being proposed in this study, could put a usable tool into educators' hands to assist them in fighting the pandemic of plant blindness in a meaningful and lasting way.

1.4 FOCUS OF THE STUDY

This study focused on Grade 10 and 11 Life Sciences educators, specifically with respect to their teaching of topics relating to botany, as prescribed by the South African Curriculum Assessment Policy Statement (CAPS) (DBE, 2011). According to the South African government web page (http://www.gov.za/), the CAPS document is a policy document for all subjects from Grades 1 to 12 which provides guidance to educators pertaining to teaching and assessment of content. The researcher drew upon the relevant literature to design and develop an intervention with the twofold purpose of informing educators about plant blindness as well as empowering them with a tool and strategy which can be used along with the curriculum content to combat plant blindness and foster a love for plants among their learners (McDonough MacKenzie et al., 2019). Following the development of the intervention, it was assessed by subject experts and experienced Life Sciences educators, after which it was further refined and developed, based on the feedback provided by the reviewers.

1.5 PROBLEM STATEMENT

The importance of the pursuit of motivating learners to really notice plants lies in the fundamental role of plants in the world and implications that plant blindness holds. Plants make up 80% of the planet's biomass and provides many important resources like oxygen, shelter, and food just to name a few (Abrie, 2016; Jose et al., 2019). In addition, plants provide suitable habitats for animals and remove greenhouse gasses such as carbon dioxide from the atmosphere (Kueffer, 2020; Sanders, 2019). In fact, plants are so intertwined with humans' daily lives that many people might not even give them a second glance. Plants are used for practical applications like food, fuel and for fibres to make clothing, but they are also useful in more abstract ways like providing artistic

inspiration, helping to increase mental health, and even treating clinical depression (Hartman et al., 2019; Sanders, 2019).

When all these facts about the usefulness and relevance of plants are taken into account it might seem puzzling why a phenomenon such as plant blindness is so prevalent in this day and age. More than two decades of research into this topic has established quite unequivocally that it is a definite problem with very real ramifications for the future of plant sciences and environmental sciences as a whole (Amprazis & Papadopoulou, 2020). The fact that educational experiences play a crucial role in reinforcing or combatting plant blindness is of particular interest to this study.

Plant blindness among school-going learners, if not properly addressed, has a snowball effect as this negative or apathetic attitude towards plants will be manifested once these learners become professionals, whether in the capacity of educators, lawmakers, scientists, or citizens in any other area of employment (Krishnan et al., 2019; Krosnick et al., 2018). Lawmakers who undervalue plants are one of the key reasons why legislation and state funding heavily favours conservation efforts focused on animals rather than plants, although research clearly shows that plant species are becoming extinct at a more alarming rate than birds, mammals and amphibians combined (Balding & Williams, 2016; Briggs, 2019; Marguiles et al., 2019; Sanders, 2019). Such zoochauvinistic perceptions have already started to cause a shortage of botanical experts as fewer undergraduates are interested in studying botanically-focused degrees, which indirectly perpetuates the destruction of natural ecosystems (Drea, 2011; Fančovičová & Prokop, 2011; Sanders et al., 2017).

The abundance of research on plant blindness and its related topics has established that this phenomenon rises and falls on the types of interactions humans have early on in life with plants as well as the quality of these interactions (Hartman et al., 2019; Wandersee & Schussler, 2001). The relevant literature unfortunately paints a bleak picture about the presence of plant blindness in a variety of social and educational spheres.

An idealistic state of affairs with regards to Life Sciences classrooms involve educators who are passionate and excited about plant sciences, aware of plant blindness as a real problem needing to be addressed and proactively working to increase plant appreciation amongst the learners in their classes (Abrie, 2016; Abell, 2007, Coetzer, 2019; Frisch et al., 2010).

The unfortunate reality of what transpires in classrooms worldwide is that the majority of both educators and learners unknowingly suffer from plant blindness or plant neglect (Abrie, 2015; Hershey, 2002; Jose et al., 2019; Krosnick et al., 2018). As a result of ignorance on the part of educators, teaching that relates to plant sciences is often characterised by poor pedagogy and uninteresting, ineffective teaching strategies (Coetzer, 2019; Krosnick et al., 2018; Lombaard, 2015). Based on a previous exploratory study, the researcher concluded that some educators are completely oblivious to the concept of plant blindness and the knowledge that it can be successfully combatted and therefore they do not intentionally work to alleviate the problem (Coetzer, 2019). The tiny minority of educators who are informed and working toward combatting plant blindness have cited considerable struggles pertaining to a lack of resources which are relevant to their context and geographic location, as well as a lack of self-confidence with regards to facilitating hands-on learning (Brewer, 2002).

Multiple role players in tertiary education have reported on the drastic decline in the number of students who have enrolled in botany-focused courses at tertiary level during the last decade (Boa, 2016; Drea, 2011). This decline in interest to study botany is, however, not limited to tertiary education as Prokop, Prokop, & Tunnicliffe (2007) discovered. They reported a definite decline in school-going learners' interest in botany as they progress into increasingly higher levels in the educational system. Abrie (2016) has further noted that botany is underrepresented in the South African curriculum as well as in many of the textbooks used to teach content. These findings are concurrent with what Honey (1987) found in the international context. Many other areas, such as environmental conservation and policies surrounding the care and protection of plants on a global scale are disadvantaged by this phenomenon because learners are generally

illiterate with regards to botany and therefore vastly undervalue plants (Prokop & Fančovičová, 2019).

There have been multiple international endeavours among the scientific community to find ways to combat plant blindness by cultivating a love for plants and empowering educators to teach in such a way that learners are eager to learn about plant sciences and genuinely interested in botany as a subject (Brewer, 2002; Fančovičová & Prokop, 2011; Frisch et al., 2010; Lindemann-Matthies, 2006; Wandersee & Schussler, 1999). Such attempts, specifically relating to plant blindness, seem to be lacking in the South African context which results in many Life Sciences educators either being unaware of the concept of plant blindness altogether or generally apathetic about it and therefore showing little or no effort to cultivate a love of plants (Coetzer, 2019). This state of affairs is quite unfortunate as much effort has gone into developing strategies and approaches for educators to combat plant blindness (Bermudez, Díaz, & De Longhi, 2018; Brewer, 2002; Fančovičová & Prokop, 2011; Frisch et al., 2010; Howes, Lim, & Solomon, 2007; Krosnick et al., 2018; Pany et al., 2019).

Prokop and Fančovičová (2019) have however, noted in a recent study that there are real challenges with regards to implementation of strategies to combat plant blindness. Some of these challenges cited by educators include lack of information, difficulty to find time to ascertain the necessary resources and the paucity of resources which are relevant to their specific locale and contexts (Prokop & Fančovičová, 2019). The development of such a location- and context-specific intervention for Life Sciences educators, designed with the challenges of the South African educational system in mind, is therefore the logical next step in fighting the infamous battle against plant blindness. Such an intervention would need to address the lack of knowledge and misconceptions with regards to plant blindness and simultaneously empower educators to start teaching in a way that their learners will once again develop a love for plants and plant sciences.

1.6 PURPOSE OF THE STUDY

The purpose of this study was centred around the development of an intervention which aimed to inform Life Sciences educators about the important theory relating to plant blindness and to give them tools and guidance relevant to their specific contexts. The intervention was based on the use of an existing mobile application to facilitate increased interaction with plants and provide users with relevant information. Once the intervention was developed, it was tested by experts to determine its effectiveness prior to it being administered. The intervention aimed to cultivate plant appreciation amongst the participating educators and increase their confidence to adapt their teaching such that plant love and appreciation would be promoted, and plant blindness would be diminished amongst their learners. Therefore, the aim of this project was to establish whether such an intervention could influence the plant blindness and confidence of Grade 10 and 11 Life Sciences educators in the South African educational context. The educators who took part in this study were teaching in the Gauteng province in a variety of schools.

1.7 RESEARCH QUESTIONS

The primary research question developed for this study was:

What is the influence of an intervention on the plant appreciation in subsequent teaching of Grade 10 and 11 Life Sciences educators?

Secondary research questions were formulated to support the main research question:

1. How much plant appreciation do educators show before they participate in an intervention aimed at improving plant appreciation?
2. How do educators utilise a designed intervention in their daily teaching to promote plant appreciation?
3. How does an intervention influence the confidence that Life Sciences educators have and the knowledge base that they use when teaching toward fostering plant appreciation?

1.8 CONCEPT CLARIFICATION

To contextualise this study, it is important to give meaning and understanding to certain terms used within this study.

Plant blindness refers to an inability to see or notice the plants in one's own environment, leading to a neglect and underappreciation of plants in general (Allen, 2003; Jose et al., 2019; Wandersee & Schussler, 1999).

Visual perception limitation: Wandersee & Schussler (2001), drawing on research done by Nørretranders (1998) about human visual processing, developed this term to refer to an apparent inability of humans to process visual information regarding plants. This phenomenon was proposed by Wandersee & Schussler (2001) as a possible reason for the prevalence of plant blindness.

Plant mentors are individuals who act as facilitators of learning in the context of botany education and can be a role fulfilled by an educator, parent or peer (Allen, 2003; Wandersee & Schussler, 1999).

Biophilia is a concept developed by Wilson (1984) to refer to the inherent attraction felt by humans towards nature (Flannery, 2019)

Zoochauvinism is a term proposed by the pioneering researchers of plant blindness to refer to a pervasive perception that plants are inferior to animals (Hershey, 1996).

Zoocentrism also refers to a perceptual problem with regards to plants which often manifests in humans with preference being given to animals while pushing plants to the periphery (Balding & Williams, 2016).

1.9 WORKING ASSUMPTIONS

For the purpose of this specific study, the researcher assumed certain constructs based on an extensive review of the relevant literature and personal experience. It was assumed that plant blindness is a real phenomenon and would be found to be present among the

participants of this study. Although some educators might have exhibited strong plant appreciation, this study presupposed them to be a minority and that educators were generally unaware of the idea of plant blindness, its implications, and the ways in which it could be combatted. This assumption was based on a previous study done by the researcher (Coetzer, 2019). Linking closely to the latter idea is the presupposition that educators are doing very little or nothing at all to combat plant blindness as a result of their ignorance or the lack of the appropriate resources. The researcher further presumed that the positive results which have been produced by interventions in other countries that used technology and exposure to nature as a means to increase interest in plants, might be reproduced in the South African context. Although very few studies have focused on Life Sciences educators in South Africa, some assumptions that were made for this study was informed by the three most relevant studies in this regard (Goodwin, 2008; Hersey, 2002; Lombaard, 2015). The two assumptions that were drawn from these studies include the notion that educators have an influence on the attitudes of learners and that learners can also influence the attitudes of their educators.

1.10 OUTLINE OF THE DISSERTATION

Chapter 1 provided an overview of the study in which the main themes in plant blindness research and its role in the South African landscape as well as globally were briefly summarised. In addition, the purpose of the study as well as the research questions, assumptions, and the rationale for the study were laid out.

Chapter 2 presents an exploration of the background of the genesis of plant blindness research and aims to show how it relates to pedagogy. In this chapter, an effort is made to show the links between educators' personal backgrounds and their own attitudes towards plants in light of the tremendous responsibility they have to teach plant sciences effectively. Subsequently, a case is made for the ways that educators could be supported in their efforts by drawing on research about mobile learning and interventions to increase plant appreciation.

Chapter 3 is where the methodological assumptions that undergirds this study are discussed. This is followed by a detailed description of the research design used for this research project as well as the approach to data collection, documentation, and analysis. This is followed by discussions about the ways in which rigor was pursued throughout this study and the ethical considerations which guided the planning and decisions made during the research process.

In **Chapter 4**, the data, collected during this study, were analysed, and interpreted by considering this study's theoretical framework. To provide an understanding of the influence that an intervention could have on Life Sciences educators, data were collected in five different ways throughout this study. Themes that emerged during the coding of the data are described at the start of the chapter to give the reader a broad perspective of the different aspects of perception and experience of educators that was inquired into with the various data collection events. Because data collection took place at strategic points during the participants' involvement in the intervention, it was deemed most appropriate to present the results from that data in the same order that it was collected. The data analysis was therefore organised and presented under the headings of the respective data sources in sequential order.

In **Chapter 5,** the key findings of this research process in relation to the three secondary research questions of this study are presented and how the findings relate to local and international literature regarding plant blindness in education is discussed. Each of the secondary research questions considered a different aspect of the main research question to enable the findings of this study to give a well-informed description concerning the influence of an intervention on the plant appreciation of Life Sciences educators. The findings and conclusions presented in this chapter are therefore organised according to these three secondary research questions. During the data analysis, a new theme emerged which pertains to the main research question, although it does not speak directly to any of the secondary research questions. It is rather, a collectivised viewpoint which allowed the conclusions from the various research questions to be consolidated into a concise description of the effects of the intervention on the participants' plant

appreciation. This new theme was used to design a framework which could be used to understand the interaction between educator and learner as well as the influence that an intervention could have on those interactions.

Chapter 6 is the concluding chapter of this dissertation and presents a summary of the key findings of this study in relation to the research questions and the main contributions to the field of Life Sciences education. The chapter concludes with a discussion of the limitations of this study and a brief description of recommendations for future research in Life Sciences education.

1.11 CONCLUSION

In Chapter 1, the background of the research in the realm of plant sciences education was delineated and I proposed that one of the problems is that, although much research has been done about pedagogy and plant blindness, educators are not receiving enough support to enable them to join the efforts to encourage plant appreciation in their teaching (evidence for this claim is provided in the literature review and later sections of this dissertation). In order to address the research problem, previous research about interventions based on teaching botany was drawn on and it was proposed that it could be applied directly to the educators as compared to most studies who focus primarily on learners. The rationale of the study focused on the implications that this research could have on the developing field of plant blindness research in education as pertaining to educators and the challenges they face when being required to teach plant sciences. Chapter 1 ended off with an explanation of the key terms which were used in this study.

CHAPTER 2: LITERATURE REVIEW

2.1 CHAPTER OVERVIEW

The notion that humans seem to be significantly more interested in animals compared to plants has been a subject of research since the early 1980s. Four decades later, it is still inspiring new ways of looking at education relating to plant sciences to prevent it from fading into the proverbial background amidst a generation of technology-obsessed, anthropocentric school-goers (Abrie, 2015; Baird, Lazarowitz, & Allman, 1984; Pany, 2014; Uno, 1994; Wandersee, 1986; Wandersee & Schussler, 1999, 2001). James Wandersee pioneered the concept of plant blindness by drawing on his own research as well as that of many key role players in research regarding science education. He defined it broadly as “the inability to see or notice the plants in one’s own environment” and the “the inability to recognize the importance of plants in the biosphere and in human affairs” (Wandersee & Schussler, 1999. p. 82). The fact that plant blindness is a real and pervasive problem that necessitates serious intervention, is unanimously accepted among the academic community as its effects have been seen and confirmed in a multiplicity of research fields (Abrie, 2016; Balding & Williams, 2016; Hershey, 2002; Jose et al., 2019; Prokop et al., 2007).

In recent years, the trend among research relating to plant blindness has taken a slight turn with a change of focus from working to combat plant blindness to rather attempting to induce plant love in learners and educators alike. This new perspective has been aptly described by Balding and Williams (2016), as flora appreciation. McDonough MacKenzie et al. (2019) further developed the idea and proposed the use of a term antithetical to plant blindness like plant love as the new focus of research. Multiple scholars have joined this new movement along with Sanders (2019) and rediscovered part of the work done by Wandersee & Schussler (2001) about the use of unusual plants to attract people’s attention back to plants.

Both Sanders (2019) and Flannery (2019) refer to biophilia as a concept guiding their research. Flannery (2019) investigated the disinterest among her students by giving them a drawing assignment requiring them to simply draw a tree and later choose one tree to focus on for a semester to increase their visual literacy with regards to plants. A similar approach was taken by Krosnick et al. (2018) who used 'pet plants' to encourage personal engagement with plants and Pany et al. (2019) who found that the incorporation of useful plants into teaching can significantly increase plant visibility. Hartman et al. (2019) spearheaded one of the first projects that integrated the use of a mobile application into plant blindness research. Their study found that a treasure-hunt mobile application can successfully link botany lessons with the real world of plants as all student participants reported that the intervention helped them significantly to relate to the lecture content in a meaningful way (Hartman et al., 2019).

2.2 EXPLICATIONS ON PLANT BLINDNESS, ITS ROOTS AND IMPLICATIONS

2.2.1 Visual perception limitation

Our eyes and our ability to observe the world around us is one of the most underappreciated of our five natural senses, although without it, much of the beauty and wonder of life would be missed. The general idea of visual perception limitation is aptly summarised by the famed William Shakespeare in one of his early plays:

> Good Lord Boyet, my beauty, though but mean,
> Needs not the painted flourish of your praise:
> Beauty is bought by judgement of the eye,
> Not utter'd by base sale of chapmen's tongues.
> *- Love's Labours Lost, William Shakespeare Act 2 scene 1-*

A more modern way of articulating this idea is often phrased as "beauty is in the eye of the beholder" and, although it has become a bit of a cliché, it hints to a reality of human biology and the limits that are inherent in the way that our visual processing systems function (Marijan, 2017).

When one starts to enquire into the ideas that led Wandersee & Schussler (2001) to suggest a term such as plant blindness, it is quite useful to consider what is meant by visual perception limitation and how it impacts on the way that humans perceive plants. Nørretanders (1998) made a brilliant case for such a limitation while writing about the proverbial bandwidth of consciousness. He refers to the fact that, although millions of information bits enter our eyes every second, our brains are merely able to process around 40 bits per second through conscious processes (Nørretanders, 1998). It is quite startling to contemplate the fact that humans are only able to really 'see' a fraction of all that is around them. This assertion consequently raises an obvious follow-up question of what determines that our brains focus on one fraction of data and not another. One of the most prominent theories is that our brain acts like a filter which uses goals, experiences, and potential biological relevance to determine what its limited processing power should focus on (Cohen, Dennett, & Kanwisher, 2016; Jose et al., 2019). In simpler terms, one could say that at any given moment humans unconsciously see objects based on what is beneficial or useful to them and are effectively momentarily blind to everything else which their brain essentially disregards (Cohen et al., 2016; DelSesto, 2020; James, 1899; Jose et al., 2019).

In their research, Cohen et al. (2016) proposed two distinct types of perceptual blindness: change blindness and inattentional blindness. Change blindness broadly refers to an individual's inability to detect differences between multiple scenes or pictures, especially when they remain mostly the same with minor changes (Cohen et al., 2016). Inattentional blindness is defined as a difficulty in recognising otherwise reasonable stimuli because of attention being directed elsewhere (Cohen et al., 2016). The most well-known practical example of this phenomenon of perceptual blindness is an experiment in which researchers told participants to count the number of times a group of people passed a basketball around. Because the participants' attention was focused on counting the number of ball passes, they did not even notice a person wearing a gorilla suit casually walking around right in front of them (Simons & Chabris, 1999). This effect was later replicated by a research team that asked 24 radiologists to look at a computerised

tomography (CT) scan of a person's lungs (Drew, Võ, & Wolfe, 2013). The researchers inserted a picture of a gorilla in several of the slides and remarkably, 20 of the 24 radiologists did not notice the gorilla at all. This is especially telling as these individuals are experienced in finding small details and peculiarities when looking at images of lungs.

Research regarding plants and people's perceptions about them has since enquired into this peculiarity of perception to find that which Wandersee & Schussler (1999) referred to as plant blindness, is concurrent with that which is reflected in the psychological literature. One of the questions that carried the most interest was related to the agency behind our brain's decision to specifically focus on certain things. DelSesto (2020) is an example of a researcher who used the lens of visual perceptual limitation more implicitly to explore people and their interactions with plants and answer that very question. By drawing on previous research done by James (1899), DelSesto suggests that the feelings a person harbour towards an object or being has a strong influence on whether they will place their attention on it or not. The implication is that whatever a person feels is worth their time, money, or attention (that is, they have a positive perception about it) is what they will choose to spend their limited cognitive resources on (DelSesto, 2020; James, 1899).

The challenging aspect of plants is that it is quite easy for plants to be overlooked by humans as they generally do not pose any immediate threat and in the 21st century, they are often not as eye-catching as the computers, cell phones and television screens that compete for our attention. Some of these challenges with regards to the way plants look, have been discussed in light of the presence of plant blindness becoming a nearly unanimously-accepted fact in most countries where it has been studied. Lampert et al. (2019) alluded to the difficulty of edge detection, referring to the challenge of discerning where the boundaries of objects (such as plants), begin and end. This is especially relevant when plants are not busy flowering or producing fruit, causing them to be perceived as unremarkable and unworthy of much attention. This visual chromatic homogeneity, which Wandersee & Schussler (1999, 2001) also hinted at, is one of the strongest arguments why people seem not to notice plants at all and merely treat them as a green background behind whatever else seems more interesting and worthy of

attention (Knapp, 2019). There is however hope for plants, as Marguiles (2019) pointed out, that although quite probable, plant blindness is not necessarily an unavoidable fact of life, but rather symptomatic of a certain historical and socio-cultural trajectory of the modern age which can be addressed quite effectively. Some authors have aptly stated that humans do not merely suffer from plant blindness but rather something like everything-but-vertebrate blindness in many cases (Knapp, 2019). There is however much consensus that although research about people's interaction with plants is not an end in itself, it is an excellent place to start the process of addressing plant blindness (Amprazis & Papadopoulou, 2020; Knapp, 2019).

2.2.2 Relationship between life concept and motion

Drawing on what is known about the influence of the feelings and perceptions people harbour towards the world around them, it is useful to contemplate its relevance to the learning process. One of the pioneering educational psychologists of modern times, Jean Piaget (1973) was the first to propose that there is an important connection between motion and children's conception of something being alive. Later studies that inquired into this connection confirmed this proposition and labelled this conceptualisation as people's life concept regarding an object or being (Yorek et al., 2009). The general idea of this proposition was that objects or beings that displayed some apparent form of movement had a good chance of being regarded as alive, as opposed to objects which do not move or move too slowly to be easily perceived (Bardel, 1997). This notion was subsequently confirmed by various studies such as that of Dolgin & Behrend (1984) who found the same strong connection between people's life concept and motion even to the extent that non-living objects were sometimes perceived as living by their participants because of their perceived movement. Analogously, Wandersee (1986) and Kinchin (1999) recognised the same trend in their research among various age groups. Both researchers reported that the most common reason cited by participants for being interested in animals rather than plants was the perceived movement of animals and the presumed lack thereof in plants.

A more recent study that investigated the characteristics which educators and ninth grade learners consider when classifying living organisms and attributing value to them, found strong evidence of zoocentrism and even anthropocentrism from their surveys and interviews (Yorek et al., 2009). They found that life concept was most commonly ascribed to humans, dogs and birds among a large number of other options (Yorek et al., 2009). These findings were also congruent with the findings of Lindemann-Matthies (2005) who reported that pet animals were most frequently appreciated and perceived as living compared to plants which were often not even regarded as alive. Research probing into the South African context found similar misguided perceptions among foundation phase learners with regards to plants. Naude (2015) reported that the learners who participated in his study generally thought of seeds, flowers, plants and trees as non-living objects.

A contention which rises to the surface as one contemplates the results of the abovementioned studies, is the fact that we know scientifically and practically that plants do in fact move much more than most people give them credit for. Everyone who has placed a house plant close to a window and paid the slightest attention to it would have observed phototropism in action as the plant bends and grows (moves) itself closer to the light source. Sanders (2019) also refers to the *Mimosa* plant which is capable of closing its leaves quite rapidly as a response to physical stimuli. The biggest challenge with plants, however, is that their movement and rate of change seems slow compared to humans and animals and for the most part they will look approximately the same tomorrow as they did today (Sanders, 2019). It is interesting to note that although plants might seem to move very slowly, the movements are actually quite complex and sometimes merely invisible to the human eye because it happens too fast (Guo et al., 2015). A remarkable example of this is the flower stamens of the Bunchberry dogwood (*Cornus canadensis*). This plant is able to catapult pollen into the air by opening its flower in less than 0.5 milliseconds (Edwards, Whitaker, Klionsky, & Laskowski, 2005). Nonetheless, the lack of obvious changes in visual cues and movement in addition to their slow life cycles, is what creates the perception that plants are not truly alive and worth considering (Jose et al., 2019; Wandersee & Schussler, 1999, 2001).

The important aspect with regards to how people perceive plants is the amount of meaningful interaction they have with plants. If people started interacting closely with plants on a more frequent and prolonged basis, they would easily be able to recognise the wondrously vibrant lives that characterises plants and appreciate their complexity. There is a clear trend which has been observed during the review of the literature on this topic, being that the majority of studies found people to perceive animals or even humans as more alive than plants. The essence of this trend is that there is always a strong correlation between the amount of interaction participants have with a subject and how alive they perceive a subject to be. This would, at least partly, explain why Lindemann-Matthies (2005) found that participants saw their pets (with whom they probably had ample interaction) as more alive and interesting that plants. The same trend is to be observed in the study done by Yorek et al. (2009), as all the subjects which were commonly cited as being alive, were those with which the participants would most likely have had a decent amount of interaction, such as dogs, cats, birds and humans. There is therefore strong incentive for interventions that aim to address this dilemma of disinterest in plants by means of increasing the amount of meaningful interaction people have with plants (Flannery, 2019).

2.2.3 Roots of plant blindness in humans and educators in particular

There has been much discussion about plant blindness as it relates to the general public, but for the purpose of this study it is more relevant to explore the roots and implications of plant blindness in respect of education and especially the educators who drive the process of learning. A disproportionally large amount of the available literature gives insight into the sphere of undergraduate students and their lecturers as well as preservice educators. Research that inquires specifically into the realities of secondary school educators is still quite sparse, which is one of the reasons why this study can be profitable, especially in the South African context. It is, however, useful to consider some of the research regarding the various other educational spheres as it still provides a good overview of some of the major challenges and trends regarding plant blindness.

Whether it is specifically plant blindness or a combination of zoochauvinism and anthropocentrism, there is clearly a disparity between the way students view plants compared to animals (Hartman et al., 2019). Bebbington (2005) reported that 86 percent of A-level biology students were incapable of naming more than three common wildflowers (Hartman et al., 2019). Undergraduate students have also been found to be able to recall images of animals much better than that of plants after being shown a montage of pictures, even after they had completed a course in Botany (Hartman et al., 2019). In addition to the apparent plant blindness, multiple scholars have also noted the stark decline in the study of botany at undergraduate level as well as a serious decline in the status of botany as a worthy field of study for undergraduates (Drea, 2011; Stagg, Wahlberg, Laczik, & Huddleston, 2009). Hartman et al. (2019) also reported this lack of interest in studying plants amongst undergraduates which has resulted in many tertiary institutions drastically decreasing the number of botany courses they offer to students or merging it with other courses that teach plant sciences as something that can merely be glanced over. A clear example can be seen amongst tertiary institutions in the United Kingdom (UK) in which only 23 institutions offered plant-related programmes compared to 86 institutions offering zoology-based degrees for the 2018 academic year (Hartman et al., 2019). Moreover, the effects of plant illiteracy can even be seen at high academic levels. Jose et al. (2019) interestingly relates an anecdote of a biomedical student in their senior year being totally amazed after watching a video of a *Mimosa* plant moving as a response to a stimulus and exclaiming: “It’s alive!” while watching the video. Such responses beg the question on what went wrong in the educational career of such an individual with regards to the teaching of plant sciences.

Symptoms of plant blindness and plant illiteracy have historically been blamed on zoocentric teaching and zoochauvinistic perceptions which are harboured by educators and unintentionally being transferred to the learners whom they teach (Knapp, 2019). The unfortunate reality is that, in the absence of some intentional intervention or revelation, educators will invariably teach in the way that they were taught (Luera & Otto, 2005). Even before the dawn of the 21st century, researchers have noted that many educators

tend to spend most of their time teaching about animals and genetics and then rush through the plant-related content which they are required to teach (Fisher, 2001; Hersey, 1993, 1996). Pany et al. (2019) noted that this propensity to neglect plants has persisted over two decades into the 21st century with educators disproportionately referring to zoological examples even when new concepts relating to genetics and microbiology need to be explained.

There is consensus about the notion that there is a very strong interrelationship between educator attitudes towards, and interest in plant sciences and the way they approach the subject (Kim, Kim, & Kim, 2018). After conducting research among preservice educators, Kim et al. (2018) once again confirmed what Hersey (1996) suggested about the critical role educators play in influencing their students' attitudes towards plants. The reason for this is twofold. Firstly, because of the important mentoring role of educators, their students are naturally inclined to pick up on any negative or positive attitudes they have toward certain topics. Secondly, research suggests that whatever attitudes educators harbour about a topic such as plants or environmental education, will influence their teaching practice (Kim et al., 2018). This idea is in keeping with that of Hidi, Renninger, & Krapp (2004) who proposed that individuals are inclined to have a positive attitude towards and greater knowledge about subjects which they themselves find to be interesting.

Although educational contexts differ tremendously, the common denominator among educators who actually do have a keen interest in plants is that the vast majority of them report having meaningful experiences and interactions with plants at some point while they were growing up. Notable examples that have been reported by various researchers include growing up on a farm, being involved with a vegetable garden or having strong mentors that taught them about plants (Coetzer, 2019; Kim et al., 2018). The results from a recent study which focused on educators and their bent towards environmental education confirmed the influence of the factors discussed in this section quite well. The study found that educators with the most pro-environmental inclinations were also incidentally those who reported having the most significant and frequent interactions with the natural environment (Kim et al., 2018). It is noteworthy that although the

aforementioned study focused on environmental education, there is good reason to assume that its premise also holds true for plant studies.

2.2.4 Curriculum Assessment Policy Statement (CAPS)

The CAPS document, otherwise known as the Curriculum Assessment Policy Statement, is the official policy document of South Africa, which outlines general and specific aims and requirements of teaching. In addition, it also specifies the content that needs to be taught for each subject from Grades 1 to 12 (UMALUSI, 2014). The CAPS document can be simply defined as a performance-based, syllabus type curriculum. As this study centres around the teaching of plant sciences (as part of Life Sciences in the context of South Africa), it is useful to briefly consider the requirements of the CAPS document and the research surrounding it. One of the general aims (1.3 a) which can be found in the CAPS document states the following:

> The National Curriculum Statement Grades R-12 gives expression to the knowledge, skills, and values worth learning in South African schools. This curriculum aims to ensure that children acquire and supply knowledge and skills in ways that are meaningful to their own lives. In this regard, the **curriculum promotes knowledge in local contexts**, while being sensitive to global imperatives (DBE, 2011, p. 4) [emphasis added].

Another useful general aim to consider with regards to the way that learning is expected to take place is numbered 1.3 C and reads as follows:

> The National Curriculum Statement Grades R-12 is based on the following principles […] Active and critical learning**: encouraging an active** and critical approach to **learning**, rather than rote and uncritical learning of given truths […]. (DBE, 2011, p. 4) [emphasis added].

From these two quotes, it should be clear that the policy expects educators to teach in ways that are relevant to their local contexts and to encourage active learning. This shows that there is still an underlying expectation that educators should use their own initiative to create meaningful opportunities for learning, based on constructivist theory.

Careful study of the CAPS document specifically for Life Sciences has shed some light on the state of plant topics among the rest of the Life Sciences curricula (Abrie, 2016). The general conclusions based on the document is that, although all the important learning areas are covered, plant sciences have the lowest prominence in the curriculum compared to the rest of the topics. The trend which was observed starting at Foundation Phase and moving up to the Further Education and Training (FET) phase is that there is a strong zoocentric tone to be found throughout (Abrie, 2016). The reason why this is problematic is that this document forms the bedrock of what is supposed to be taught in South African schools, and therefore any form of plant neglect and zoochauvinism will filter down to influence the pedagogy of educators. Tunnicliffe & Ueckert (2011) explain that it is vital that educators are intentional about drawing attention to plants as plants cannot draw attention to themselves in the same ways that animals often do.

This suggests that learners need to be assisted to look meaningfully at plants through the pedagogy of their educators. What it comes down to is that unfortunately, the burden is placed on the shoulders of educators to swim against the proverbial stream of zoocentrism which abounds in textbooks as well as the curriculum policy, to give plants their due place as equally important compared to zoological and anthropological topics in Life Sciences (Abrie, 2016; Lombaard; 2015; Schussler, Link-Pérez, Weber, & Dollo, 2010; Vujaković, 2019). From these considerations it should become reasonably clear why there is a dire need for interventions aimed at informing, encouraging and empowering educators to be able to fulfil the difficult task that is set before them.

2.3 PLANT BLINDNESS AS IT RELATES TO PEDAGOGY

2.3.1 Pedagogical content knowledge and constructivism

The term pedagogy has its origin in the French and Latin language where it was broadly used to refer to the oversight of a child as well as the idea of someone leading a child to school so that they can learn (Mortimore, 1999). This is in essence what it means to be an educator. One of the most influential researchers of the 20th century in the area of pedagogy was Lee Shulman, who initiated a field of study which was aimed at describing

the way in which educators navigate the spheres of pedagogy and subject content knowledge to ensure effective learning can take place (Shulman, 1986). The term for this field of study is pedagogical content knowledge (PCK) and it relates closely to the various teaching practices that might be used by educators to teach content, like using analogies or illustration to enable learners to understand taught content (Garbett, 2011; Shulman, 1986). Later elaborations on the practical aspects of PCK resulted in the formation of a new concept termed topic specific pedagogical content knowledge (TSPCK) which has been studied quite extensively internationally and to a somewhat lesser degree in the South African context (Coetzee, 2019, Lombaard, 2015; Rollnick & Mavhunga, 2013).

The reason why TSPCK is a useful lens for considering teaching practices is that it is concrete and necessitates thinking about the challenges and pitfalls which typify a specific subject (Lombaard, 2015). In Life Sciences, for example, implicit in the expectation of teaching the content in the syllabus, is the requirement for educators to know names of animals and plants and to be able to facilitate explorations of the natural environment as well as the organisms it houses. Unfortunately, these are skills and expertise that cannot easily be mastered without being in the context of actual teaching practice. The sad reality of the educational milieu is that too often the onus is on educators to develop and grow their pedagogical practices and research suggests that their own interests, fears and insecurities will most likely cause them to lean towards certain ways of teaching and to place emphasis on what they find fascinating (Deci, 1992; Kim et al*.,* 2018).

Another important topic which needs to be considered when contemplating pedagogy, especially in the scientific subjects, is the theory of teaching and learning known as constructivism. Fundamentally, it refers to a learner-centred pedagogy which requires educators to act as facilitators of learning by orchestrating contexts in which learners are able to learn through active engagement and exploration of subject content (Luera & Otto, 2005). In accordance with this view of constructivist education, Olsen (1999) cites three fundamental roles that educators are required to fulfil to adhere to its principles. Firstly, educators are expected to create motivating conditions for student learning. The second role is that of taking responsibility for creating problem situations which encourage critical

thinking and engagement with subject content. Lastly, and probably most importantly, educators are called on to focus on cultivating a process of engagement and learning and not merely on generating a product of learning (Olsen, 1999). What is therefore essentially advocated for is a teaching model which is in some ways the polar opposite of the traditional transmission model of teaching through lecturing or chalk-and-talk teaching. Rather, the proponents of the constructivist mode of learning endorse active, experiential learning through hands-on experience (Luera & Otto, 2005; Olsen, 1999).

The educational community were swift to realise the value of constructivist teaching, although researchers and pedagogical experts are still wrestling with the challenge of incorporating constructivist learning techniques into pedagogy at grassroots level (Richardson, 1997). Overall, the research suggests that, when experiential learning takes place, it provides for deeper and more meaningful learning experiences than the traditional ways of teaching and learning. Luera and Otto (2005) were able to demonstrate through their research that social constructivist teaching methods lead to superlative increases in content knowledge among preservice educators.

More recently, Hartman et al. (2019) showed that active learning techniques can be used to engineer learning experiences that can be linked to theoretical material from normal lectures to result in heightened learning experiences that were deeper and more enjoyable for university students.

The task of implementing constructivist teaching into daily teaching has however left many educators at their wit's end. This is because, although it is a good idea on paper, this type of learning is very challenging and time consuming to implement in classrooms amid all the other challenges educators must face. This quote by Richardson (1997) quite aptly summarises one of the core problems with the implementation of constructivist pedagogy:

> *We have a tendency to attempt to work out the complexities of our theories in the hallowed halls of academia and academic conferences. And then, quite cavalierly, we turn it over to the practitioners to work out the practices.*

> *'Here's a neat idea', we say 'it's called constructivist teaching. You should be doing it in your classrooms.' We don't mention the theoretical disagreements, nor do we admit that turning a theory of learning into a theory of teaching is an inexact process at best* (Richardson, 1997, p. 12).

There is much truth to this statement and now, more than ever, educators need to be guided and assisted to find ways to put theory into practice on a regular basis in their teaching.

2.3.2 Relationship between plant blindness and pedagogy

The realisation that plant blindness and its related issues are deeply connected with pedagogical practices is both unnerving and encouraging at the same time. This is because these revelations allow researchers and pedagogical experts to generate new solutions through which plant blindness can be addressed more effectively.

The main problems with regards to pedagogy have been described quite aptly by scholars who have written about this very subject quite recently. Lima (2020) suggests that the two phenomena, which go hand-in-hand with plant blindness, are extinction of experiences (with plants) and nature-deficit childhoods (as a result of industrialisation and urbanisation). In accordance with these suggestions, she cites various examples of endeavours (in addition to her own) which has been previously undertaken to engage young people with nature in both cognitive and physical ways through experiential learning (Lima, 2020; O'Brien & Weldon, 2007). Maura Flannery, writing about her own teaching experience in addition to her own research, suggested that biology blindness is a learned behaviour and explained that many students trained themselves to ignore all things related to plants because of many unpleasant educational experiences with plant sciences (Flannery, 2019). Sanders (2019) mentioned the intriguing idea that humans live quite asynchronously with plants and do not have patience or interest to linger with them long enough to see them as beautiful and fascinating. It is therefore quite obvious that educators have a pivotal role to play (as they are so well situated in society to address plant blindness) and that the most promising way in which this should be done is by facilitating meaningful people-plant interactions.

DelSesto (2020) looked at such people-plant interactions and the ways in which it can be brought about. One of the general findings of his research was that there is a plethora of ways for people to interact with plants, but that certain types of interactions are better suited for certain contexts than others. Examples of such interactions include sensory engagement with plant environments, walking through plant-filled environments, sorting and examining plant material and various forms of gardening (including planting, weeding, and harvesting) (DelSesto, 2020; Haller, Kennedy, & Capra, 2019). In keeping with the idea of meaningful interactions, Pany et al. (2019) was able to positively influence student attention through inquiry-based learning which involved interactions with plants and Krosnick et al. (2018) found that their 'pet plant project' (which required students to grow a plant from seed) resulted in increased awareness and appreciation of plants among their 209 student participants.

2.4 ADDRESSING THE APPARENT PROBLEM

2.4.1 Ways to combat plant blindness

Although a brief survey of the relevant literature about plant blindness might paint a grim picture about the status quo, especially in the context of plant sciences education, there are good reasons to be optimistic about the future. This is because, since the challenge of plant blindness was first identified, it has received a reasonable amount of attention among academia who have launched interventions of various kinds to address it. Among the many different endeavours, most fall into one of three categories namely, outdoor/nature-based activities, indoor/non-nature-based activities and conceptual activities requiring some form of thinking about plants.

The activities that prompt some form of thinking and relating to plants have been employed by various researchers who have identified lack of plant appreciation in their spheres of influence. An example of such an effort is the 'plant love stories' initiated by McDonough MacKenzie et al. (2019) in the days leading up to a Valentine's Day. They encouraged people to share stories that are dear to them which involve plants in some way, whether it is happy, sad or something in between. Stagg & Verde (2019)

spearheaded a more extensive project along a similar line when they launched an educational theatre production with the goal of improving learners' knowledge and attitudes towards plants. The production was called *'Story of a Seed'* and took the form of interactive theatre with professional actors acting out a story which chronicles the various phases of plant reproduction. Researchers were intentional in ensuring that the actors facilitate frequent participation from the learners in the audience, which is in accordance with what is known about the usefulness of active participation in the learning process (Stagg & Verde, 2019). The results of the project were very promising with significant improvements observed from Likert-scale measurements regarding learners' overall attitudes about plants.

Regarding activities that were not necessarily based in nature or the outdoors, it has also been shown that creative ways of incorporating aspects of participants' daily lives, can be quite effective in addressing negative attitudes and encouraging meaningful learning about plants. One such creative initiative was piloted by Moscoe & Hanes (2019) who hosted a series of events on a university campus that used food as a means to combat plant blindness. The events, aptly named *'Taste for Life'*, consisted of a brief presentation about plants and phylogenetic relationships after which participants were served a five-course meal highlighting major plant life lineages. In addition to the meal, participants received conversation starter cards which were meant to spark discussion about interesting facts regarding plants and their unmistakable importance. Their exit surveys showed that participant attitudes towards plants were significantly impacted while many students noted that they truly enjoyed the activities and felt empowered to take action about the current issues facing plants.

Turning to the classroom environment, Pany & Heidinger (2015) designed an intervention to combat plant blindness among learners ranging between Grades 5 and 12 by facilitating active learning and physical interaction with plants. Their utilisation of useful plants proved to trigger increased interest in certain useful plants and counteract plant blindness among the participants. Although some critics contest the use of plants that are merely labelled as useful to humans to combat plant blindness (warning of the possibility

of falling into a utilitarian trap), it is still worth considering for the design of future interventions with similar goals (Knapp, 2019).

The last general category of interventions aimed at addressing plant blindness are those that take place outdoors and immerse participants in nature. Although there are many examples of such interventions, those that make use of mobile technology, and the idea of treasure-hunts are most relevant to this study. Kissi and Dreesman (2018) led one of the first projects that combined these two ideas to develop a treasure hunt-like quiz which made use of mobile devices to encourage learner interaction with plants. Although, the timeframe for the intervention was quite limited, they found that the activities increased environmental awareness and increased the enjoyment factor of the learning process. Shortly thereafter, Hartman et al. (2019) created a similar intervention, but this time it was aimed at university students with equally positive results. As this study draws on their findings and suggestions, some of the important particulars are discussed briefly in a later section.

2.5 INTERVENTIONS

2.5.1 Technology use and mobile learning

The generation of student educators and school-going learners who are currently moving through the educational system (or have done so recently) are known as Generation Z. They are the first truly digital and globalised generation and the majority of these individuals have never experienced a world without the presence of computers and cell phones (Robertson, 2009). The spread and availability of technology has increased to such an extent that individuals who are part of Gen Z, have seen it being integrated into many spheres of their lives (Roberton, 2009). The unfortunate reality in much of the educational arena is that it has not followed suit with the integration which has been happening in all walks of life. While mobile devices and their accompanying applications have become the norm in terms of communication and acquiring information, many educators still rather opt for the traditional way of teaching which is similar to what they experienced when they attended school. This is not surprising, as Luera and Otto (2005)

have previously pointed out, because without the necessary guidance and motivation, educators will invariably be inclined to teaching methods similar to the ways they themselves were taught. As we find ourselves more than two decades into the 21st century, there should be no doubt about the necessity of incorporating technology into teaching and learning (Shen, Wang, & Pan, 2008).

Various authors have written extensively about the proliferation of mobile technology and how its near universality has already started to impact the way in which educators teach content and facilitate learning experiences (Chiu, Pu, Kao, Wu, & Huang, 2018; Gan, Li, & Liu, 2017; Hartman et al., 2019). Research into the field of mobile learning looks very promising, with reports of it being used to supplement and enhance traditional learning (Ng'ambi & Lombe, 2012) and some countries like Taiwan have made mobile learning one of their main foci with regards to the design of teaching and learning (Chiu et al., 2018). A generally accepted definition of mobile learning is a form of student learning which is done via some form of wireless communication device (Ng'ambi & Lombe, 2012). This is a category in which a large portion of mobile technologies fall, including smartphones, electronic tablets/ iPads as well as laptop computers (Gan et al., 2017)

Considering what is known about the potential benefits of mobile learning, it is encouraging to find that many studies report such learning to be advantageous to the teaching and learning process. One of the most cited conclusions among various studies is that mobile learning is able to increase student motivation to learn and elevate their engagement in learning activities (Chiu et al., 2018; Kukulska-Hulme, Sharples, Milrad, Arnedillo-Sánchez, & Vavoula, 2009; Zydney & Warner, 2016). These studies confirm the claims made by Zelezny (1999), who found in a study about mobile learning that games and simulation increased the interest of students when learning about plants and improved their understanding of the topics covered. Another interesting advantage of mobile learning is that learning is not bound to a classroom setting and can take place at any time or place. The usefulness of this characteristic has been noted by multiple scholars who suggest that this makes such learning ideal for studying plants in their natural environment, as opposed to merely looking at examples in a classroom (Chiu et

al., 2018; Hartman et al., 2019). This is especially good for teaching plant sciences as learners could potentially have the freedom to explore an ecosystem and see plants in their natural context.

Some studies have, however, not drawn such favourable conclusions. The contention which is raised most often relates to the claims of mobile learning being superior to traditional ways of learning. Schmitz, Klemke, & Specht (2012) reported a lack of compelling evidence that mobile games improved learning outcomes and Cheung & Hew (2009) found no clear difference in student test scores for a study that compared learning with a mobile device compared to paper-and-pencil approaches. These studies are sobering and point to the fact that much work still needs to be done to improve mobile learning. Nonetheless, the mere fact that these learning strategies have such a positive effect on student engagement and motivation to learn, is enough reason for educators to seriously consider incorporating mobile learning into their daily teaching.

Another interesting factor which might shed some light on the lack of positive evidence found in some studies is the idea of Task Technology Fit (TTF), which could have a significant impact on learner attitudes toward mobile learning technology (Gan et al., 2017; Goodhue & Thompson, 1995). From the perspective of TTF, students will only feel motivated to use mobile technology if the characteristics of a certain type of technology fits in with the characteristics of a given task which they must complete (Goodhue & Thompson, 1995). It is for this very reason that this study settled on the idea of using a mobile application which enables educators and learners to actively engage with plants as they learn about their habitat, morphology, and role in their ecosystems. Although the idea of a treasure hunt is used for this study, the applications of this mobile application and ways in which it can be used to teach plant sciences are manifold.

2.5.2 Justification for doing a treasure hunt with mobile application

As a response to the proliferation of technology and the favourable results which have been achieved during outdoor-based active learning initiatives, scholars have attempted to integrate these two ideas into interventions to address the plant blindness problem

(Hartman et al., 2019; Kissi & Dreesman, 2018). Kissi & Dreesman (2018) based their project on the assertion that some form of empathetic linkage is necessary to combat plant blindness, and that physical interaction is a good way to provide the means for the formation of such links. The conclusion from their study was that, although they did not cure plant blindness, the data shows a significant increase in environmental awareness (including plants) as well as an increase in the students' understanding of systematics. A useful consideration with regards to studies such as theirs is that research has shown that long-term interventions are more effective at improving attitudes toward plants (Dillon et al., 2006).

These two contentions could be interpreted such that it would make a lot of sense to enable educators to facilitate such interventions throughout the year as part of their daily teaching which means that the benefits could be greater as a result. Shortly after Kissi & Dreesman's study, Hartman et al., (2019) used a similar approach to attempt to increase awareness and appreciation of plants. Their findings were congruent with Kissi & Dreesman's study, and they found that many learners reported being able to link their lecture content with the real world of plants more effectively (Hartman et al., 2019). A survey of the literature showed that no study has inquired into the implications of such an intervention in the context of Life Sciences in the South African context. In addition, the majority of studies on this topic involves researchers leading an intervention for learners but neglect making intentional efforts to guide educators on how to facilitate similar activities in their daily teaching.

2.6 CONCLUSION

In this chapter, the general background of the locus of research was laid out to which this study aims to contribute. The historical underpinnings of constructivist teaching methods were summarised, and a case was made for the necessity of active learning to become integral to the way that educators teach about plants. This chapter explored the main problems that educators face with regards to teaching about plants as well as the ways in which similar problems have been proved to be addressed effectively in other contexts.

The various intervention efforts that have been launched in this field of research and their general results were expounded and pointed to the fact that educators have been neglected as crucial role players in such interventions. The chapter ended with justifications from the literature for an intervention which is aimed at assisting educators to feel empowered to teach about plants in engaging and meaningful ways with the assistance of mobile technology.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 CHAPTER OVERVIEW

In Chapter 2, the theoretical landscape of research pertaining to Life Sciences education with specific reference to Botany teaching and plant blindness was discussed. The ideas which were discussed therein formed the foundation on which the conceptualisation of this study was predicated. The purpose of Chapter 3 is to show how the methodological decisions made for this study aligns with its research questions and the general purpose, as stated in Chapter 1. This chapter begins by presenting the theoretical framework for this study and justifying the paradigmatic perspectives adopted for the research process. This includes discussions about the methodology, research design and a general overview of the format which the research project adhered to. The rest of the chapter is devoted to explaining the sampling of participants, data collection and documentation as well as the ways in which the various forms of data was analysed and interpreted. Finally, the chapter concludes by expounding on the research rigour measures that were employed during this study and the ethical guidelines followed during the research.

3.2 THEORETICAL FRAMEWORK

The plethora of research about plant blindness has unequivocally shown that it is a phenomenon which is systemic in schools among educators and learners alike (Stagg, Dillon, & Lindsay, 2020). Previous research into the presence of plant blindness in the South African context has found it to be just as pervasive as is reported in the international literature (Coetzer, 2019; Lombaard, 2015). Over recent years, a necessary shift in focus has taken place which directed the attention of researchers away from looking for plant blindness in schools, to finding ways to address it in meaningful and lasting ways (Brewer, 2002; Frisch et al., 2010; Goodwin, 2008; Lindemann-Matthies, 2006; Wandersee & Schussler, 1999). Many of these ventures have addressed plant blindness quite successfully and found that an outside intervention could encourage positive perceptions

of learners and even educators towards plants in the classroom (Hartman et al., 2019; Stagg et al., 2020).

One of the main concerns identified with regards to the trajectory that such efforts to address plant blindness is taking, is the fact that the majority of the studies place a disproportionate amount of focus on learners and neglect to consider the role of educators as part of the solution. The reality is that researchers cannot indefinitely sustain the interventions which have been found to be useful in addressing plant blindness in learners. If there is to be any lasting influence on learners and their plant blindness, their educators must be on board with the process and adapt the way they teach to foster plant appreciation among their learners. Since the initial conceptualisation of plant blindness, Wandersee & Schussler (2001) have emphasised the important role that an educator can fulfil as a plant mentor. Simply put, a plant mentor is an individual who acts as a facilitator of learning about plants in addition to inspiring interest among learners. Research has shown that educators have a strong influence on their learners through their teaching methods and the way they portray certain sections in a curriculum (Wubbels & Brekelmans, 2005). It is therefore crucial that efforts to combat plant blindness in learners include a determined focus on assisting educators to become capable plant mentors and develop the desire to fulfil that role in the first place.

It is based on this reasoning that this study undertook to develop an intervention which is aimed at guiding educators to realise how they might be perpetuating plant blindness in their teaching and help them see areas in their own perception which tends toward plant blindness, zoocentrism or anthropocentrism. In addition, this study endeavoured to introduce educators to a mobile application which could serve as a tool to assist them in the process of becoming an effective plant mentor. The intervention, which was implemented during this study, consisted of two phases. The first phase consisted of a workshop which intended to inform participants and guide them on how to use the proposed tool practically. The workshop started with an information session about plant blindness followed by a practical session for participants to apply new knowledge and skills by using the Pl@ntNet mobile application.

The information session was aimed at informing participants about the concept of plant blindness, and to give them a simple opportunity to see whether they too have tendencies of such a lack of awareness and appreciation for plants. Hereafter they were informed about the reasons plant blindness poses a serious threat to Life Sciences education as well as environmental conservation efforts. This information is important for educators to realise the necessity of being intentional about addressing plant blindness in their own classrooms. Following the information session, the participants were introduced to the Pl@ntNet mobile application and guided on how to use it to instantly identify plants in their surroundings and access additional information about it through the application itself.

The decision to make use of a mobile application during this intervention was strategic as it follows the findings of the large amount of research which has been conducted with reference to the use of mobile technology in teaching scenarios. The international literature presents a compelling case for the use of mobile technology as a learning aid and most studies found the use of mobile technology to lead to increased interest and involvement of learners during teaching and learning (Chiu et al., 2018; Kissi & Dreesmann, 2018; Shen et al., 2008). In practice, educators know this too, as they constantly observe the way that their learners seem to be obsessed with their mobile devices (Bureau of Market Research, 2015). The utility of this approach lies in the fact that the workshop could assist in increasing educators' initial knowledge and skills, and the use of the mobile application in their own contexts can continue to expand their knowledge about the plants in their school environment.

Brewer (2002) found that the lack of appropriate skills and knowledge to identify and acquire information about their environments was one of the major barriers preventing educators from using the plants and organisms in their surroundings as part of their teaching. She suggested that new resources be developed which could assist educators in this regard. Since Brewer's research was conducted, the focus has shifted away from written exercises to incorporate various forms of technology which provides access to information via the internet.

One of the aims of the workshop designed for this study was to guide the participants in the use of the mobile application to such an extent that they would feel confident using it in their own classrooms. The added benefit of the use of a mobile application is that it gives educators the opportunity to acquire information about plants around them, which could cause them to be perceived as knowledgeable by their learners. This could positively impact the educators' self-confidence when teaching about plants.

Plant appreciation is a concept with refers to the physical awareness of plants as well as an appreciation of the novelty and significance of plants. This intervention endeavoured to increase the plant appreciation of the participants of this study through the workshop and their implementation of the knowledge and skills learnt therein during the subsequent reflective phase.

Figure 3.1 shows the chosen conceptual framework for this study which is based on a framework that Lombaard (2015) adapted from Magnusson, Krajcik, & Borko (1999) and Rollnick, Benett, Rhemtula, Dharsey & Ndlovo (2008).

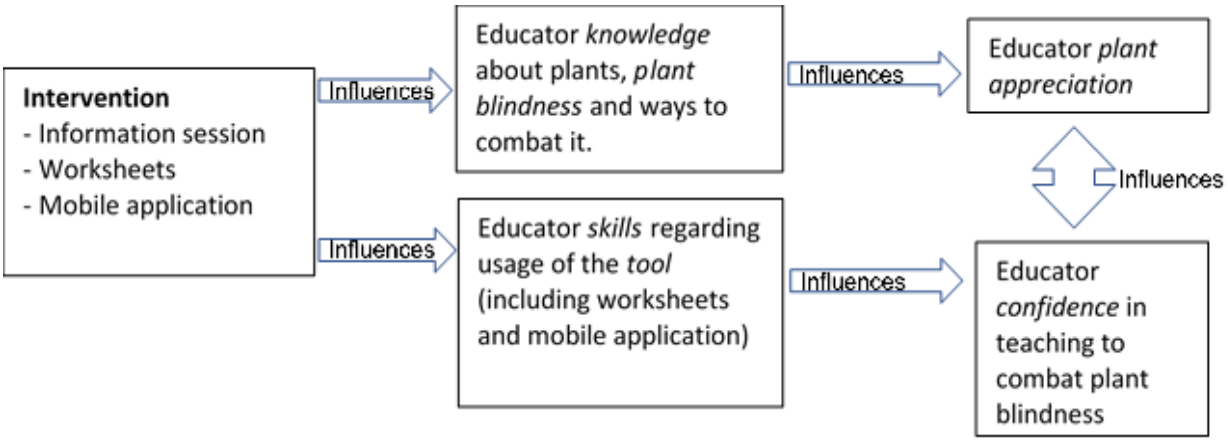

Figure 3.1: Conceptual framework adapted from Lombaard (2015)

This framework was adapted specifically to depict the relationship between the planned intervention and the resulting plant appreciation and confidence of the participant educators. This framework suggests that an intervention, such as the one designed for this study, could potentially influence the knowledge of participants regarding plant

blindness and the ways that it can be addressed as well as their skills regarding ways that a mobile application can be used to facilitate meaningful interactions with plants. As participants start to implement these skills and knowledge in their own context, it would plausibly have an influence on their consequent plant appreciation as they themselves become more aware of plants. Furthermore, their ability to apply what they have learnt in their teaching could also influence their confidence as well. The purpose of the intervention was therefore to inform Life Sciences educators about plant blindness, increase their plant appreciation and develop their confidence in teaching towards addressing plant blindness in their own students and growing a culture of plant love in their respective classrooms. With this purpose in mind, the intent of this study was therefore to determine the influence of such an intervention on the confidence and plant appreciation of participating educators.

3.3 PARADIGMATIC APPROACH

For the purpose of this study, the interpretivist paradigm was presupposed and used as the lens through which its findings were ultimately explicated. This paradigm is appropriate for qualitative studies as it places a strong emphasis on the relationship between the researcher and the research participants to gain deep and meaningful understanding of phenomena in various contexts. In alignment with interpretivism, this study incorporated a relativist ontology to interpret the various forms of data that were aggregated (Sefotho & Du Plessis, 2018). The general premise of this ontology is that reality is understood as multiple mental constructions which are socially and experientially based and therefore dependant on the individuals that hold the constructions (Guba & Lincoln, 1994). According to this view, interpretations derived from data are merely more or less informed, as opposed to them being either true or false. This is because the degree to which a phenomenon can be understood is assumed to be contingent on the scope of information the researcher is able to acquire about research participants (Guba & Lincoln, 1994; Sefotho & Du Plessis, 2018).

The concept of epistemology refers to the way in which a person can acquire knowledge about reality (Nieuwenhuis, 2016a). In keeping with the relativistic ontology, this study used a subjectivist epistemology to understand how knowledge is generated and should be interpreted. The general assumptions are that reality is subjective and that truth and meaning is socio-culturally constructed by individuals, thus resulting in multiple co-existing realities rather than a single objective actuality (Guba & Lincoln, 1994; Sefotho & Du Plessis, 2018).

The paradigmatic perspectives that are discussed above are advantageous for research based on people's experiences because they allow researchers to prompt participants about unobservable phenomena to gain contextually relevant insight. The interpretivist paradigm was deemed suitable for this study as it required the researcher to draw on the views and experiences of individual educators and experts as the main sources of data.

The researcher is cognisant of the challenges regarding the chosen paradigm and was intentional about addressing them throughout the study. Although this paradigm is subjective, the researcher was intentional about preventing bias from influencing the study and utilised multiple modes of collecting data to allow for crystallisation as an effort to increase the trustworthiness of the study (Nieuwenhuis, 2016b). The multiple types of data that were collected at strategic points throughout the intervention further allowed for triangulation of findings between all those data sources. The lack of generalisability with this paradigm is not viewed as a disadvantage as such in this study, as the goal was merely to explore the effects of an intervention on participants.

3.4 METHODOLOGICAL APPROACH

This study approached the research process qualitatively, because its aim was to inquire into individual and collective experiences of multiple educators. The use of this approach allowed for the generation of data which is context-specific and rich in meaning regarding the involvement of the participants and the influence of the intervention (Nieuwenhuis, 2016a). The qualitative approach is commonly used in research which necessitates meaning-based data generation in natural settings (Nieuwenhuis, 2016a). One of its

advantages is that it allows for holistic understanding of experiences by yielding rich data and interpretations which are thick in meaning (Rahman, 2017). Furthermore, this approach is flexible and allows for the research design to be reconstructed as new revelations make adaptations necessary (Maxwell, 2012).

The limitations of the qualitative approach are based mainly on the lack of generalisability of research findings to other contexts, especially because of the small sample sizes for which the qualitative approach is known. This, however, does not invalidate the research conducted in this study as the goal was merely to explore the usefulness of an intervention which was developed during the study. Data generated during qualitative research may sometimes be time consuming and tedious to analyse, which is why the study incorporated various methods of data collection which are easier to decode in conjunction with traditionally-used methods such as interviews.

3.5 RESEARCH DESIGN

In keeping with the methodological approach, this study employed a multiple case study design, as its objective was to acquire in-depth understanding of the experiences and perceptions of various educators in their everyday contexts (Bromley, 1990; Nieuwenhuis, 2016b, Schneider, 1999). An important advantage is that this design allows the researcher to interact closely with the participants to yield data that is rich in meaning (Nieuwenhuis, 2016b). The researcher was cognisant of this design's susceptibility to evolve into a study which would be too broad and unfocused and therefore the cases were clearly demarcated at the onset of the study (Nieuwenhuis, 2016b).

This study involved a multiple case study of five different cases followed for a period of time (7 February until 26 May 2021) to explore the influence that the intervention had on each case or participant educator. The decision to conduct a multiple case study, rather than a single case study was informed by the knowledge that consideration of multiple cases regarding the same phenomenon could contribute to the rigor of this study. According to Schneider (1999), the two most important advantages of multiple case study design are the possibility it creates for cross-case comparisons as well as the ability to

make observations that are more generalisable. Although generalisability was not the express purpose of this study, it was useful to be able to note patterns of behaviours and perceptions across multiple cases as this could provide some intimation of the true state of affairs regarding Life Sciences educators.

Cases, as defined in this study, encompassed the various participating educators in their individual contexts and all the factors which influence their respective abilities and levels of confidence. Each educator along with their experiences at the school they teach as well as in their personal lives with respects to the implementation of the intervention, is considered as a single case. The fact that multiple cases are considered in this study with differing contexts and experiences, adds to the richness of the data collected during this study.

It is useful, at this point, to take note of the general context in which the participants of this study were situated. This is discussed at length in the next chapter and therefore some general descriptions are provided. The educators who participated in this study are all secondary school Life Sciences educators and teach learners ranging from Grades 8 to 12. They have varying amounts of experience in secondary school teaching and followed different academic paths to become qualified as practicing educators. These educators also have their own unique backgrounds in terms of upbringing and the experiences to which they were exposed in addition to the perceptions they might have adopted from their own Life Sciences educators. Furthermore, these educators find themselves in schools with varying amounts of resources like plants on school grounds and access to wireless internet. There is a lot that is dissimilar about the educators who took part in this study, some of which is discussed in Chapter 4 of this dissertation.

Something that all the participants do, however, have in common is that they are all confronted with the mammoth task of translating an imperfect curriculum and assessment document into meaningful learning during their lessons. This is in addition to the many challenges that are inherent to the South African school context. Research has confirmed that plant blindness is an ever-present challenge among many educators and learners in

South Africa, and it is in this context where these educators must take up the challenge of teaching plant sciences in engaging and exciting ways (Coetzer, 2019; Lombaard, 2015).

3.6 SELECTION OF PARTICIPANTS

The choice of sampling which was utilised during this study was guided by the case study research design, as suggested by Lopez & Whitehead (2013) and therefore it employed non-probability sampling comprising of purposive, convenience and snowball sampling. Purposive and convenience sampling are often used simultaneously during studies which require the sourcing of participants with specific credentials relevant to a project's research questions (Acharya, Prakash, Saxena, & Nigam, 2013).

The convenience sampling of this study involved the researcher selecting educators who were conveniently available in terms of time, access and willingness to take part in this study (Lopez & Whitehead, 2013). This is the most inexpensive and quickest way to assemble a sample, although it might result in a quite homogenous sample frame and data which cannot realistically be extrapolated to a much broader population (Valerio et al., 2016). The researcher was, however, intentional about finding educators who resemble an array of differing contexts and backgrounds.

The purposive sampling, used in conjunction with convenience sampling, allowed the researcher to select a sample comprising individuals with credentials which allowed them to contribute to answering the research questions of this study. The sampling process therefore focused on experienced Life Sciences educators who are teaching concepts relating to Botany in their classrooms. The specificity of the variables which were used to select participants was aimed at contributing to the rigor of the study, although it was quite time consuming to find appropriate participants (Valerio et al., 2016). Therefore, purposive and convenience sampling were used synchronously.

The challenge of identifying educators who possess the required characteristics was addressed by using snowball sampling. This type of sampling is often used to find

participants who fit the sample description, and are otherwise hard to reach, by relying on the relationships and social networks of the initially sourced participants (Valerio et al., 2016). The personal referral system, on which snowball sampling relies, gives credibility to the study, although it might discourage participants to share freely during data collection (Valerio et al., 2016). This concern was addressed by emphasising the confidentiality with which the data collection and documentation was done to participants throughout the research process.

Although some critics of these three sampling methods point to the lack of generalisability of results to the broader population, this was not a concern for the proposed study as the goal was merely to explore the effects of an intervention, as shown in Figure 3.1 (Lopez & Whitehead, 2013; Valerio et al., 2016).

This study was conducted during the Covid-19 pandemic, which had a considerable influence on the sampling of participants. Because of the restrictions that were placed on schools, the number of participants who were able and willing to participate in this study was less than originally planned. Five participants agreed to participate in this study, and they all decided to continue with the second (implementation) phase of the intervention once they had attended the workshop. It should however be noted that, although, the sample size is quite small, this was compensated for by collecting a large amount of detailed, rich data throughout the entirety of the intervention. This allowed for a more comprehensive understanding of the influence that the intervention had on each of these participants. The purpose of this study was not to achieve generalisability to a larger population, but rather to determine whether it is worthwhile to pursue an intervention such as the one used in this study on a wider scale. This is because this intervention was probably the first of its kind in the South African Life Sciences education context.

3.7 THE INTERVENTION AND WHAT IT ENTAILED

An intervention was designed at the onset of this study with the aim of addressing plant blindness in participant educators by increasing their plant appreciation and assisting them in addressing it in their own classrooms. By definition, an intervention refers to the

action of interfering with an outcome or course of a condition or process as to prevent harm or improve functioning (Merriam-Webster, n.d.). For the purpose of this study, the intervention was designed to address plant blindness and foster plant appreciation by impeding the cycle of plant neglect between educators and learners in the South African classroom. The intervention, therefore, refers to the entirety of the process that guided participants through a workshop and then encouraged them to implement what they had learnt in their own context over the course of four to five weeks.

Before starting the intervention, the participant educators were required to complete an open-ended online questionnaire which served as a baseline of their perceptions and confidence prior to the intervention and provided some initial insight into each participants' context. Another reason for this preliminary questionnaire was to allow the researcher to compare the initial data of each participant with the data that was collected subsequent to the workshop and implementation phase of the study. The intervention which formed the bedrock of this study involved a workshop which informed educators about plant blindness, after which they were guided on using the PI@ntNet mobile application to increase their confidence about involving plants in their daily teaching (*cf.* Appendices A & B). The implementation of the workshop in the participants' classrooms was recorded through a reflective diary which was completed weekly by participants. A final reflection of each participants' experiences and the influence of the intervention was acquired by means of an open ended semi-structured telephonic interview with each of the educators who participated in this study.

3.7.1 Open-ended online questionnaire

The purpose of this questionnaire was to provide insight into each participant educator regarding their background, current context, and general perceptions regarding plants. The three secondary research questions and the various themes they represent were considered to ensure that there were multiple questions probing into each theme. The themes that were addressed in the questionnaire were: (a) participant background and context in which they teach; (b) their perception about plants and teaching botany; (c) the

perceptions of their learners regarding plants, based on their own experience; (d) the amount of confidence they have with regards to teaching about plants. The questionnaire questions were submitted for scrutiny and feedback from experts in research practice and adapted based on feedback to increase its validity. The answers to the questionnaire questions provided a snapshot of the condition of each participant prior to the interventions, thereby allowing for comparisons with their conditions and perceptions subsequent to the intervention.

3.7.2 The workshop

The workshop took place on 18 February 2021 after school hours and was attended by all the participants simultaneously. The location for the workshop was a school in Pretoria which has a large variety of plants on its premises and the presentation was held inside a classroom which had access to a data projector to show the presentation to participants. The workshop began with a brief introduction by the researcher, which was promptly followed by a presentation which lasted less than 15 minutes. One of the first goals of the intervention was to introduce participants to the idea of plant blindness in an interactive way. This was done by showing participants a picture which contained equal numbers of images depicting plants and animals and asking them what they see (*cf.* Appendix C). The inspiration for this idea originated from research conducted by Schussler & Olzak (2008) as well as Balas & Momsen (2014) and this study assumed that some of the participating educators would react in a similar manner to what these previous studies had found. Both previous studies found a definite bias leaning towards animals in terms of what the participants observed first when they were shown images of animals and plants. After allowing the participants to respond, the researcher pointed out that the image contained both plants and animals. The purpose of this exercise was to allow the participants to realise that they too, possibly have a certain amount of plant blindness that influences the way they perceive the world.

This activity was then followed by a short presentation which informed participants about plant blindness, its influence on the educational system, as well as the ways that it could

have a detrimental effect on future generations (*cf.* Appendix D). In addition to this, the presentation also made reference to various examples of ways in which plant blindness have been successfully addressed in the local and international context. The participants were then introduced to the Pl@ntNet mobile application, which is freely downloadable on both Apple and Android applications stores. This mobile application makes use of a cellular phone's camera to take pictures of plants and identify them by comparing the pictures to an online database which is peer reviewed. In addition to providing the user with the scientific and common name, images can also be viewed of various parts of the plant's morphology. The application also provides the user with a link to a Wikipedia page where additional information about the specific plant can be found.

After introducing the participants to the Pl@ntNet application as a tool which can be used while teaching botany, the participants were given instructions on how to download the application on their own cellular phones and create a profile. The instructional page also contained a step-by-step guide on how to use the application to identify a plant and access all the possible information (*cf.* Appendix E). The venue for the workshop contained a variety of plants which were used to allow participants to practise using the application themselves and collaborate with the other participants. Once all the participants were well acquainted with using the application, they were provided with worksheets and a map of different parts of the school grounds which detailed a treasure hunt that had been worked out beforehand by the researcher. The participants were divided into groups and tasked with using the maps and clues on their worksheets to find different plants on the school grounds (*cf.* Appendix B). Once they had successfully found the plants, they were required to identify them with the Pl@ntNet application and answer questions which required them to use the information provided through the application's online database and the Wikipedia link. Twenty minutes were allocated for this activity.

After completion of the treasure hunt, participants returned to the venue for a brief discussion about their experiences and to discuss the answers they had found. They were then prompted to reflect on their experiences of engaging in the activities, considering the

ways that such a mobile application could be used in their own classrooms to enrich their teaching and help them as educators while teaching about plants.

3.7.3 Implementation and reflection

This phase lasted a total of five weeks in which participants were encouraged to attempt to implement the knowledge and skills which they had acquired during the workshop in their own contexts. The researcher had minimal contact with the participants during this time and only saw or spoke to each participant once for a semi-structured interview at the beginning of this phase. The participants were given templates for a weekly diary which they were asked to complete weekly to reflect on ways that they might have implemented what they learnt during the workshop in some way. The purpose of the diary was to ensure that participants remained cognisant of the intervention and to act as an incentive to apply what was learnt.

3.8 DATA COLLECTION AND DOCUMENTATION

Data were collected in various forms at different times during the research project (as shown in Table 3.1) to ensure that all the stated research questions could be answered adequately. The data collection events are organised in five distinct phases which took place at different times during this study.

3.8.1 Phase 1: Exploration of general context and background of participants

The first phase of data collection was in the form of a structured open-ended questionnaire (*cf.* Appendix F). The goal was to explore the attitudes and perceptions of a group of participant educators toward plants and how confident they are about teaching topics relating to plants. It should be noted that this leg of data collection was fundamentally exploratory in nature and was used by the researcher to establish key themes relating to the theoretical framework and research questions. These themes were subsequently probed into during the following phases of data collection. This questionnaire was administered via email through the Qualtrics surveying software prior

to the intervention and consisted of open-ended questions. Open-ended questions in a questionnaire allow for the collection of honest, detailed answers to complex questions in which the thinking processes of the respondents are revealed (Lopez & Whitehead, 2013; Maree & Pietersen, 2016). The possible challenge posed by the coding of such open-ended questions was addressed by making use of the Atlas.ti coding software to assist in the thematic coding of the collected data (Maree & Pietersen, 2016).

3.8.2 Phase 2: Plant appreciation intervention

Phase two started with the commencement of the workshop during which the researcher collected field notes of the interactions with the participants and the ways that they responded to various parts of the workshop. After the workshop, all the participants were asked to write a short reflection about their perceptions regarding its utility (*cf.* Appendix G).

3.8.3 Phase 3: Post hoc interview

After the workshop, a post hoc interview was conducted with each participant to further probe into the effects of the intervention. The purpose of these interviews was to determine what the participants had learnt during the workshop, whether they thought it could be useful in their respective school contexts and which challenges they foresaw regarding the implementation of their new skills and knowledge (*cf.* Appendix H). These interviews were open-ended and semi-structured to allow the researcher the opportunity to probe into lines of reasoning which could provide rich understanding of the educators and their perceptions regarding the teaching of botany (Nieuwenhuis, 2016b). The semi-structured interview was characterised by a conversational tone and involved specific open-ended questions asked by the researcher which were sometimes followed by subsequent probing questions to gain a holistic understanding (Nieuwenhuis, 2016b). Such a holistic understanding of the educators' confidence and perceptions was necessary prior to the implementation of their newfound knowledge to allow for a comparison when subsequent data were collected about their experiences in applying what they took from the intervention.

3.8.4 Phase 4: Implementation of intervention

The fourth phase of data collection consisted of a weekly reflective diary and photographic evidence about each participant's experience throughout the project. The weekly diary contained open-ended guiding questions which the participants were asked to complete at the end of each week for a period of seven weeks. The questions were meant to guide the educators to reflect on the implementation of knowledge and skills relating to the intervention in which they participated (*cf.* Appendix I). The educators were asked to take screenshots of the Pl@ntNet application when it was used to supplement teaching and present photographic evidence if they noted instances in which they implemented knowledge from the workshop into their teaching (*cf.* Appendix J). Qualitative research diaries have been widely used to gain rich understanding about phenomena because it facilitates the process of reflection and growth of individuals because of its use (Hyers, 2018; Radcliffe, 2013).

3.8.5 Phase 5: Final feedback from participants

Lastly, participant educators were asked to give a final reflection about their experiences relating to the implementation of the intervention and their confidence in teaching Botany (*cf.* Appendix K). In addition to their experiences, educators were asked to reflect on any challenges they had encountered during the implementation phase and possible solutions to these challenges which might be meaningful. Participants were given the choice of answering the reflection questions in writing or telephonically (which was recorded and transcribed).

Table 3.1: Table showing phases of the research process.

Phase 1	**Exploration of general context and background of participants**	
Strategy	Purpose	Time frame: 7 – 14 February 2021
Structured questionnaire (Appendix F)	Establish what perceptions are held by respective participants regarding plants. Establish how confident participants are about teaching plant-related content (inside & outside classroom). Establish participant background and experience as is relevant to the study.	

Phase 2	**Plant appreciation workshop**	
Strategy	Purpose	Time frame: 18 February 2021
Informative presentation	Inform participants of the research about plant blindness (what it means, why it should be important to them as Life Sciences educators and the implications of plant blindness in a general sense).	
Introduction to Pl@ntNet application (Appendix E)	Explain to the participants what the application does and how it could potentially be useful to assist in facilitating meaningful interactions with plants. Tutorial inside classroom where educators received documents with instructions and were guided on how to use the application to scan and identify plants with examples.	
Treasure hunt for plants with the use of Pl@ntNet application and designed worksheet (Appendix A & B)	Show participants how the application works in a practical way with plants on school grounds. Give participants an idea of the ways in which an application such a Pl@ntNet could be used to facilitate learner interaction with plants at their schools through the example of a plant treasure hunt designed by the researcher.	
Post workshop reflection (Appendix G)	Gain feedback on participant experiences during workshop. Gain insight into the ways that participants perceived the intervention to be able to influence and guide the ways they teach about plant related topics. This enabled the researcher to have an initial/ before concept for each participant with which the actual enacted use of the intervention could be compared after the rest of the data was collected.	
Phase 3	**Post hoc interview**	
Strategy	Purpose	Time frame: 1 – 5 March 2021
Semi-structured interview with open ended questions (Appendix H)	Probe deeper into participant context (school environment, access to plants, available resources, and general socio-economic status of learners). Probe deeper into participant background, past experiences with plants (good and bad) – this was informed by information which was provided in the plant perception questionnaire preceding the intervention. Probe into the perceptions of the participants with regards to plants and teaching about plants. Get an idea of the level of confidence that participants have with regards to teaching about plants inside and outside the classroom.	
Phase 4	**Opportunity for participants to implement intervention in their own school context and personal lives**	
Strategy	Purpose	Time frame: 22 February – 7 May 2021

Weekly diary for reflecting about possible implementation of intervention during each week (Appendix I) Duration: 5 weeks	Ensure that educators remain cognisant of the intervention and what they have learnt about its utility. Facilitate the process of reflection to assist participants in thinking about how they were able to adapt their pedagogical approaches because of the intervention or find out what challenges or barriers they faced when trying to do so. Find out how participants utilised the intervention in their own contexts	
Phase 5	**Final feedback from participants about their experiences during Phase 4 and suggestions for possible future interventions**	
Strategy	Purpose	Time frame: 3 – 26 May 2021
Telephonic semi-structured interview (Appendix K)	Find out what participants experienced during the time of reflection and whether they perceived the intervention to be helpful. Establish whether the intervention and implementation process had an influence on the confidence and plant appreciation of participants.	

3.9 DATA ANALYSIS AND DOCUMENTATION

The types of data collected during this study included both written content as well as verbal interaction (Nieuwenhuis, 2016c). Consequently, the data were scrutinised and organised by utilising both content analysis as well as conversational analysis which incorporated codes and themes derived by means of open coding (Nieuwenhuis, 2016c). A locus of *a priori* codes (Table 3.2) was compiled prior to data collection by consulting the relevant literature. This study, however, also made use of emergent coding as new themes and phenomena useful for coding surfaced from the analysis of the initial structured questionnaire and the subsequent interview transcriptions and participant diary analysis.

Nieuwenhuis (2016c) argues that the use of such a directed approach to data analysis allows for knowledge about phenomena to be supported and extended. This strategy therefore fits well with the explorative nature of this study, which is why it was employed. The aforementioned method of coding was used to analyse the initial structured questionnaire as well as the diaries from each of the participants. The interviews were transcribed verbatim by the researcher and analysed like the preceding data sets. Emerging themes were triangulated from all data sources to produce a holistic view of all

the data and intra-coder reliability (stability) was ensured by consistently using the same codes throughout the process of analysis (Nieuwenhuis, 2016c).

Table 3.2: List of a priori codes

A priori list of codes compiled by surveying relevant literature and plant perception questionnaire		
Codes relating to educator confidence	**Codes relating to teaching plant sciences in secondary schools**	**Codes relating to perceptions about plants**
Awareness of resources Confidence in teaching about plants	Challenges and barriers to teaching plant sciences Implications of plant blindness Interactions with plants Outdoor/ experiential learning Relationship between pedagogy and plant blindness Technology & mobile learning	Anthropocentrism Attitudes towards plants Learner plant perception Educator plant perception Zoocentrism/ Zoochauvinism

3.10 QUALITY ASSURANCE

Any study which undertakes to use qualitative data analysis as its main methodology faces the challenge of making a convincing case to the reader that the data and its interpretations are worth considering in the first place. Unlike quantitative data analysis which can employ metrics like reliability and validity to prove its legitimacy, qualitative researchers must make a more intricate case for what is commonly referred to as the trustworthiness or the rigor of a study (Amankwaa, 2016; Connelly, 2016). Although there are still some disagreements about technicalities and semantics, most researchers in the sphere of qualitative research ascribe to the aspects of trustworthiness, as suggested by Guba (1981). The initial list of aspects consisted of credibility, dependability, transferability, and confirmability (Guba, 1981; Lincoln & Guba, 1985). A later revision of these aspects resulted in the addition of a fifth aspect which Lincoln and Guba (1986) referred to as authenticity. In the following section, these five aspects of trustworthiness

are briefly described, after which the ways in which this study endeavoured to establish each of these aspects is explained.

3.10.1 Credibility

Simply put, credibility refers to the assurance that a researcher can provide that the findings of the study are true and in accordance with reality (Connelly, 2016; Guba, 1981; Polit & Beck, 2014). This metric is also meant to give an indication about the degree to which the standard procedures and practices were adhered to as required by the chosen methodology and research design (Connelly, 2016). This study aimed to establish credibility in several ways.

The researcher spent a large amount of time with the data throughout the research process. One of the main reasons is the fact that the researcher transcribed all the interviews by carefully listening to the recordings. The researcher also did a preliminary analysis of the answers the participants gave in the initial open-ended questionnaire. This allowed for identification of areas of interest with regards to each of the participants' context and background which was subsequently probed into during the post-hoc interview. The fact that participants were given the opportunity to respond to and confirm answers which they gave during the initial questionnaire, contributed to the credibility of the collected data (Connelly, 2016; Guba, 1981). This process is also sometimes referred to as member checking (Connelly, 2016). In addition, the researcher was intentional about collecting various forms of data in multiple ways and at different times throughout the study. This multiplicity of data sources allowed the researcher to triangulate the data by drawing on the various sources. Lastly, the fact that data were collected before, during and after the implementation of the intervention made it possible for the researcher to get a holistic view of the influence that the intervention had on the participant educators.

3.10.2 Dependability

A study that is regarded as dependable needs to be planned and executed in such a way that it can be repeated in similar contexts to find results that are analogous to the

replicated study (Connelly, 2016). In this respect it is quite similar to reliability in quantitative research. For the purpose of this study, the researcher kept track of all the important events during the research process and the various decisions that were made along the way to adapt to the challenges and barriers that surfaced. Such a record is sometimes referred to as an audit trail, and it is regarded by many researchers as a good way to demonstrate dependability, as it provides clarification and justification for the way the research process was managed (Lincoln & Guba, 1985; Shenton, 2004).

3.10.3 Transferability

Qualitative research is generally not focused on making interpretations and conclusions which are generalisable to a much broader context, but rather to explore and interpret data for certain cases or contexts (Nieuwenhuis, 2016a). This is because of the underlying interpretivist perspective which asserts that experiences, therefore data, are socially and culturally constructed and distinct from one person or case to another (Sefotho & Du Plessis, 2018). To increase trustworthiness, researchers often undertake to argue that the findings of a study are applicable to other contexts and can be useful to consider in light of other research settings (Shenton, 2004).

The degree to which a study can be considered to be transferable is contingent on the quantity and quality of descriptive information available (Shenton, 2004). Therefore, rich and thick descriptions was provided about as many aspects of the research process as possible. In the following chapter, the profiles of the various participants in this study and their unique contexts are discussed in detail as well as the data collection methods employed and how it was conducted. This would hypothetically allow other researchers to consider samples and methods which are similar to this study based on the provided descriptions and apply some of this study's findings in future research.

3.10.4 Confirmability

A factor that poses a challenge to all research, albeit somewhat less in quantitative data collection, is the bias that researchers might have toward certain outcomes for their

research. The close connection and extended interaction between qualitative researchers and participants in a study, however, makes it even more crucial to consider ways in which research bias can be minimised (Nieuwenhuis, 2016a). Some authors have also referred to confirmability as the neutrality of the researcher during a research project (Guba, 1981). The researcher attempted to maintain such neutrality by keeping an audit trail of all the stages of the research process. This makes it possible to explain and justify the choices made with regards to the collection of data and deviation from what was initially planned when it was necessary.

3.10.5 Authenticity

The idea of the authenticity of a study is a recent addition to the well-established locus of techniques and metrics of quality control in qualitative research (Connelly, 2016). It is a factor which is unique to the domain of qualitative research and especially relevant and necessary in case study research, which is the design of this study. According to Lincoln and Guba (1986), the authenticity of a study refers to the degree to which it can portray a wide variety of contexts and realities and provide insights about the meaning behind phenomena. By communicating these ideas clearly, researchers can increase the insight readers gain into phenomena. This study attempted to do just that by sourcing participants who were diverse in their background, context and personality and providing ample description about these factors to show the individuality and distinctiveness of each participant. This was important for this study as the participant educators are regarded as experts of their respective milieu with valuable insights because of their lived experiences.

3.11 ETHICAL CONSIDERATIONS

This study was intentional about commencing only once ethical clearance was granted by all relevant role players. The University of Pretoria ethics committee was consulted for clearance of the study (clearance number: EDU070/20) and permission was obtained from the Gauteng Department of Education to conduct research in schools (*cf.* Appendices L & M). Letters were sent to the governing bodies and principals of the schools of every participant educator to explain the purpose and process of the proposed

research and to acquire their permission (Maree, 2016) (*cf.* Appendices N & O). Each participant educator received informed consent forms for voluntarily taking part in this study with the freedom to withdraw at any time (*cf.* Appendix P). The process and purpose of the study and its expectations were explained to the participants, and they were assured of complete anonymity and confidentiality (Silverman, 2017). Pseudonyms were used for each participant throughout the study to ensure anonymity. The researcher was careful to adhere to all the stipulated ethical principles of the University of Pretoria and the Gauteng Department of Education regarding research.

3.11.1 The use of the Pl@ntNet mobile application

One of the key aspects of the intervention, which was designed during this study, was the Pl@ntNet mobile application. According to the information on their official website, the service is described as a participatory science project accessible as a mobile application which enables its user to identify plants from photos which are taken by a mobile camera. The mobile application is accessible from the Apple- and Android application stores for free. It also has a web-based version of the service which allows photos to be uploaded and identified. At the time of this study, the Pl@ntNet database had a total of 1794096 images uploaded by contributors and 27909 distinct species which users can identify though the mobile application or their dedicated website (Pl@ntNet, 2021).

Users can upload images of a plant which they want to identify to the mobile application. The application then uses the database of images to make a suggestion about the plant species that matches most closely to the uploaded images. Once the user has identified a plant, they can get access to a large variety of images about various parts of the plant's morphology and common names, and it provides a direct link to a Wikipedia page with additional information about that specific plant species. Once an identification has been made, the images are added to the database and the quality of identification is peer reviewed by contributors. The peer reviewing process allows each identification to be scrutinised by experts and general contributors to ensure its correctness.

The Pl@ntNet administration office was contacted to inform them about the ways that their services were to be used for this study and to obtain permission to use screenshots from the use of their mobile application in this dissertation. The administration responded positively and gave permission to all aspects of use that were requested. Furthermore, they provided information about a beta version of their mobile application which would allow the use of many of its functionalities without a mobile data connection. This would be very useful for future endeavours as access to mobile data was one of the most prominent challenges that were linked to the use of the Pl@ntNet mobile application. A record of the abovementioned correspondence can be found in Appendix Q.

3.12 CONCLUSION

The general purpose of Chapter 3 was to provide a comprehensive description of the research methodology implemented during this study and the paradigm which guided the ways in which the planning and implementation of the research process was approached. The case study research design of this study was discussed and situated this research project in the context of South African Life Sciences classrooms. This was followed by elaborations on the ways participants were selected, the ways in which data were collected and the approach that was used to analyse and interpret the data. This chapter concluded by describing the ways in which quality assurance was considered and the ethical measures that guided the implementation and planning of this study. In the following chapter, the data collected during the different stages of the research process is discussed and how it has bearing on the research questions that the researcher set out to answer as a result of this study.

CHAPTER 4: DATA ANALYSIS AND RESEARCH FINDINGS

4.1 CHAPTER OVERVIEW

The purpose of this chapter was to discuss the data analysis and emerging findings of this study. This discussion starts out with a brief overview of the primary research question and the secondary research questions. These questions guided the data collection process to ensure that a comprehensive answer could be suggested from the data for the main question posed by this study. This is followed by a brief discussion of the conceptual framework which undergirds the data collection and analysis for this study. Hereafter the data collection timeline and approach that was taken for the analysis of the emerging data are described, followed by a summary of the demographics of each of the five educators who participated in this study. Once this background information has been reviewed, the remainder of the chapter is devoted to presenting the various forms of data which was collected during this study and concludes with a brief summary of the general trends which were identified from the entirety of the collected data.

4.2 THE RESEARCH QUESTIONS

The following research questions provided the foundation for data collection and analysis. The secondary research questions assisted the research process by providing a framework for the data collection to ensure that the findings were able to speak to the primary research question.

The primary research question for this study is:

What is the influence of an intervention on the plant appreciation in subsequent teaching of Grade 10 and 11 Life Sciences educators?

The secondary research questions supporting the main research question are:

- How much plant appreciation do educators show before they participate in an intervention aimed at improving plant appreciation?

- How do educators utilise a designed intervention in their daily teaching to promote plant appreciation?
- How does an intervention influence the confidence that Life Sciences educators have and the knowledge base that they use when teaching toward fostering plant appreciation?

4.3 THE CONCEPTUAL FRAMEWORK

The data as presented in this chapter are approached through the lens of the conceptual framework of this study, as delineated in Figure 3.1 in Chapter 3. This framework was adapted from Lombaard (2015) to allow the researcher to propose a model for the relationship between an intervention focused on secondary school educators and their resulting plant appreciation and confidence regarding the teaching of botanically-focused content.

4.4 THE DATA COLLECTION TIMELINE

The collection of data commenced in the second week of February 2021 and continued throughout the first and second quarters of the same year. Table 4.1 provides an overview of the timeline for initiation and completion of the various phases of data collection.

Table 4.1: Data collection timeline

Type of data collected	Period over which data was collected
Plant perception questionnaire	7- 14 February 2021
Post-workshop reflection	18 February 2021
Individual interviews	1 – 5 March 2021
Weekly diaries	22 February to 7 May 2021
Final reflection	3 – 26 May 2021

4.5 THE DATA ANALYSIS APPROACH

Data were collected in the form of written or typed text as well as audio recordings. The interview and post intervention reflection were done in person with some participants and telephonically with others who could not meet in person. Both these data sources were audio recorded and transcribed. The researcher made use of Atlas.ti qualitative data analysis software for content analysis and thematic analysis of the final reflection and interview transcripts as well as the plant perception questionnaire, post workshop reflection and weekly diaries once it was imported into the program. A graphical representation of the relationship between the major codes, sub-themes, themes, and research questions can be found in Appendix R. Alternatively, Table 4.2 shows a more concise representation of these relationships.

Table 4.2: Summary of themes and sub-themes in relation to the research question

Secondary Research question	Theme	Sub-themes
1.What is the influence of an intervention on the plant appreciation in subsequent teaching of grade 10 and 11 Life Sciences educators?	1.1.Appreciation of the novelty and importance of plants	1.1.1.Participant plant perception 1.1.2.Learner plant perception 1.1.3.Influence on plant appreciation 1.1.4.Positive influence
	1.2.Plant awareness	1.2.1.Increased awareness of plants during teaching 1.2.2.Plant blindness in results 1.2.3.Zoochauvinism/ Zoocentrism/ Anthropocentrism
2.How do educators utilise a designed intervention in their daily teaching to promote plant appreciation?	2.1.How participant used knowledge base	2.1.1. Incorporating plants into other topics 2.1.2. Teaching about plant topics 2.1.3 Teaching non-plant topics
	2.2.How participants used Pl@ntNet application	2.2.1. Pl@ntNet application in classroom during teaching 2.2.2. Pl@ntNet application in personal life
	2.3.General application of intervention	2.3.1. Educators addressing plant blindness in learners 2.3.2. Actual intervention Application 2.3.3. Plants as teaching resource
	2.4.Intervention perceptions and suggestions	2.4.1. Initial intervention perception 2.4.2. Final intervention perception 2.4.3. Intervention future use
3.How does an intervention influence the confidence that Life Sciences educators have and the knowledge base that they use when teaching toward fostering plant appreciation?	3.1.Educator knowledge base	3.1.1. Knowledge about plant topics and related challenges 3.1.2. Knowledge about resources
	3.2.Educator confidence	3.2.1. Confidence in teaching plants

Secondary Research question	Theme	Sub-themes
	Additional theme which emerged from data and does not speak specifically to the secondary research questions	
	Positive feedback loop	Learner influence on educator Educator influence on learner Interrupting the feedback loop

4.5.1 Transcribing the interview and post intervention reflection

The initial interview schedule was compiled in English and the researcher endeavoured to keep all communication in English where possible. During the interviewing process, it became clear that although Participants 3, 4, and 5 were able to communicate in English, they were not able to express themselves as well as they are in their mother tongue, which is Afrikaans. The researcher, therefore, used the interview transcript as shown in Appendix H, and translated the questions during the interview so that when the questions were posed to these participants, it was done in Afrikaans. This process was also repeated with the post-intervention reflection, which was done telephonically for all the participants. All the interviews as well as the post-intervention reflections were recorded and transcribed by the researcher. At this stage, it must be stated that the researcher is fully bilingual (English/Afrikaans) and was well-equipped to conduct the interviews in both English and Afrikaans and then translate the Afrikaans interview transcriptions into English.

These transcripts were saved as Microsoft Word documents and imported into the qualitative data analysis software. A set of a priori codes were provided in Chapter 3, and these formed the basis of the initial coding of the data sources. There were however multiple additional codes which emerged from the data as it was analysed and processed, and these were added to the locus of codes which were used to analyse all data that were collected. Guided by the three secondary research questions for this study, these codes were processed to form themes and sub-themes. Each of these themes and sub-themes speak to a specific aspect of the various research questions. All the relevant themes and sub-themes have been summarised and presented in Table 4.2.

4.5.2 Content analysis of plant perception questionnaire, post workshop reflection and weekly diary

The plant perception questionnaire was sent to participants via email, and they were able to complete it online in their own time by means of Qualtrics surveying software. A report of all the answers provided by participants as a pdf document was exported and

summarised in a table which can be found in Appendix S. The post workshop reflection was printed out and given to each participant to fill out at the end of the workshop. Weekly diaries were sent to participants via email, and they were given the option to print the document and fill in as a hard copy or to use the soft copy of the document to answer the questions electronically. All weekly diaries were returned to the researcher at the completion of the data collection phase. Electronic copies were created and stored for all the plant perception questionnaires, post-workshop reflections and weekly diaries and imported into Atlas.ti for coding and thematic analysis of the data.

4.6 DEMOGRAPHICS OF PARTICIPANTS

4.6.1 Participant 1

Participant 1 has the least experience in the research group with 3 years and 2 months of teaching Life Sciences at two different secondary schools. The participant studied a Bachelor of Education degree focused on Life Sciences education and studied Botany and its related modules up until his third year of study. This caused him to refer to himself as an expert in his field on various occasions during this study. During the interview, the participant revealed that his grandmother and great grandmother were instrumental in shaping his awareness and knowledge about plants while he was growing up. He recounted that both family members had vegetable gardens which they used to plant food to eat as well as various plants that were meant for medicinal use and that they sometimes involved him in the gardening work. He did however report that he had ignored plants while he was young and still at school. The school at which this participant was employed at the time of the study had large gardens with a large amount of plant diversity on the school grounds. The school does, however, not have Wi-Fi which would allow learners to use applications on their phones that require a connection to the internet. The demographic of learners who attend the school is quite mixed with a wide range of socio-economic circumstances being represented. The participant had an extended time of absence from the school during the time of this study due to personal reasons, which meant that he was under some pressure to ensure that he was able to catch up and finish

the syllabus with the classes he teaches. During the time of this study, the participant was teaching Life Sciences to Grade 10 learners as well as Natural Sciences to learners in lower grades.

4.6.2 Participant 2

This educator has 10 years' experience in teaching Life Sciences. At the time of this study, she had recently started working at a school which was newly built and less than a year old. Because the school was newly built, there was very little plant diversity on the school grounds and only included a few trees and grass fields. There is also no Wi-Fi which can be used by learners to access the internet. She reported that the general demographic of the school consists of mainly underprivileged learners, many of whom live in very poor circumstances. She qualified as a Life Sciences educator by acquiring two diplomas and specialising in Biology. She noted that most of her modules focused predominately on animals and human physiology with much less attention given to plants. Similar to Participant 1, this educator also recounted the influence that her grandmother had on her perception and awareness of plants. The use of plants for medicinal purposes (like the *Eucalyptus* tree, which is commonly used to treat colds and flu) was one of the ways that the participant's grandmother exposed her to plants from an early age. During the time of this study, the participant taught Life Sciences to Grade 10 learners and Natural Sciences to Grade 8 and 9.

4.6.3 Participant 3

This participant is the most experienced in the group of participants as she has been teaching Life Sciences for the last 20 years. She did not recall any meaningful interactions with plants while growing up, although she did mention that her mother loved plants. She also pointed out that she only really started to develop an interest in plants when she started her own garden as an adult. She studied BSc. Food Sciences at university, which only required her to take Botany at first year level. Interestingly, she recalled that she did not enjoy the botany content at the time. This educator was employed at a private dual medium school which follows the IEB (Independent Examinations Board) curriculum, as

opposed to the other four participants who follow the CAPS curriculum at their respective schools. This meant that the content which she taught during the time of this study was slightly different compared to the other participants. Another factor that sets her context apart from the other participants is the size of her classes. She reported that some of her larger classes consisted of 20-24 learners and the smallest class consisted of merely four learners. During the time of this study, the participant was teaching Life Sciences to Grade 10, 11 and 12 learners.

4.6.4 Participant 4

Participant 4 had 10 years' experience in teaching Life Sciences at secondary school level during the time that this study was being conducted. Her educational background involved her completing a Bachelor of Education degree during which she only studied Biology as a subject during the first year of her studies. She recalled that during the time that she was at school the textbooks they used for study had reasonably less information and detail relating to plants as compared to the amount of content about animals and human physiology. Regarding her time at university, she also recounted that they did not look at plants in any of the practical sessions included in the biology module which she took as an undergraduate. The school at which she teaches has a range of learners in attendance in terms of socio-economic background, but the majority of the learners come from underprivileged families who struggle financially. As the school she teaches at is a governmental school, the classes are quite large (in her estimation) with an average of around 26 learners per class. There is no Wi-Fi access for learners or educators to be able to access the internet with their smart devices and as a result, educators at that school who want to use the internet, are required to use their own data. During the time of this study, the participant was teaching Life Sciences to Grade 10 and 11 learners as well as Natural Sciences to learners in the lower grades.

4.6.5 Participant 5

At the time that this study was conducted, this educator had 10 years' experience as a Life Sciences educator and was employed at the same school as Participant 4. She

studied a Bachelor of Education degree with Physiology and Microbiology as her main subjects and no modules relating to botany. Much like Participant 4, she also teaches learners of whom the majority come from underprivileged backgrounds. She also reported the same challenge with regards to access to the internet as described by Participant 4 and large classes. Some of the classes she teaches has up to 38 learners in one class, which means that learners have to sit all the way to the back of her laboratory classroom. She communicated at various points that this sometimes gives rise to challenges with regards to classroom management and that she was apprehensive towards having plants or posters in her classroom because of the fear that learners would damage them. The school grounds do not have much plant diversity and the plants that are present are predominantly large trees and some grasses. It is also worth noting that the participant reported that the time at which this intervention was being implemented was a very busy time for the educators at her school with many additional administrative tasks taking up much of educators' time. At the time of this study, the Grade 10 and 11 learners at Participants 4 and 5's school were attending school on a rotational basis, which meant that they were only coming to school every second day. This rotation was due to the government-imposed restrictions in response to the Covid 19 pandemic. During the time of this study, the participant was teaching Life Sciences to Grade 10 and 11 learners as well as Natural Sciences to learners in the lower grades.

4.7 PRESENTATION OF THE DATA

One of the goals behind the design of the data collection process was to ensure that collected data was truly representative of the entire participation process. It was for this reason that five separate types of data were collected at strategic moments during this study. This process of data collection enabled this study to gain perspective into where participants were before the study with regards to their plant appreciation, how they were initially impacted by the workshop and how they eventually implemented what they had learnt during the workshop. The idea behind this planning is twofold. Firstly, it makes it possible to get a before and after glimpse into the participants' plant appreciation and teaching in relation to plants. Secondly, the abundance and richness of the data allows

for extensive triangulation to ensure that the ultimate conclusions that are drawn from the data in Chapter 5 of this study, are authentic and true to the reality of each participant.

4.7.1 Plant perception questionnaire

This questionnaire served as a preliminary probe into the background of the five participants and their educational credentials. It was also useful to determine the perceptions participants held towards plants and the amount of confidence they had with regards to teaching about plant-related topics.

The majority of the participants are seasoned educators. This is clear as four of the five participants have more than 10 years' experience, while only one participant educator had a mere three years' experience in teaching Life Sciences. None of the participants were familiar with the term, plant blindness, but it is worth noting that once it was explained to them during the presentation, the participants were in unanimous agreement that they have seen its effects. When asked which topic they preferred to teach, a clear trend was visible as all the answers indicated at least some anthropocentrism and zoochauvinism. Three of the participants indicated that they preferred to teach about organs of the human body and their processes, while the other two participants said that they prefer to teach about genetics. One of the participants mentioned that she also enjoys teaching about genetically modified organisms as it is synonymous with new developments and interesting scenarios. When participants were asked about their perception regarding the teaching of topics relating to plants, one educator stated that he is indifferent to it while another participant indicated that it is not really her favourite topic to teach. Interestingly, the other three participants responded by referring to the idea that learners dislike plant topics and find it uninteresting and unrelatable. One of the participants even exclaimed that *"the learners find it boring!"*. Later in the questionnaire, when participants were asked specifically about their experience regarding their learners' perception about plant topics, much of the same sentiments were communicated as in the previous question indicating that learners generally do not look forward to such topics. Participant 2 did not answer the question as plainly as the other educators, but she

explained that learners tend to enjoy the topics in which educators show enthusiasm while teaching.

The second part of the questionnaire inquired into the confidence of the participants with regards to teaching about plant topics. All five participants described themselves as confident with two educators referring to their past training as being useful and helping them to know the content well. Participant 2, however added that although she felt confident, she was not enthusiastic about teaching plant topics. Interestingly, when participants were later asked about whether they felt that their tertiary education adequately prepared them for teaching Botany, four of the participants indicated that they did not feel adequately prepared.

One of the aims of this study was to find out how participants would use knowledge, skills, and resources from an intervention to facilitate interactions with plants. For this reason, the questionnaire included some questions about the ways participants use plants inside and outside their classrooms during teaching. The purpose of these questions was to establish a baseline with which data collected after the intervention could be compared. Participants were asked about the extent to which they use plants from their school grounds to facilitate teaching about plants. Three of the educators indicated that they sometimes use plants from the school grounds in their teaching and another participant implied that she does not use plants in that way by referring to the botanical garden in her answer. Only Participant 3 described how she often collects plants from the school's *"beautiful gardens"* and uses them during various practical investigations. Participant 3 was also the only one who indicated that she had plants in her classroom, while the rest of the participants admitted they do not keep plants in their classrooms.

One of the educators did, however, mention that she had started to bring succulents to her classroom to use while teaching plant topics. When the participants were asked about taking learners outside their classroom to learn about plants, all of them expressed some apprehension. One of the participants mentioned the botanical gardens once again (which is normally a one-time field trip taken by learners in Grade 10 for their yearly

environmental project). Three of the five participants stated that they have, however previously done some teaching about classification with the use of plants on the school grounds, but no explanations were provided to give credence to these assertions. The other two educators mentioned time constraints and challenges with class discipline as being reasons why they have not yet taught classification in such a way.

One of the questions inquired into the possible barriers and challenges which the participants could anticipate with incorporating the school environment into their teaching. Three possible challenges were identified amongst the answers that were provided. Participants 3 and 4 referred to the challenge of controlling a large group of learners outside the classroom and maintaining appropriate discipline among learners, while Participants 2 and 5 indicated that their school grounds did not have enough plant diversity to serve as good examples. The third possible barrier was mentioned by Participant 1, who explained that the curriculum term planning stipulated a certain amount of time that should be spent on each topic. Accordingly, this places educators under pressure to cover the prescribed content within the given timeframes.

None of the participants were aware of a resource which might help them facilitate learning outside their classrooms. One participant mentioned the internet as being helpful and another mentioned smaller classes.

4.7.2 Field notes from group discussion after workshop

It is worth noting that at various points during the study, four out of the five participants indicated to the researcher that they did not look forward to attending the workshop and considered not coming at all. Some of this apprehension was clearly observed by the researcher during the presentation about plant blindness and plant appreciation which was shown to the participants prior to the practical part of the workshop. Some of the participants seemed disinterested and absentminded during the presentation part, but they became very interested and excited during the practical part of the workshop as they discovered for themselves how easy it is to use the Pl@ntNet application to engage with plants and find useful information about them.

Once the workshop was completed, the participants came back into the classroom where the initial presentation was held. They were asked for some general comments about their initial perceptions regarding the workshop and intervention in general.

All the participants indicated that they had found the workshop interesting and exciting. An idea which was mentioned by multiple participants is the assertion that the workshop and presentation sparked an interest in them as educators with regards to plants. Two of the participants also suggested that the workshop bridged the gap between the educators and the learners because of the technological aspect of the Pl@ntNet application and its interactivity, which they expected learners to be intrigued by. One of the participants noted that the workshop changed her perception about teaching plant topics (which were not her favourite) and that she believed that it would influence the learners she teaches as well. The same participant continued to explain that she believed that the change should start with her and that she thought that this year would be different because of the intervention.

4.7.3 Post workshop reflection

Educators were asked to complete a hard copy of this reflection once the workshop was completed. The reflection contained five questions, each probing into a different aspect of the experience and perceptions of the participants regarding the workshop. The list of questions can be found in Appendix G.

The first question asked participants about their general experience during the workshop. The general notion among the participants was that they enjoyed the workshop and found it informative and multiple comments were made about the impact that the Pl@ntNet application and the workshop could possibly have on their future teaching. Both Participants 3 and 4 remarked that they enjoyed the workshop and Participant 3 continued by indicating that she was interested in the intervention. Participants 1, 2, and 5 commented on the utility of the workshop. Participant 2 said that the workshop was "*eye opening*" and that she was definitely going to use it for the Grade 9 project while Participant 1 explained that it gave him as an educator a strategy to "*bridge the gap*

between the old way of learning and the new appealing way of learning to the kids". Congruent with this idea, Participant 5 explained that through the workshop, she had gained the insight that "*something that was a boring topic to teach can now be more interesting to the learners than just using slides or textbooks or pictures"*.

The next question participants were asked, inquired into whether they thought this intervention could prove to be helpful to them in their teaching. Two of the participants (1 and 2) noted that it was helpful to them to learn how to use the Pl@ntNet application practically and Participant 2 elaborated on this notion by explaining that she finds it easier to teach content which she understands and with which she is comfortable. This echoed some of the later sentiments shared by various participants who said that it was useful that they were guided about how to use the Pl@ntNet application so that they knew how to use it practically. Another point which was raised by multiple participants (1, 3, and 5) is the fact that they saw this intervention, the treasure hunt activity, and Pl@ntNet application, to provide them with a new approach to get learners more interested in plants. A statement like "*It opened my eyes to see new opportunities to get learners interested in plants*", shared by Participant 3, sheds light on how these participants perceived the intervention. Interestingly, two of the participants who referred to the interest factor for learners, also mentioned that it would also impact on them as educators. Participant 1 mentioned that he thought that this intervention could impact the way he looks at plants in such a way that it would be projected to the learners he teaches. These sentiments were echoed by Participant 3, who mentioned that she felt motivated because of the intervention.

The third question in the reflection required participants to provide feedback about the ways they planned to use what was learnt during the intervention in their own contexts. This was purposefully asked to make it possible for later comparison with the ways that they eventually ended up implementing their newfound skills and knowledge in practice. Two of the participants (1 and 2), who teach Grade 10 classes seemed very eager to use the Pl@ntNet application as part of the yearly prescribed environmental studies project. Participant 2 stated her plan quite clearly, while Participant 1 was slightly vague in his

answer, simply referring to the idea that "*learners could go on an annual journey of naming and knowing the plants*". The initial plan shared by Participant 2 with regards to the implementation of what she had learnt during the workshop centred around the annual environmental education project that Grade 10 learners have to complete as part of their school-based assessment. She explained that she planned on using the PI@ntNet application in conjunction with the project to help learners identify plant species in various biomes which they would be expected explore. For a more elaborate discussion about this plan, please refer to the discussion of the interview data under the heading: *How participants planned to practically use knowledge and skills from the intervention.*

Subsequent data, including the interview as well as the final reflection, shed some light on this statement as it is clear from those interactions that Participant 1 did in fact plan to integrate the application into the abovementioned environmental project. The other three participants mentioned ways that they planned to use the PI@ntNet application to help them get their learners more interested in the plant-related topics they were required to teach. Participant 3 said that she planned to use the PI@ntNet application to get learners interested in plants before presenting the content about plant families and Participant 5 mentioned that she intended on using it to make the botanical content "*interesting and interactive*" for her learners. Participant 4 stated that she also planned on telling her learners about the PI@ntNet application and that she intended to acquire more plants to keep in her classroom. It is interesting to note that, after the workshop in which participants were encouraged to practice identifying various plants in the classroom, Participants 4 and 5 showed a lot of interest in how to care for plants and which species were appropriate to keep in a classroom. After the workshop, the researcher gave these participants some advice about good plants to start with by referring to some of the plants that were used for the workshop.

The researcher was interested in finding out how the participants thought such a workshop could be improved in future endeavours, which was the fourth question. Participant 1 suggested that efforts be made to find an application similar to the PI@ntNet application which is not dependant on the internet. The need for this became quite evident

during later data collection phases, as access to data was one of the most prevalent challenges reported by all the educators. Another useful suggestion which came from Participant 3 was that some activities and worksheets be developed which are more closely aligned with the CAPS curriculum. Participants 4 had no suggestions and added that the intervention workshop was done excellently, while Participant 2 requested additional information based on the intervention to improve what she learnt during the workshop.

The final question, which was asked in this section of data collection, required participants to reflect on whether, at that point in the process, they perceived this intervention as effective in increasing plant appreciation of educators. All five participants answered positively to this question. Participant 2 stated that she was a "*convert*" and planned to use the Pl@ntNet application in her classroom and Participant 3 explained that she perceived this intervention to be "*a tool that will help educators to use technology to get learners motivated in plant studies*". For Participant 4, the intervention was perceived as exciting and caused her to want to know more about it. Similar to what other participants mentioned in earlier question, Participant 4 continued to explain that the intervention "*triggered*" her and that this was the reason for the excitement she felt about content which she regarded as the least enjoyable topic to teach during the plant perception questionnaire prior to the intervention. After stating that she regarded the intervention as effective, Participant 5 continued by suggesting that this approach to teaching botany should be presented to the Department of Education and the subject facilitators.

4.7.4 Individual interviews

The purpose of these interviews was to provide crucial insights into the contexts and backgrounds of the participants and probe further into their knowledge and perceptions about plants. These interviews were open ended and semi-structured, which meant that the researcher merely made use of the interview schedule (*cf*. Appendix H) as a guideline for the types of questions that were posed to the participants. There were, however, instances where participants mentioned something relevant to the general aim of the

study. In such cases, follow up questions were posed to the participants. There were also various instances where an interesting comment was made by participants in the preceding plant perception questionnaire, in which case, some additional questions were asked to seek more clarity. The interview questions covered all three of the secondary research questions, but there is a greater emphasis on secondary questions 1 and 2 as they related to the plant appreciation of educators as well as their knowledge and confidence.

In the following section, the data surrounding the main ideas which were probed into during the interviews are discussed. Each main idea is accompanied by an indication of the secondary research question to which it relates, as well as the themes and sub-themes to which they are relevant.

4.7.4.1 Knowledge about plant blindness

(Secondary research question 3; Theme 1; Sub-Theme 1)

The question that was posed to participants related to whether they had ever heard about plant blindness before attending the intervention. All the participants indicated that they had never heard of the term before. This was not surprising as the term, plant blindness, is used almost exclusively in academic circles and therefore these participants would, most likely, never have been exposed to the term unless they had participated in an academic study such as this one. What is noteworthy about the way participants answered this question is that, although they did know the term as such, they were very aware of its effects (especially among their learners). An example of an answer which showed this quite poignantly, is when Participant 3 elaborated on her answer after she stated that she had never heard about the term plant blindness. She noted that "*it was quite interesting because it made total sense*" and then continued to explain how she repeated the simple test for plant blindness in her classroom because of finding out about it during the intervention (this test is discussed later in this section along with the applications of the intervention). A representation of this informal test can be found in Appendix D. According to Participant 3, she repeated the plant blindness test in her

teaching by compiling pictures of plants and animals, much like that which was shown during the workshop, and showing it to her learners.

Participant 5 was confused about the term, but once the next question was posed to her, she explained what she understood it to be. The explanation which she gave was coherent with what was taught to the participants during the workshop and therefore it gave some indication that she indeed learnt something during the presentation section of the workshop. After stating that she had not known the term plant blindness ahead of the intervention, Participant 4 continued to explain that she thought that most people had plant blindness to some extent, which she attributed to the way people are raised and what they are taught at school. In discussing these reasons for plant blindness being so prevalent, Participant 4 referred to zoochauvinistic content and teaching styles which typified her own educational experience.

4.7.4.2 Ways in which participants thought the intervention would impact their confidence

(Secondary research question 3; Theme 2; Sub-Theme 1)

Participants were asked to make predictions on how they thought the intervention would influence their confidence when teaching about plants. In general, participants thought that the Pl@ntNet application, in particular, would prove to be useful and influence their confidence. The two most common factors that emerged from the various answers provided were access to information about plants and the technological aspect of the application being regarded as something that would interest learners. Participants 4 and 5 both said that they thought the intervention would increase their confidence and Participant 5 hinted that one of the reasons for this impact is the fact that "*you can know more about plants*". The relationship between tertiary education and confidence was highlighted in the answers given by Participants 1 and 2. Participant 1 indicated that he felt that he was well prepared during his tertiary education for teaching about plants and therefore he felt quite confident. Sometime later during the interview, he did however mention that he did think that the technological aspect of the Pl@ntNet application would

allow him to "*spark an interest* "in the learners and that this might have a positive impact on his plant appreciation. In addition to the technological aspect, Participant 1 also noted that using the Pl@ntNet application could help him to be perceived as knowledgeable by the learners he teaches, which could, in turn impact his confidence positively.

Similar to Participant 1, Participant 2 referred to her tertiary education while answering the question about confidence. She described a lack of emphasis on plants during the Biology courses she took while qualifying for teaching. She pointed to this neglect of plants in her studies as a factor which might have contributed towards her feeling slightly uncertain when teaching about plants. Bar the other participants, who merely predicted that the intervention might influence their confidence, Participant 2 stated that she was more confident than she used to be when teaching about plants. The accessibility of knowledge through the Pl@ntNet application was one of the reasons which she provided for her increased level of confidence at such an early stage of the intervention. The quotes below shows these sentiments which were communicated by Participant 2 and echoed by the other 4 participants throughout this study:

Participant 2	Its…more confident. I'm, I'm more confident than I used to be, yes definitely. There has been a great impact as it is.
Researcher	And why would you say that? What would you say would make it, would cause you to feel more confident?
Participant 2	Uh, the fact that, like, I've got information at the tips of my fingers.
Researcher	Okay.
Participant 2	So, it's just there. I can use it. Unlike before where it used to be so difficult, but now its very easy. I know how to use it and, you know, I know its…there's just information available.

The idea that the Pl@ntNet application could serve as a teaching aid was alluded to by both Participants 1 and 3. Participant 3 referred to the Pl@ntNet application as empowering and enabling as she is admittedly not very good with scientific names of plants and found the application to be useful to fill that gap. In addition, she also mentioned that she thought her learners would perceive the technological aspect as

relevant because they are constantly busy with technology in the form of their own cellular phones.

4.7.4.3 Educators showing awareness of plant blindness in themselves

(Secondary research question 1; Theme 2; Sub-Theme 2)

The general trend with regards to plant blindness among the participants in this study is that they seemed apprehensive about clearly admitting that this phenomenon characterised them in some form. Participants 1 and 3 both stated that they love plants and teaching about them. Participant 3 elaborated on this claim by explaining that, although she was not always interested in plants, she had acquired an appreciation for them once she started to cultivate her own garden at home. Participants 2, 4 and 5 did not describe themselves as having plant blindness, although some of their answers showed signs of zoochauvinism and anthropocentrism. Examples of these instances in the interview are discussed under the next heading.

4.7.4.4 Educators' perception about teaching plant topics

(Secondary research question 1; Theme 1; Sub-Theme 1)

It was clear from the answers given by the different participants that they do not dislike plants or the topics themselves, but that they have a negative perception towards the idea of the process of teaching botanical content to their learners. Participant 1 mentioned that, although he had a considerable amount of exposure to plants while growing up, he often ignored them in his daily activities. He was, however, intentional about making the point that he has a positive perception towards plants as is clear in this quote: "*I love plants. I love teaching them*." After making this statement, he continued to explain that he prefers to teach about topics other than plants because he perceives that the learners find those topics more interesting. According to him, the feedback that learners give to him when he teaches, influences the topics which he likes and he added that, based on his experience, learners do not respond positively when he teaches botany.

The explanations given by Participant 3 about her perception and experiences with teaching botany was congruent with the other four participants. Although she mentioned earlier in the interview that she loves plants, she admitted that she does not always teach the chapters of plants with the same enthusiasm. She also stated that teaching about plant-related topics is a challenge. Her justification for this lack of enthusiasm to teach about plants was that she experienced resistance from the learners and that this negative perception rubbed off onto her and influenced her to think negatively about the topics as well. The following quote shows this sentiment quite clearly: *"…if they are constantly 'ag ma'am its boring', it rubs off on you, you know.".* Interestingly, she recalled that, shortly before the interview, she saw a change in her learners' response while teaching about plants. She described how the workshop "*kickstarted*" her to "*try something else*", and that she was pleasantly surprised as, according to her observation, the learners were interactive and enjoyed the lesson content more compared to learners in previous years.

Participant 4 also mentioned the disinterest among the learners she teaches when botany is covered in her lessons and how it negatively impacts on her perception. *"I think before I did this with you* [referring to the workshop], *you know it is also because the learners are also not so…My side was really, I am also guilty of it, you know."* As this quote clearly shows, she was aware of her role as educator and that she was guilty of presenting a negative perception to her learners, but she also hinted that learners have an impact on her perception regarding the topics she must teach. Later in the interview, she also made this point more explicitly by elaborating on the negative feedback she gets from the learners she teaches when Botany is discussed.

Both of these educators (Participants 3 and 4) made reference to the resistance they perceive from the learners when they start with plant topics, as being influential in the way they feel towards teaching about plants. Similar to Participant 3, Participant 4 mentioned that she had an increased interest in plants after attending the workshop and that this also had an impact on how she perceives plants.

When asked about her perception about teaching botanical concepts, Participant 2 admitted that she used to dislike teaching about plants and that she often found herself rushing through the content to finish it quicker. She explained that *"…in the past, it was like rush, rush, rush…"* but contrasted this manner of teaching to the way she found herself teaching after attending the workshop as part of the intervention. In contrast to the way she used to teach about plants, Participant 1 described how she caught herself lingering on plant-related concepts which she would normally simply brush over and elaborate on content by providing the learners with additional information.

Participant 5 gave conflicting answers to the questions which inquired into her perception, but similar to what emerged from the other participants' answers, these dual perceptions which she held at the time, can be explained by considering the influence of learners and their feedback on a educators' perception regarding botanical content. On the one side, she said that according to her, "*plants are really not so boring"* and that it is "*more pleasurable to teach than the microorganisms".* While answering a question which probed a little further into her real perception regarding plants, some anthropocentrism was observed as can be seen in the following quotation from her interview: "*But I must tell you, I like the kidney more. I probably should not do it, but one has your preferences*.".

This participant did however explain that although plants were not her favourite topic to teach, she preferred it compared to topics relating to human impact on the environment and environmental studies. An interesting additional piece of data which emerged from the interview was the fact that she had multiple plastic plants in her classroom. When she was asked about them, she admitted that she did not know what type of plants they were, even though learners had inquired about them a few times before.

4.7.4.5 Presence of plant blindness in learners as perceived by participants

(Secondary research question 1; Theme 1; Sub-Theme 2 & Theme 2; Sub-Theme 3)

From the answers given by the five participants when asked about the perceptions of the learners they teach, it became clear that they were all aware of the negative

predispositions that learners hold towards plants and their ignorance of the presence of plants all around them.

Participant 3 related one of her experiences while teaching after she had attended the workshop, where she asked a group of learners in her class to indicate whom of them likes plants. In response to her question, only one child responded positively by raising his hand. She mentioned that learners often say that botany is boring and told a story about a boy who blatantly told her that he "*hates plants*". In addition to this, she elaborated on her interaction with learners regarding the reasons they gave for disliking plants. According to her, the major points raised by her learners include the fact that plants are stationary and not mobile and that they do not show much change over time and therefore do not present as very interesting. One of the aspects of plants which this participant reported her learners to find quite enjoyable is the practical dissection of a flower. She attributed their enjoyment of this aspect to the physical interaction which such an activity allows learners to have with plants. Some influence of the intervention was already evident at this stage as she reported that after she had adapted the way she taught in response to the workshop, she found herself in a situation where learners were asking more questions than usual during her lessons. She continued to explain that they seemed genuinely interested in the botany she was teaching and her astonishment about this was evident as she related this point.

When Participant 1 was asked to comment of the degree to which he perceived plant blindness to be a problem among the learners he teaches, he responded quite emphatically by stating the following: "*Oh…Wow! I think it's a huge problem*". He then proceeded to explain that, in his experience, the learners are not truly aware of the plants around them, and that they seemed to think that plants are "*just there*". In addition to the lack of plant appreciation, Participant 1 further related that, although he was convinced that the learners know, in theory, that plants are living, they often disregard plants completely in discussions about biotic factors. The challenge posed by the disinterest in plants among learners and the influence it has on an educator was also noted by this

educator as he mentioned that it is difficult to teach learners when there is no interest on their part in the content.

Feedback from the interview with Participant 5 seemed ambiguous and contradictory at first, but after some probing was done into statements which this educator made about learner perceptions, it became evident that her evaluation is very similar to that of the other participants. She started by stating that the *"whole topic of plants is very boring for them*" (the learners) and that they "*do not give attention to it*". She ascribed the poor performance of her learners in formal assessments to these two factors. She elaborated on the extent of the disinterest she often perceives while teaching about botany to her learners with this description: "*With the plants they just sit there, and you must hope they don't fall asleep*".

Sometime later in the interview, Participant 5 stated that the learners do not say that plants are boring and that they complain somewhat more about other topics in the curriculum. When she was asked to compare learners' perception regarding plants with anthropocentric topics like physiology and anatomy, she conceded that in comparison to those topics she thinks the learners do not like plants. An interesting piece of contextual information shared by this educator is related to the plastic plants she has in her classroom, to which she seemed quite indifferent as she did not even know their common names. She recalled interactions which she had with certain learners in her class in which they asked her about these fake plants and showed some interest in them, just to find out that they were not real. Participant 5 did however note that in her experience, the learners show more interest when they are physically exposed to plants in the classroom.

A similar notion was communicated by Participants 2 and 4 regarding the influence that they, as educators, have on the perception of learners regarding content taught in the classroom. Participant 4 explained that her experience has shown her that whatever perception is portrayed by her as an educator, is easily picked up by the learners. She also mentioned that she has found learners generally disinterested when she teaches about plants. Correspondingly, Participant 2 also mentioned that "*learners can see"*

(referring to the perceptiveness of learners about the confidence of their educator and the attitude they hold about certain topics) and that *"you can't give what you don't have".* She also elaborated on this point by explaining that she thought that her newfound interest in plants and the confidence with regards to teaching about it would be observed by the learners and that it would invariably have an impact on their perception.

4.7.4.6 Perception of participants regarding the usefulness of the intervention and its influence on their pedagogical approach.

(Secondary research question 1; Theme 1; Sub-Theme 3 & 4)
(Secondary research question 2; Theme 4; Sub-Theme 2)

From the various ways participants answered questions regarding the usefulness of the intervention, the viewpoints were quite homogenous with two main ideas being mentioned by nearly all the participants. The first of these two ideas is the notion that the intervention sparked an interest in them as educators, which caused them to feel motivated to teach about plants again. The practical implications of the Pl@ntNet application in generating interest around their teaching was the second idea which was also mentioned quite often.

Participant 3 described how she felt the workshop had "*tickled*" her brain and motivated her to try changing the way she teaches about plants. She explained that an individual who has been teaching for a long time (like her) could easily get stuck in their ways in terms of how they teach certain topics. This sentiment is related quite vividly in this quote: "*And I…It just kickstart me to try something else. Because otherwise, I would just have go on and say 'okay, the kids don't like it, let's rush through it".* One of her main takeaways from the workshop was a determination to open the eyes of her learners and address their lack of plant appreciation, of which she was already distinctly aware. It is this determination which led her to attempt to implement new ideas into her botany teaching such as encouraging her learners to bring plants into the classroom to increase their awareness and foster an appreciation towards plants. When asked about the usefulness of the intervention in her opinion, she referred to the ease of access to information like scientific names and other information which caused her to feel empowered. In addition,

she also thought that the Pl@ntNet application would make it easier to facilitate learning about plants outside the classroom.

The motivation to bring plants into the classroom was shared by Participants 4 and 5 who were colleagues at the time. After attending the workshop, Participant 4 had already started to make plans with her colleague to bring plants from their homes to keep in their classrooms. She explained to the researcher that, in terms of plants as a teaching resource, the workshop caused her to gain a different perspective and become more motivated to teach about plants. From her answers, it was clear that she was determined to put in effort to produce an increase in her learners' interest concerning plants.

Her initial reasoning is summed up quite clearly in this quote after describing the impact an educator has on a learner's perception: "*But I think if one would put in some effort, which I will definitely do now, to trigger them…because it definitely did it for me and caused me to look differently and I am excited now to present it*".

Participant 5 described the same sentiments as Participant 4 and added that she found the advice about plants that are appropriate for classrooms and how to care for them (which she received after the workshop) to have been particularly useful. She also said that she felt that she wanted to bring plants into her classroom to allow learners to observe them.

Similar ideas were shared by Participants 1 and 2 with regards to the usefulness of the intervention as well. Both these educators mentioned that they perceived the Pl@ntNet application to fit well with the prescribed Grade 10 environmental studies project. Participant 2 explained that, already at that point, the intervention brought a new perspective in her with regards to plants and that she found it "*very, very interesting*". According to Participant 1, the workshop did not influence his perception *per se* (as he mentioned earlier that he already had a positive disposition towards plants), but that it provided him with a tool to influence the perception of his learners through the Pl@ntNet application. He continued to explain that he thought that the learners would "*find it more cool*" to work with the mobile application while learning about plants and that it could be

useful to link the content taught in class with what learners do with the Pl@ntNet application.

4.7.4.7 How participants planned to practically use knowledge and skills from the intervention

(Secondary research question 2; Theme 4; Sub-Theme 1)

Considering the fact that each of the participants who took part in this study have their own unique context with its accompanying challenges and barriers, it is not surprising that there were a variety of ideas shared during the interviews about plans to implement the intervention.

Participants 1 and 2 were both planning to integrate the Pl@ntNet application into the environmental ecosystem project which is prescribed by the CAPS curriculum. Participant 1 mentioned that he might also copy the idea of having a treasure hunt on the school grounds, much like the activity which was facilitated during the workshop. During the interview, he did not provide much information on how he planned to arrange the ecosystem project. He explained that his first step was to get the learners to download the application and that, at that moment in time, he did not have a plan beyond that.

Unlike Participant 1, Participant 2 had her plans for the implementation of the ecosystem project well thought out and she described the steps she planned to take during that process. Firstly, she planned on teaching her learners how to use the Pl@ntNet application. She would then give them the instruction to choose a 15 m^2 area in an ecosystem close to their own house. They would be expected to take pictures of the environment and use the Pl@ntNet application to scan the plants in the demarcated area and identify them. These pictures taken with their cell phones, coupled with a list of all the animals in that same area would be submitted along with a completed worksheet (set by the Department of Education).

By the time that this interview was conducted, Participant 2 had already explained the project to her learners and she mentioned that some of them were apprehensive about it

because they realised that they would have to use their own data for the Pl@ntNet application. Participant 1 explained that she addressed this by telling the learners that the activity was going to count towards their formal assessment marks, after which she reported that they seemed more willing because, as she puts it: "*they all want marks".* In addition, she planned to address the challenge posed by the fact that only some of the learners have mobile phones and access to mobile data, by intentionally grouping learners with access to the necessary resources together with those who do not have access to such resources.

The plans proposed by Participants 4 and 5 were quite similar, although each of them had their own unique ideas about using the skills and knowledge which they had acquired during the intervention workshop. Both of these participants said that they planned to collect plants from their own gardens and bring them into their classrooms. Their plan was to use their own phones to scan the plants with the Pl@ntNet application and show the process to the learners. A common concern that was shared by these participants was related to class management and both maintained that it would be impractical to require learners to do the plant identification exercise on their own because many of the learners do not have a cell phone or data to allow them to use the Pl@ntNet application. During the interview, Participant 4 seemed to contemplate taking the learners outside her classroom with the help of an assistant to look at the plants on the school grounds. She also considered possibly allowing learners to leave the class for this activity along with an assistant on a rotational basis.

It is worth noting, however, that Participant 4 did not have a concrete plan for such an exercise at the time at which the interview was conducted and that she eventually did not implement such an activity. In addition to the use of the Pl@ntNet application in her classroom, Participant 4 also mentioned how she planned to use the Pl@ntNet application in her personal life. She explained that she planned to encourage one of her friends to download the Pl@ntNet application and show him how to use it. She also mentioned that she planned on showing it to her child and encouraging him to use it to explore their garden at home and learn more about their plants.

In addition to her abovementioned plans, Participant 5 mentioned that she also planned to ask learners to collect a leaf while they were on their way to school and bring it to class so that she could let them scan it and identify the plant to which it belongs.

Participant 3 had a slightly different approach to the idea of bringing plants into her classroom for further study. At the time of the interview, she had already started to implement her plan. She described how she had already told learners to each bring a plant (very inexpensive or taken from a garden) to her classroom on the following Monday. Once all the learners had brought their plants to the classroom, she planned to guide learners to use the Pl@ntNet application to scan their plants and determine their scientific names. The scientific names, along with the learners' names would then be written on a sticker and stuck to the plants after which it would be placed on a shelf in the classroom where it would be visible and easily accessible. She added that she planned on telling the learners to look at their plant everyday as they enter the classroom and "*say hello to it"*. In addition to this plan, she also stated that she planned to take the learners outside her class, to the school gardens, where she would use the Pl@ntNet application and a few questions on a worksheet to facilitate learning about dicotyledonous and monocotyledonous plants. She also considered the challenge of some learners not having access to their own data or a mobile phone and said that she planned to divide learners into groups, much like described previously by the other participants, to ensure all learners were able to see and take part in the use of the Pl@ntNet mobile application during the various planned activities.

4.7.5 Weekly diaries

For the purpose of this section, each participant and what they reported in their weekly diaries is discussed for each participant individually. The questions that guided the process of reflecting on what was done during the week inquired into 1) the content that was taught; 2) whether plant-related information was incorporated into teaching; 3) whether skills or knowledge from the intervention was used; 4) whether the Pl@ntNet application was used and 5) whether plants outside the classroom were used during

teaching (Appendix I). Participants did not always answer all the questions; however, the general application of the intervention can still be seen by considering their respective weekly diaries.

4.7.5.1 Participant 1

Although Participant 1 planned to use the Pl@ntNet application for the environmental studies projects, unforeseen changes in the prescriptive year planner given by the Department of Education caused the date of this project to be moved much later in the year. This made it impossible for this study to follow the participant during its implementation as it was outside the scope of time allocated for the research process. This participant did not do any activities with the learners as was initially planned. There are, however, multiple instances during the time of keeping the diaries when he noted that he now approached the teaching of plant related topics differently. The content that was taught during this five-week period only explicitly involved plants during the last week, while the first four weeks centred predominantly around environmental studies. The participant noted in his diary that he was intentional about making his learners aware of their plant blindness. He also stated on multiple occasions that he was curious and looking forward to seeing how his learners perceived plants in the broader scheme of environmental education. He mentioned multiple instances where he noted plant blindness in the way learners approached the work they were doing, to which he responded by drawing their attention to it and helping them to see the importance of plants in the environment. He made multiple reference in the diary to the alternating timetable which learners were following (attending school every second day due to Covid-19 restrictions) which resulted in him being pressed for time to teach the prescribed content.

4.7.5.2 Participant 2

This participant educator also noted similar challenges with regards to the changing of the year planning for certain topics in Grade 10, but she did however record various ways in which the intervention had an impact on her teaching. The first week for which she kept a diary was devoted to teaching about the various biomes found in South Africa (which is

not an exclusively plant-focused topic). The participant described how she realised that, in previous years, she would have dwelt on information regarding the animals found in the various biomes but seemed surprised that she found herself lingering at information about different plants while she was teaching the topic this year. She explained that she felt that the way she taught this topic during this year was more balanced in terms of focus on animals and plants. She also mentioned that she felt more confident while teaching during the first week of keeping a diary and that it was also more enjoyable to her.

The use of the Pl@ntNet application in a personal and professional capacity was also described by this participant as she related how she "*randomly used the app to identify some plants in the school yard*" and at her home too. She reported that the pictures that were taken at school were of an *Artemesia absintium L* plant, which she knows in her culture as *Lengana* and said that she used this information to teach her learners about this tree.

The only other instance in which this participant practically used the Pl@ntNet application in her classroom was in week four in which she had to teach about nutrient cycles (which contains a little content about the role of legumes). She decided to place a strong emphasis on the role of these plants by bringing various legumes to school, including lentils and chickpeas, and scanning them with the Pl@ntNet application to find their scientific names. Figure 4.1 shows some of the screenshots she took while using the Pl@ntNet application for the various activities she described.

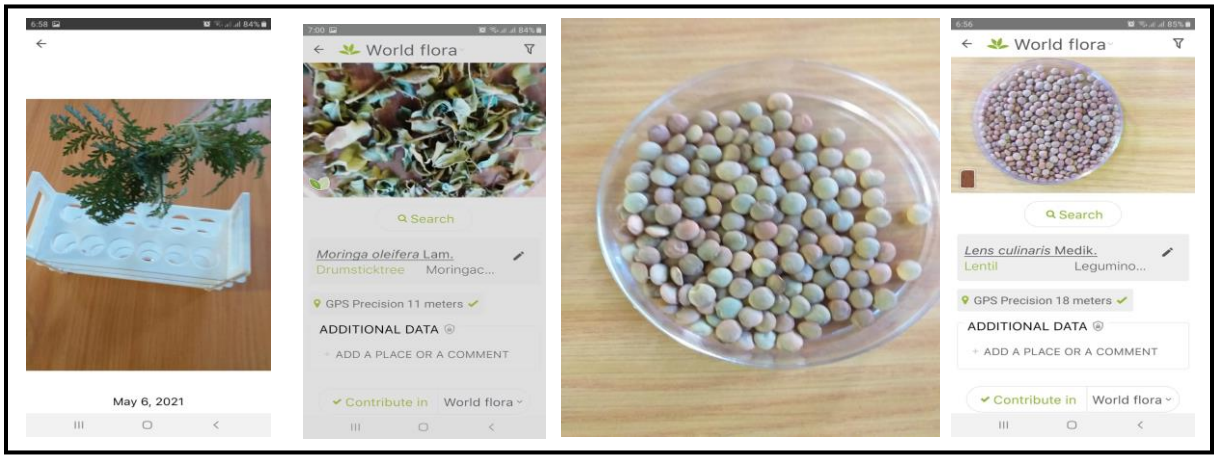

Figure 4.1: Pictures submitted by Participant 2 showing the use of the Pl@ntNet application (with permission from Participant 2)

For the rest of the time, she taught content, which was not explicitly plant focused, but she noted that she placed more focus on plants while teaching the content. She also mentioned that she used the Pl@ntNet application on multiple occasions to identify plants, which she found interesting, as she went about in her personal capacity.

4.7.5.3 Participant 3

This participant reported a variety of ways in which she implemented the knowledge and skills gained during the workshop. Although she taught both plant-focused topics as well as non-plant topics, the diary shows that she made an effort to address plants in some way during most of her teaching.

She implemented the plan during her first week of using the diary and explained that her motivation for teaching was to "*open the learners' eyes to the world of plants*" and to "*cure their plant blindness*". She recorded in her diary that each learner in her class brought their own plant as she asked them to do prior to her interview. They were guided to use the Pl@ntNet application to identify their plants and complete a short worksheet (*cf.* Appendix T), which facilitated the process of discovery and learning about their plants. An interesting addition to her initial plan was to encourage her learners to give their plants a nickname based on the information they had acquired. She made a note at the bottom

of the page of the diary stating that "*It was a huge success. The learners enjoyed it so much*". One example of such a creative nickname that a learner gave to his spider plant was "Peter Parker plant" (making reference to the main protagonist in the spiderman film franchise). Photographic evidence of some of the plants that learners brought to school and gave names to can be seen in Figure 4.2.

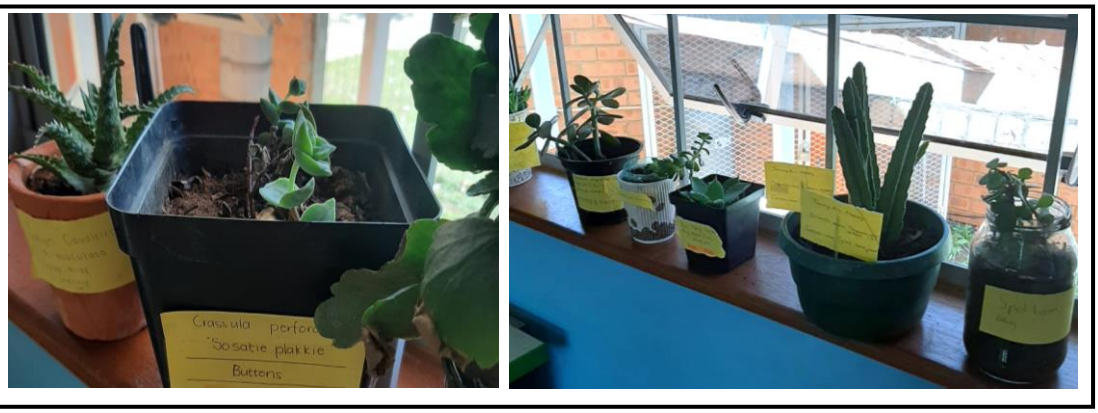

Figure 4.2: Examples of plants that were brought to school by learners including nicknames and scientific names (with permission from Participant 3)

Later diary entries recorded how this educator allowed learners to collect leaves from the school grounds and scan them to research their adaptations while teaching about plant transport systems. She even integrated the Pl@ntNet application into her normal way of teaching plant reproduction with the dissection of various kinds of flowers by requiring learners to identify the flowers by using the mobile application. Yet another comment from this participant which accompanied the description of this activity, noted that the learners "*enjoyed it a lot*". This participant used the diary as a reflective tool for a period of four weeks. During this time she reported that she felt an increase in motivation to incorporate plants from the school grounds into her teaching and to use the Pl@ntNet application to enrich her lessons. She also mentioned multiple times that the learners enjoyed using the technology (referring to the mobile application) and that they found the hands-on nature of these lessons particularly enjoyable.

4.7.5.4 Participant 4

This educator used the weekly dairy as a reflective tool for a total of five weeks. During the first week she did not note any implementation of new knowledge or skills into her teaching. She did, however, mention that she scanned moss and fern plants in her own garden at her home. During the following week she brought examples of moss and fern plants from her garden to use inside her classroom. The diary entry for that week shows that she demonstrated to her learners how to use the Pl@ntNet application while she identified plants which she had brought to her classroom. This was in accordance with the plan she described during her interview. The use of the mobile application was, however limited to her own cell phone as there were no specific opportunities recorded in which learners tried identifying the plants themselves.

In a later week, this participant also recorded that she used the database of the Pl@ntNet application to show examples of various types of flowers to her learners. She supplemented this activity by bringing flowers from her house to explain the relationship between pollinators and flower adaptations. There is one instance of personal use of the Pl@ntNet application noted in the diary. During that diary entry the participant described how she used the Pl@ntNet application during her break duty to scan plants on the school grounds and that she showed the process to a few Grade 12 learners.

4.7.5.5 Participant 5

This educator had similar ideas to Participant 4, as is reflected in their respective interviews, and therefore there is a clear similarity between what she recorded during the four weeks that she made use of the diary and what was recorded by Participant 4. She also recorded an instance when she brought moss and ferns from her home into her classroom. One way that she differed from Participant 4 is that she reported to have shown some of her learners how to use the Pl@ntNet mobile application and allowed them to use their own phones to identify the moss and fern plants. She explained in the diary that she was "*trying to make it more interesting for the learners*". That same diary entry recorded a description of the challenge posed by a lack of mobile data for her

learners. Participant 5 explained in that section that only a few learners who had mobile phones and access to enough cellular data were able to participate fully in the activity of identifying the plants with the Pl@ntNet application.

While teaching about flowers, this educator recorded that she brought roses from her home into her class and, once again, used the Pl@ntNet application to identify them and show the results on her phone to her learners. She also noted that she found herself incorporating the Pl@ntNet application into all her teaching about plants.

Another planned activity which this participant mentioned during her interview and ended up implementing, involved learners bringing leaves to the classroom. She asked her learners to bring leaves to class and she reported that they "*used the app for the different shapes of leaves and to identify the plants".* Although she did not explicitly say that the learners did this activity, the fact she refers to a group of individuals when making the statement and the fact that the learners were the ones who brought the leaves, leads the researcher to assume that the learners were in fact involved in this activity.

4.7.6 Final reflection about intervention

A short interview was conducted with each participant to serve as a final reflection on the entirety of the intervention in which they participated. These final reflections were done at various times that suited each participant's schedule between 3 and 26 May of 2021. This constituted the fifth phase of data collection as illustrated in Table 3.1. (Page 56). Four of the participants opted for the reflection to be done telephonically while only one participant asked for it to be done in person. The interactions which constituted these discussions with the participants were recorded with voice recording software and transcribed verbatim. Some of the participants decided to answer questions in their mother tongue, Afrikaans. In these cases, the conversations were translated into English during the transcription process as this allowed the researcher to ensure that the translated text was as close as possible to that which the participant were communicating during their reflections.

4.7.6.1 Intervention usefulness

(RQ2; Theme 4; Sub-Theme 2)

When Participant 1 was asked to reflect on the usefulness of the intervention, he suggested that it could have been useful were it not for the challenges he was confronted with during the time of the intervention. He explained that the shortage of time because of learners attending school every second day, is the main reason behind his statement. Later in the reflection, the participant summarised his perception of the usefulness of the intervention as two factors. Firstly, he stated that he did not know about plant blindness before the intervention and that the fact that he was suddenly aware of it influenced his teaching. His second point follows from the first, as he concluded that the intervention ultimately taught him a different way of approaching the way he teaches botany.

Participant 2 indicated in her final reflection that she had not yet been able to implement her plan of using the Pl@ntNet application in the facilitation of the environmental studies project. She did however make the point throughout the conversation that she regarded the intervention as useful and that she predicted that it would prove to be even more useful during her future teaching. A change in her perception toward plants and the acquisition of new knowledge about plants and the ways in which it can be used to teach botany explains the usefulness of this intervention. A noteworthy comment which this educator made about the process of the intervention was in relation to the influence of the weekly diary on the way she implemented what she had learnt during the workshop. While describing how she adapted the way she taught, she mentioned the weekly diary multiple times as one of the driving forces behind the additional effort she put into her teaching. From her descriptions it is clear that reporting on her teaching in the diary, acted as a catalyst for her to start adapting the way she taught botany.

Participant 3 also said that the intervention was useful to her because it "*makes one aware of the fact that you can do more to spark an interest in the learners regarding plants*". She remarked that it showed her a new way to ensure her learners are more hands-on when she teaches about plants. In addition to these remarks, she also mentioned that she

thought the workshop was well designed and that the documents they received were particularly useful and effective in showing the participants new ways to approach botany teaching. Similar to the comments made by the other participants, this educator said that the intervention helped her get out of something she described as a "*groove"* in which educators could find themselves. She elaborated on this idea by explaining that the negative feedback she gets from learners when teaching about plants sometimes causes her to rush through the work and accept the negativity in her learners. According to what she experienced, the Pl@ntNet application and workshop motivated her to adapt her pedagogy, as she was convinced that her learners would enjoy using their mobile phones to learn. This prediction was ultimately found to have been correct as she reported in this final reflection about the enjoyment that she perceived amongst her learners during the activities described in the weekly diaries.

Participant 4 mentioned that she thought that the intervention was useful to her personally, and she gave evidence that it also indirectly influenced her learners in a positive way. She explained that she had difficulty in getting some learners to download the Pl@ntNet application. A positive aspect of the intervention which she described is that the Pl@ntNet application made the plant topics seem more interesting to teach, which caused her to approach her teaching with more positivity. She mentioned that she thought that this positivity, as the educator, was beneficial to her learners. The technological aspect involved with using the Pl@ntNet application was useful as it "*triggered*" the learners to think differently about plant topics.

In her final reflection, Participant 5 was emphatic about the fact that she thought that the intervention was very useful to her and that she was very thankful that she was able to take part in the intervention. She told the researcher that it is possible for an educator to stagnate in their teaching by relying principally on PowerPoint presentations and textbooks. Elsewhere in her interview she made it clear that she considers this state of affairs to have been true prior to the intervention. She also referred to the technological aspect of the intervention as being useful to teach in a way that is relevant to the learners and said that the ease of access that the Pl@ntNet mobile application gave to information

was very useful. Interestingly, she noted that she found it easier to explain botanical content to learners as compared to animal-related content. She ascribed this to the increased interaction with plants which she realised was possible while participating in this intervention.

4.7.6.2 Possible future use of intervention knowledge and skills

(RQ2; Theme 4; Sub-Theme 3)

Participant 1 was not able to implement his plans because of time constraints. He did, however, indicate that he planned to make use of the Pl@ntNet application, and the knowledge and skills acquired during the workshop more extensively during his future teaching. According to him, this would only be possible once the learners were allowed to attend school every day of the week. Participant 2 had a similar experience as Participant 1 as both were not able to use the Pl@ntNet application in conjunction with the environmental studies project as originally planned. Both these participants indicated during their reflections that they were still planning on implementing it when they start with that project. Participant 2 related stories about how she used resources and knowledge from the workshop in her personal capacity at home. She told the researcher that she was excited to use it even more in the future.

Participants 4 and 5 indicated that they were planning on repeating the way they taught about plants during the intervention (which incorporated what was learnt during the workshop) in their future teaching. Both suggested that they had plans to incorporate the Pl@ntNet application into many other topics which they teach because of the positive response they had received from their learners.

Participant 3 said in her reflection that she definitely has plans to use what she learnt during this intervention in her future teaching. She described how she planned on incorporating the Pl@ntNet application into her teaching of plant families as well as monocotyledonous and dicotyledonous plants. The plants which learners had brought

into her classroom and the activities surrounding them, resulted in one of the ideas that this educator said she planned on repeating in the following year as it was so successful.

4.7.6.3 Influence of intervention on educator perception about plant topics

(RQ1; Theme 1; Sub-Theme 3 & 4)

There is evidence from the final reflections of each of the five participants that the most important influence of this intervention was that it introduced them to a different way of thinking about teaching botany. With the exception of Participant 2, the other four participants indicated that they generally appreciate plants and are aware of plants, although they dislike teaching about it. Participant 1 mentioned that he used to overlook plants before the intervention, and he stated that it had changed as a result of participating in this intervention. During her reflection, Participant 1 described how her awareness and appreciation of plants increased substantially since taking part in this intervention. She continued to explain the growth she had experienced by stating: "*I need other people to also appreciate the plants the way I do*". Participants 2, 3, 4, and 5 each alluded to the fact that they felt more motivated and excited to teach about plants after the intervention. A noteworthy perceptual change, reported by Participant 2, involves the way she felt about teaching about plant topics after the intervention. While elaborating on this point she mentioned that, during the course of the intervention, she realised that it is easier for her to teach about plants in a practical and exciting way as compared to animals. Her reasoning behind that statement was that plants allow for more interaction as you can easily bring specimens into your classroom, as opposed to the fact that "*you can obviously not bring an elephant into the classroom*".

4.7.6.4 Perceived influence of the intervention on learner plant appreciation

(RQ1; Theme 1; Sub-Theme 2)

From the answers that were provided to this question, it was evident that the cases in which the educators made an effort in reforming their teaching, saw learners undergoing a positive shift in their perceptions about plants. Participant 1 described the least amount

of change in the perception of his learners and said that he saw that only some of his learners' eyes were opened.

He stated during his reflection that he was only able to get one of his leaners to download the Pl@ntNet application. There were, however, multiple instances during the reflection when he predicted that he would see a significant change in their perception later during the year. Participant 2 was also optimistic about the indirect impact that she thought the intervention would have on her learners' perception after completion of the environmental project. Unlike Participant 1, Participant 2 reported a considerable change in the perception of learners she teaches with regards to botany. She described how, in previous years, she found that while teaching about ecosystems, learners placed a strong emphasis on animals and disregarded plants. According to her, the only type of plant learners mentioned in some instances was grass. She contrasted the disregard for plants with the way she saw learners reacting after the intervention when she teaches botany. She referred to an activity which was done during the workshop in which participants were shown an image of animals and plants and asked what they saw first in order to identify plant blindness and zoochauvinism. According to her experience during and after the intervention, she stated that "*these days, when I show them, they're able to see the roses, they're able to see*". In addition to this statement, she said that her experience at that point in time was that her learners were more aware of plants than animals during her lessons.

Participant 3 also reported during her reflection that she observed a noticeable change in her learners' perception about plants during and after the intervention. She explained that "*learners do not look forward to plants in general*" and that she observed a change in this perception during and after the intervention. One example which she mentioned to substantiate this claim was the way learners reacted on the first day that they returned to school after a short holiday. She described how "*extremely excited*" her Grade 11 learners were to see the changes in their plants which had occurred while they were on holiday. These were the plants that each learner brought to school for an activity that this participant had designed in conjunction with the Pl@ntNet application. After the activity

was completed, the plants remained in the classroom and the learners were encouraged to greet their plants daily and ensure they were healthy and growing well. Some learners found new leaf growth and others found that their plants were flowering, all of which produced noticeable interest among these learners and their peers towards the plants in her classroom. A possible reason why this educator believed learners were reacting so positively was the fact that they each had ownership of a plant and that it caused them to be more invested and look more intently.

Both Participants 4 and 5 said that they observed a positive change in some of their learners' perception about plants. In both their cases, they reported that it was the fact that learners were able to interact practically with plants that was instrumental in reshaping the way these learners perceived plants. While Participant 5 was reflecting on the intervention, she also considered the academic performance of her learners over the period of the intervention. It is in that context that based on her observations, she felt that the learners performed better, academically, compared to previous years.

4.7.6.5 Future recommendations

(RQ2; Theme 4; Sub-Theme 3)

The participants were asked to comment on any recommendations they might have for future interventions based on their experiences during the study. This question was purposefully asked to get insight into which aspects of the intervention could be improved upon if it was to be developed further. Participant 1 referred to the challenge posed by a lack of access to cellular data to enable access to the online database of the PI@ntNet application. He suggested that an offline database which could be used in conjunction with a mobile application would help to ensure more learners and educators are able to access information about plants which they identify. He based this on his personal experience which involved learners being unwilling to download and use the PI@ntNet application because they did not have access to cellular data or Wi-Fi.

Participant 2 had no suggestions about the design of the intervention itself, but she suggested that it would be prudent to ensure that the time of year that future interventions are held, align more closely with the teaching of the environmental education content. She alleged that such an alignment would make it possible for educators to implement the knowledge and skills learnt during the workshop as well as the Pl@ntNet application (or a similar application) into the prescribed environmental education project, as prescribed by the CAPS curriculum. These sentiments were also shared by Participant 1.

Participants 3, 4, and 5 made similar suggestions which all amount to them recommending that the intervention be expanded to be presented to a larger group of educators. Participants 4 and 5 specifically proposed that this intervention be presented to the Department of Education to allow it to be developed into a programme which can benefit all educators in the country.

4.8 GENERAL OBSERVATIONS ACROSS THE ENTIRE SET OF COLLECTED DATA

As this study collected data during various stages of the intervention, there are certain categories of which a clear picture could not be obtained from a single data source. This is because these concepts were mentioned sporadically by participants throughout the various stages of data collection. The following discussions elaborate on some of these categories of data which have particular relevance to the main research question of this study.

4.8.1 Challenges and barriers

To enable the researcher to properly interpret the data, which was collected during this intervention, it was important that participants be given the opportunity to express the challenges and barriers they experienced during the study. The following discussion provides a summary of the collective responses from all participants.

The types of challenges that were mentioned by participants can generally be categorised as involving either a shortage of certain resources or issues with class management. One of the challenges that was specified in terms of resources by Participants 2, 4 and 5 include a lack of plant diversity on school grounds. They reported that there were mostly trees and grasses on their school grounds and very few herbaceous or shrub-like plants. Another resource which posed significant challenges to the participants was access to mobile data. Although the participants reported that most of their learners have mobile phones, they consistently mentioned throughout the intervention that they themselves and their learners do not have access to wireless networks. This means that they would have to use their own mobile data to utilise the online database of a mobile application like Pl@ntNet.

The third resource, which was clearly limited throughout this intervention, is the amount of time the participants had at their disposal. Four of the participants reported that their learners were attending school on a rotational basis (due to restrictions that were in place to adhere to Covid-19 protocols) which meant that they only saw them every second day. Participant 4 made this challenge particularly clear when she stated that "*time is precious right now*" and that the adapted timetable caused her to feel as if "*you do not really have the learners*", because her teaching was fragmented into alternate days. This adapted timetable was a change that most public schools adopted during the time of this study to allow for adequate social distancing of learners in classrooms. Participant 1 also commented that he felt pressured to finish the curriculum because of expectations from his management as well as the prescriptions in the Departmental pace setter document (which specifies amount of time which can be spent on each topic). The necessity to administer formal assessments during certain timeframes was one of the factors that Participant 1 mentioned which reduced the amount of time he had at his disposal to teach. The alternating timetables further exacerbated the problem as some prescribed assessments took as much as an entire week to administer.

The second type of challenge that was reported by all the participants, relates to the management of learner behaviour when they are taken outside the classroom. Three of

the participants said unequivocally that they would not be able to take learners to learn and complete activities outside their classroom because of behavioural challenges. They mentioned that they were concerned that the learners would be noisy and disturb other classes, and that they did not think they would be able to keep a large group of learners well behaved and focused. One of the reasons cited by multiple participants for their apprehension about practical work and outside learning is the large number of learners in some of their classes where participants reported to have as many as 38 learners in a single class.

4.8.2 Positive feedback loop

During the various stages of data collection, it became apparent that there exists a relationship which resembles a positive feedback loop between educators and learners with regards to their perception about plant topics. The theoretical case for this speculation is discussed more broadly in Chapter 5 of this study. The following headings therefore merely constitute groupings of the data which relate to important aspects of this preposition.

4.8.3 Learner influence on educators

All throughout this study, participants noted that the perception of the learners they teach and the feedback they receive from learners had a significant impact on their own perception of teaching botany. All the participants indicated at some point during the study, that their own negative perceptions with regards to teaching botany could be ascribed directly to the feedback which they get from learners whom they perceived as clearly uninterested in plants.

Participant 3 mentioned that she previously did not approach teaching the topics about plants with the same enthusiasm as she did with other topics, because she felt that she would need to somehow get the learners to like topics about plants. This was a challenge in her experience, as she explained that she felt resistance from the learners when teaching about plants. She clarified this statement by relating that disheartening

statements like "*ag Ma'am, it's boring*" (referring to plants) are quite common when teaching botany. This negative feedback from learners while teaching about plants was also noted by the other participants to such an extent that all the participants in this study indicated that they had accepted that these negative perceptions are inevitable among their learners. Participant 1 further echoed what was described by Participant 3 when he stated that the feedback that he normally gets from learners when teaching about plants is negative and reflects significant disinterest in those topics.

4.8.4 Educator influence on learners

When the participants from this study were asked about the perception of their learners regarding plants, they often mentioned that they believed that their own apprehension towards teaching about plants had a significant influence on their learners' perceptions.

Participant 4 described the relationship quite clearly when she stated that "*that which you portray is also picked up by the learners*". Participant 2 also made the point that an educator cannot give what they do not have, referring to an interest and excitement about a certain topic. Participant 4 developed this idea even more when she explained that an educator who is excited about what they are busy teaching could also influence their learners to feel the same way about a certain topic.

4.8.5 Interrupting the positive feedback loop

The relationship between the perceptions of the participants and that of their learners was summarised quite succinctly in the final reflection given by Participant 4. She explained that the workshop caused her to acquire a positive outlook towards teaching about plants because she developed a greater interest into the ways Botany can be taught. This positivity, she continued, caused her to teach the topics about plants differently compared to previous years because she did not feel compelled to brush over the content as soon as possible. According to Participant 4, the perceptions of her learners towards plants were influenced by the positivity projected by their educator.

During the final reflection, multiple participants commented that teaching about plants during this year was more enjoyable to them than previous years. There are also many instances in which the participants imply that one of the reasons for their increased enjoyment of teaching Botany was the fact that their learners responded more positively to the content as opposed to previous years.

4.9 CONCLUSION

The purpose of this chapter was to present the findings of this study as it relates to the influence of an intervention on the plant blindness of Life Sciences educators. The approach that was taken with regards to the collection and analysis of data to ensure the findings are representative of the entirety of the intervention process for each participant was discussed. The findings were presented in the order that it was collected and grouped according to the various types of data sources. The presentation of findings was followed by general observations regarding the analysed data. Based on the entirety of data, it is clear that each of the participant educators were impacted by the intervention and that they felt that it also had an indirect influence on the learners they teach. There were reports of increased plant awareness and positive perceptions regarding plants on the part of educators and learners alike.

CHAPTER 5: DISCUSSION AND FINDINGS

5.1 CHAPTER OVERVIEW

This chapter presents summaries of the findings from the various data sources that formed part of this study and contextualises these in terms of the secondary research questions. The various themes relating to each research question are grouped together to ensure that a general answer for each of the questions is clearly discernible from the discussions. In addition, the findings that emerged during data collection and analysis are compared to previous studies and the international literature to indicate how this study contributes to the locus of research regarding plant blindness and education.

After discussions about the secondary research questions, a discussion on a novel theme which emerged from the data collected during this study is presented. Following this discussion, a graphical representation of a framework which could be used to understand the influence of an intervention on educators and their learners is proposed. The chapter concludes with discussions regarding the limitations of this study as pertaining to the research as well as suggestions for possible future endeavours to further pursue the findings of this study.

5.2 RELATIONSHIP BETWEEN THE INTERVENTION AND PARTICIPANT PLANT APPRECIATION

RQ 1: How much plant appreciation do educators show before they participate in an intervention aimed at improving plant appreciation?

The first aspect which was considered during the design of this study, was the plant appreciation of the participating educators. For the purposes of this study, plant appreciation simultaneously refers to a general awareness of plants as well an appreciation of its novelty and importance. The data were therefore organised into two themes, each of which speaks directly to one of the two aspects of plant appreciation.

5.2.1 Appreciation of the novelty and importance of plants

This theme involves findings that relate to the way participants were found to think about plants and the importance that they ascribed to it. The analysis of the data that were collected during this study, indicated that most of the participant educators had a modest appreciation of the novelty of plants and their importance prior to the intervention. This was congruent with the findings of Lombaard (2015), who also reported that educators in her study acknowledged the utility and importance of plants although they showed clear signs of zoochauvinism and plant blindness. There was, however, various indications that this intervention awakened seemingly dormant positive perceptions about plants in some of the participants and encouraged them to look at plants with a fresh perspective.

5.2.1.1 Participants' plant perception

The findings of this study are congruent with the existing literature concerning the perception of educators towards plants. Previous studies in the South African context found that educators generally do not like to teach about plants and have strong zoochauvinistic tendencies (Coetzer, 2019; Lombaard, 2015). From the data collected in this study, a disjunction was observed between the perceptions of the participants regarding plants and their perceptions regarding the act of teaching about plants. The majority of the participants in this study indicated that they like or even love plants. Three of the participants reported extensive interactions with plants in their personal lives. In some cases, these interactions were facilitated by grandparents who were traditional healers and in other cases, it was simply the fact that participants have their own garden which they tend. The family members seem to have fulfilled the role of plant mentors, which has been referenced in much of the literature regarding plant blindness (Borsos, Borić, & Patocskai, 2021; Hershey, 2002). The findings from this study concur with the suggestions made by Fritsch & Dreesmann (2015) as well as Wyndham (2010). These authors found that the familial context, especially parents and grandparents, is one of the principal sources for the formation of a person's knowledge and perceptions about plants.

It was, however, quite striking that all the participants had a negative perception towards teaching about plants, irrespective of their past exposure to plant mentors. An interesting perspective in this regard is the distinction between the perception of educators about plants in general, compared to the way they feel about actually teaching about plants. Lombaard (2015) found that, although some educators viewed plants in a positive light, they had negative perceptions about teaching the topic of plants to their Natural Sciences learners.

It is however noteworthy that participants explicitly stated that they like plants. These two observations about the participants' appreciation of plants should not be regarded as conflicting, but rather as reflective of the pervasiveness of plant blindness among educators (even those who do not specifically dislike plants). It is important to note at this point that when plant blindness is used as a description of participants' perception, it is not referring to an outright dislike of plants, but rather a lack of awareness of plants. This is clearly the case with all the participants who participated in this study.

Further exploration into the roots behind such apprehension to teach botany found that the educators were significantly influenced by the feedback they received from learners while teaching. This notion has been found in many previous studies which inquired into plant blindness and zoochauvinism in education, although it is merely given a cursory glance whenever mentioned (Conley, 2009; Lombaard, 2015). Lombaard (2015) made reference to educators stating that they prefer to teach about zoological or anthropological concepts because their learners seemed to relate better to those topics. One of the most notable accounts of such perceptions noted by Lombaard (2015) in Natural Sciences educators, involves an educator candidly admitting that the fact that she perceived that her learners did not enjoy the plant-focused topics was one of the reasons why she did not enjoy teaching about plants. It was clear from the data that the content to which learners respond negatively are perceived as unpleasant and laborious topics to teach by the participants. The opposite was also found to be true as there were many instances in which participants indicated that a positive response from their learners to a certain topic also had a positive effect on their own perceptions toward teaching that topic. From the

data collected at the start and early in the process of the intervention, a clear trend was observed in the changing perceptions of the participants towards teaching about plants. All the participants indicated that they did not enjoy teaching about plants. The most cited reason for this dislike of teaching botany was the influence of negative feedback from learners.

5.2.1.2 Learner plant perception

The participants were asked throughout to comment on the perceptions of their learners toward plant topics based on their perspective. The feedback in this regard was unanimous that the learners are generally disinterested in botany and do not enjoy it except when they are busy with practical work. These findings are in agreement with the relevant literature as many authors have reported the same disinterest among learners regarding plants. Some of authors point to misconceptions that learners often have about plants, while others report that learners are simply not interested in botany because of their botanical illiteracy (Lombaard, 2015; Uno, 2009; Yorek et al., 2009). Participants mentioned at various points during the research process that they were acutely aware of the fact that the learners are able to discern how their educators feel about the various topics that must be taught. In addition, it was the experience of all participants that the learners showed interest in content when they themselves show interest and the learners appeared dispassionate when the participants are perceived to be apprehensive towards teaching a certain topic. When this finding is considered in light of the crucially important role of educators as plant mentors, it is not surprising that Lombaard (2015) recorded instances in which educators spoke about the awareness of the impact that their negative perceptions about Botany have on their learners.

It was interesting to note, during the analysis and interpretation of the data from this study, that, although both the participants and their learners were not really excited about teaching and learning about plants, the perceptions of both groups improved during the time of the intervention. This finding was one of the main reasons for consideration of what seems to be a cycle of plant neglect and negative attitudes in classrooms as an

entirely separate theme. Although many studies have reported about both sides of negative perceptions (either learners or educators, or both), there are very few instances in the literature where these factors are explicitly construed as showing a causal or strong correlational relationship at the very least (Conley, 2009; Lombaard, 2015). This relationship between the attitudes of educators and learners on each other has been aptly referred to as a cycle of plant neglect by Stagg et al. (2020), although she proposed that this should not be regarded as an actual cause of plant blindness. Based on the findings of this study, it seems that it might be time to shift the focus away from merely trying to prevent plant blindness, which we know to be ubiquitous in most schools, towards addressing and preventing the perpetuation of negative attitudes towards plants. A more in-depth discussion of this suggestion is presented in Section 5.5 of this chapter which is labelled as: *Positive feedback loop between participants and learner perceptions***.**

5.2.1.3 Influence of the intervention on participant plant appreciation

It was important for this study to get an indication of the way in which participants thought about plants before starting the intervention as well as after its completion. None of the participants indicated that they disliked plants *per se*, but it was clear that most of the participants had some level of plant blindness and zoochauvinism. It is appropriate, therefore, to propose that these participants were essentially indifferent to plants. This indifference correlates with the findings of Lombaard (2015) who also noted that educators do not really dislike plants, but that they are also not excited or particularly interested when they consider such topics. Such apathetic attitudes are most likely the result of their own plant blindness in addition to their negative attitudes to teaching about plants because their learners responded with resistance and disinterest to plant topics. During this study, it became clear that the educators were either unaware of their own plant blindness, or simply accepted their negative attitude about plants as *status quo*. An important aspect in which this study's intervention proved to be useful was the fact that it made educators aware of their plant blindness. There were instances of participants conceding that they became aware of their own plant blindness after attending the

workshop where it was explained to them, after which they became determined to start addressing the issue.

The participants in this study unanimously reported that the workshop sparked a fresh interest in plants and caused them to feel motivated to teach plant-related content once again. One of the reasons the participants thought the workshop had such a positive influence on their interest was the fact that it presented them with novel ideas to consider regarding the teaching of botany. In addition, the Pl@ntNet mobile application added to the motivational factor of the workshop as participants were eager to use it in their own contexts. It was apparent that the guidance provided during the workshop on how to use the application and the various ways that it could be utilised to enrich teaching and learning was an important factor in persuading educators to rethink the way they taught botany.

In considering the reactions of the participants, it is likely that the fact that they were given a physical tool and a generic strategy on how to use it, sparked an interest in them and kickstarted the growth they experienced during the intervention. It is worth noting that this factor set this study apart from most other studies focused on plant blindness or plant appreciation. This was because it placed a tool in the hand of educators and allowed them to decide for themselves how it could best be implemented in their unique contexts The fact that the participants expected the learners to enjoy the use of new types of technology in their lessons also clearly had an influence on the way they felt about the prospect of teaching botany.

The idea of using mobile applications as tools to assist teaching and learning about plants has recently become one of the main ways in which researchers have attempted to address plant blindness and promote interest in learning about plants. Two of the most notable studies that followed this pathway were conducted with a focus on university students and both made use of another mobile application, somewhat similar to Pl@ntNet, which allowed the researchers to develop a treasure hunt for plants (Hartman et al., 2019; Kissi & Dreesmann, 2018). Embedded in the treasure hunt was a series of

questions of various kinds, which pertain to each of the plant species that needed to be found by using prompts.

Kissi & Dreesmann (2018) pioneered the first example of a study that examined the impact of mobile learning in a botanical garden taking into consideration the knowledge, attitudes, and motivation, after which Hartman et al. (2019) followed suit with a similar idea. Both these studies involved a single day in which the participating undergraduate students used the Actionbound mobile application to complete a treasure hunt. In the case of Hartman et al. (2019), the participants were given an introductory PowerPoint presentation where they were introduced to the way the Actionbound application works and informed about the logistics of the treasure hunt activity which followed thereafter. Both these studies found that participants' plant blindness was not meaningfully impacted, although they did report increased environmental awareness and positive attitudes towards the environment. Kissi & Dreesman (2018) speculated that the fact that their project did not have as great an impact as they had anticipated might be related to the duration of their study. This assertion was based on the fact that a much earlier study by Mittelstaedt, Sanker, & Van der Veer (1999), which involved a five-day summer school programme, found that student attitudes regarding the environment could be enhanced considerably through such a programme. Dillon et al. (2006) made a similar pronouncement about the notion that meaningful impact on attitudes and perceptions can only be achieved by programmes that last five days or longer.

During the design phases of the intervention that formed the backbone of this study, I considered these abovementioned suggestions. Consequently, the intervention was intentionally designed in such a way that it extended over a period of multiple weeks. Although the workshop in this study was a single event, participants were asked to reflect weekly about their implementation of what was learnt in a diary. This was an attempt to motivate prolonged engagement of participants with the ideas that were presented during the workshop.

This study provided support for what was proposed by Dillon et al. (2006) as it found that the attitudes and perceptions of participants were significantly impacted with regards to teaching relating to plants. It was interesting to note during the analysis and interpretation of the data from this study, that, although both the participants and their learners were not initially excited about teaching and learning about plants, the perceptions of both groups improved during the time of the intervention. This gives further credence to the idea that the attitudes of educators and their learners are influenced by each another.

5.2.2 Awareness of plants

The intervention clearly had a positive influence on the awareness that the participants and consequently their learners had concerning plants. All the participants noted that they ignored or neglected plants to some degree, especially while teaching prior to the intervention. Informing participants of plant blindness and the reasons why they might be concerned about it, was precisely one of the pivotal aims of the workshop which the participants attended. It was quite evident from the data that this simple bit of information was another imperative factor which contributed to a change in the participants' perceptions. In most cases, the participants were acutely aware of plant blindness among their learners (although not specifically by name), but they were blissfully unaware of the extent to which their own teaching was characterised by it.

The usefulness of the workshop, as described by more than one educator, was therefore that they were alerted to ways in which they were neglecting plants and underemphasising them in comparison to other topics. In this regard, the weekly diary was mentioned as being another important factor in the process as the act of reflection guided educators in the process of discovery about the ways in which their teaching was anthropocentric and zoochauvinistic. Once the participants became aware of the problem in their perception and way of teaching, they soon felt compelled to make efforts to address it.

One way that this played out during the intervention was that participants suddenly became very attentive to their learners and themselves, looking for signs of plant

blindness and lack of plant appreciation. When they inevitably found the signs thereof, most of the participants immediately started to address these by pointing them out to the learners and guiding them to think differently about plants.

There was ample evidence that the fact that all the participants made use of the Pl@ntNet application during the intervention was instrumental in increasing their own plant awareness. The ease of use and ability to gain access to information about plants meant that participants felt less intimidated to explore new plants in their environments, both at school and at home. Unsurprisingly, these interactions caused the participants to become better acquainted with those plants and more aware of them in the future.

The impact of this close interaction with plants and the lingering of the participants over plant-related content which they would previously have rushed through, also had an observable impact on the learners who are taught by the participant educators. Four of the educators described, with disbelief in some cases, that (during the time of the intervention) their learners seemed to have become more interested in the botany content which they had previously regarded as boring. It is worth noting at this point that the participants who saw positive changes in their learners' plant awareness after the intervention, were precisely those educators who were the most intentional in addressing the lack thereof during their teaching by implementing what they had learnt from the workshop.

5.3 UTILISATION OF THE INTERVENTION BY PARTICIPANTS

RQ2: How do educators utilise a designed intervention in their daily teaching to promote plant appreciation?

5.3.1 How participants used their knowledge base

It was interesting to note that, once participants became aware of the necessity of addressing plant-blindness and realised that it can be done, they started to apply their knowledge base in diverse ways. One way was the instance in which participants

incorporated their indigenous knowledge of useful and medicinal plants into their teaching to foster an appreciation for plants among their learners.

Another way that teaching was intentionally enriched through an educator's knowledge involved the participants adding to that which is prescribed by the CAPS curriculum from what they learnt during their tertiary education. An example of such a case is the addition of plants to the conversation about taxonomy and classification to emphasise the fact that plants are classified just like all other living organisms (which is not part of the prescribed curriculum content). There were many other instances noted throughout this study where participants were not teaching content that had any reference to plants, but still found creative ways to incorporate plants into their teaching.

5.3.2 How participants utilised the Pl@ntNet mobile application

The Pl@ntNet mobile application was undoubtedly the factor which participants were most excited about. It was clear from the reflections about this application that all the participants considered it to be a tool which could be used to add interest to their teaching. There was also a strong sense among the participants that they felt empowered by having easy access to information about any plant which they might encounter. One of the noteworthy applications involved a participant replicating all the important aspects of the workshop, excluding the treasure hunt activity, in her own classroom. She made use of the Pl@ntNet application by guiding her learners to use it to identify plants which they had brought to school. She explored the additional information which is obtainable through the database of the application to facilitate learner-centred activities in which learners used the application in addition to worksheets that she had designed to teach content about plants.

Those participants who faced the challenges of time constraints and large classrooms, still found ways to use the Pl@ntNet application while they were teaching about plant families and in some cases, guided leaners to use the application themselves.

The two participants who teach Grade 10 learners communicated disappointment about the fact that they were not able to use the application as part of the prescribed environmental project. This was because the Department of Education had changed the order in which certain topics should be taught, which postponed the project to later in the year, causing it to fall outside the scope of this study. They were both insistent about their resolution to implement their plan once the time arrived to do the project with their learners and use the Pl@ntNet application as a resource.

An unexpected way that participants were found using the Pl@ntNet application was in their personal and family life. There were instances of participants reporting the use of the application while at a hardware store or in a mall when they saw a plant that interested them or which they wanted to buy. Several accounts also described how participants used the application on their own while moving about on the school grounds to identify plants which they knew in their home language and or to acquire information of plants in their own gardens. It is safe to conclude that the Pl@ntNet application sparked curiosity in the participants which caused them to become more inquisitive about plants which they would have normally ignored and therefore increased their plant awareness substantially. Various participants also related how they showed the application to their friends and family and experimented with its use in that way.

Based on these observations and discussions, it appears that this personal interaction which the participants had with the Pl@ntNet application played a crucial role in increasing their plant awareness and caused them to become excited about teaching botany for the first time in many years. It is also worth noting that this process happened entirely as a result of the participants' own initiative, which means that this change of heart regarding plants could potentially be sustained long after this intervention.

5.3.3 General application of the intervention

This sub-theme considered all the ways in which participants responded to the intervention and applied what they had learnt during the workshop. Many participants indicated that the workshop which they attended was eye-opening and that it had a very

positive impact on them. During this workshop, they learnt about what plant blindness is, they were shown the Pl@ntNet mobile application, they were guided through a process of learning how to use it themselves and then shown an idea of how it could be used in the context of the classroom. It was clear from the plant perception questionnaire (which was done prior to the workshop) that all the participants were strikingly aware of the negative perceptions that are held by their learners toward plants and especially toward learning about plants. This was because these participants experienced it first-hand during their time of teaching Life Sciences.

Many of the participant also conceded that, prior to this intervention, they had accepted that learners dislike learning about plants and were not motivated to try to change that attitude. Therefore, it was interesting to see that once the participants had attended the workshop, they immediately started to think about the ways in which they could replicate a similar experience for their learners. It was clear that all the participants were optimistic that their learners would respond positively to the new ways they were planning to approach the teaching of botany in their classrooms.

Some participants endeavoured to replicate certain parts of the workshop in their own classrooms as they were curious about the impact that it could have on their learners. These participants used the same approach used during the workshop to identify plant blindness in their learners and reported a strong motivation to start addressing it right away. Furthermore, the participants found creative ways to use the ability to identify plants through the Pl@ntNet application into their teaching. All the participants reported that they became surprisingly aware of the ways their learners related to plants and there were numerous instances where the participants addressed plant blindness in their learners as soon as they recognised it.

One common way that participants addressed their learners' plant blindness was to continually emphasise that plants are just as alive as animals. These participants communicated that their learners often do not even consider plants as alive. This confirms that such misconceptions, which have been discussed extensively by Yorek et al. (2009),

are also present in South African Life Sciences classrooms. These misconceptions were continually addressed by subsequent teaching, which resulted in a perceivable decrease from the participants' perspective. This finding is in line with the findings of Strgar (2007) and Borsos et al. (2021) who reaffirmed the tremendous influence that educators can have on their learners when they become intentional about being plant mentors.

Another interesting way to address their learners' appreciation of plants was by teaching them about indigenous knowledge regarding useful and medicinal plants. During the time of this study, as the coronavirus pandemic was at the forefront of everyone's minds, these educators focused on plants that are used in traditional medicine to fight flu and other illnesses. This was well received as the demographic of the learners in these participants' schools is such that many of the learners have previously been exposed to traditional remedies. The two most prominent examples used were *Artemisia afra*, otherwise known as Lengana and *Siphonochilus aethiopicus* which is otherwise referred to as Serokolo.

Although the participants indicated that they thoroughly enjoyed the treasure hunt facilitated during the workshop, none of them made any attempt to replicate it in their own contexts. This finding corresponds with the previous studies that also used the idea of a treasure hunt in which participants indicated that they found the treasure hunt for plants to be quite enjoyable (Hartman et al., 2019; Kissi & Dreesmann, 2018). The most probable explanation for the lack of implementation of the treasure hunt idea in the participants' own contexts pertained to the most cited barrier to attempting any learning outside the classroom, which was the large number of learners in each class group. The general perception was that they would only be willing to consider learning outside the classroom if they had an assistant or colleague present to assist with the discipline of their learners.

The solution to this challenge, which was adopted by four of the participants, was to bring plants into the classroom and facilitate interactions with it in the space where they felt able to manage their learners more effectively. During the time of this intervention, participants showed creativity in the ways they brought plants into their classroom. One participant instructed each of her learners to bring a plant to school. She encouraged

them to name the plants and started an initiative which resembled what has been described in the international literature as the ‘Pet Plant Project’ (Krosnick et al., 2018). Similar to the findings of Krosnick et al. (2018), this act of encouraging more personal interaction with plants similar to that with a pet, resulted in a definite impact on learner plant blindness.

Previous studies have shown that learners enjoy learning when it involves practical interactions and this aspect was once again confirmed during this study (Kissi & Dreesmann, 2018; Luera & Otto, 2005; Uzunboylu et al*.,* 2009).

5.3.4 Perceptions and suggestions regarding the intervention

The final evaluation of the intervention from the perspective of the participants was that it was useful to them in multiple ways. In general, the participants considered the workshop as the most useful aspect of the intervention The fact that they were informed about plant blindness and were given a tool with which they were able to start addressing it in their teaching, changed the way in which they thought about teaching plant topics and resulted in them being pleasantly surprised by the impact it had on them as well as their learners.

It became apparent during the time of the intervention and after its completion that the lack of access to mobile data was one of the most influential barriers to learners buying into the use of the Pl@ntNet application. It was clearly a frustration to some of the participants and detracted from the positive impact that could have been experienced both by the educators and their learners. This challenged the participants to think outside the box and find ways to work around the challenge by using their own mobile data and cellular phones or by dividing learners into groups which contained at least one learner with the necessary cellular data required for the interactive activities. Recent new developments in the design of the Pl@ntNet mobile application involve an offline version of the application which would no longer be dependent on mobile data to identify plants. This would be very useful for future iterations of an intervention such as the one proposed in this study as it would directly address one of the major challenges reported during this study regarding the use of the Pl@ntNet mobile application. The fact that the participants

were able to use the Pl@ntNet application in their personal capacity, had a considerable influence on their plant awareness as the intervention progressed.

Although the intervention was regarded as generally useful, there were some factors which participants mentioned which could allow it to be even more useful. One such suggestion was that the intervention be redesigned to align more closely with the CAPS curriculum. Multiple participants mentioned this suggestion and especially referred to the way that it could be easily and effectively integrated into the environmental studies project prescribed for Grade 10 learners. The most common suggestion for future interventions was that it be implemented on a much larger scale to involve more participants. There were even some participants who insisted that the intervention should be presented to the Department of Education so that they can disseminate it as their reach is able to access more educators.

5.4 INFLUENCE OF THE INTERVENTION ON CONFIDENCE AND KNOWLEDGE BASE OF PARTICIPANTS

RQ3: How does an intervention influence the confidence that Life Sciences educators have and the knowledge base that they use when teaching toward fostering plant appreciation?

5.4.1 Influence on participant knowledge base about plants, plant blindness and resources

The participants were expressly asked ahead of the workshop whether they knew of any examples of resources that could facilitate teaching and learning outside the classroom. None of them were aware of such resources and as more data emerged from the research, it became clear that the participants were all using the standard technological aids in their classrooms like overhead projectors and PowerPoint presentation software. Such use of age-old methods of teaching has been the norm in the majority of classrooms, both internationally and in the South African context (Bolkan & Griffin, 2018; Cerbin, 2018; Coetzer, 2019; Lombaard, 2015). They were transparent about the fact that they disliked teaching about plants and seemed at their wit's end with regards to the disinterest they

noted amongst their learners regarding plants. This is not surprising when it is considered through the lens of recently published literature which found that learners are bored during lessons where they are merely passive receivers of knowledge and that a diversification in teaching strategies is one of the most effective ways of sparking their interest (Bolkan & Griffin, 2018; Goetz & Hall, 2014). It was therefore an exciting experience to all the participants to be introduced to a new resource which is free, easily accessible and has the potential to help them add interest to their botany teaching. The general consensus among the participants was that identifying plants and classifying them according to scientific names was challenging.

The Pl@ntNet application served to fill that gap and allow participants to have easy access to such information about the plants in their immediate surroundings. Some of the educators commented that they suddenly felt like they had information at their fingertips, and this made it easy for them to increase their knowledge base about the plants around them. There are no similar studies in the local or international literature that have focused on such an intervention. A similar recent study inquired into the impact of a plant-based Android mobile application on learner attitudes and perceptions (Aldya & Arifendi, 2021). One of the key findings of that study was that active learning activities, especially those that involve physical interactions with real plants resulted in significantly deeper understanding of taught content compared to the use of merely PowerPoint presentations and chalk-and-talk teaching (Aldya & Arifendi, 2021).

One of the main contributions of this study is that it sheds light on the way in which an intervention which also utilises mobile technology and novel teaching approaches, can impact Life Sciences educators. The vast majority of studies into plant blindness and interventions to combat it is aimed at learners while disregarding the importance of educators as well-positioned agents of change if they can be assisted properly. This study found that a simple prolonged intervention can result in a meaningful increase in educators' knowledge base.

5.4.2 Influence on confidence of participants

The plant perception questionnaire, which participants completed at the beginning of the research process, found that all the participants considered themselves to be confident when teaching about plants. An important distinction in this regard is the difference between feeling confident about teaching plant-related content straight from a textbook and using physical plants from the immediate environment as a means to constructivist teaching and learning. None of the participants in this study felt confident about the latter form of teaching. This finding is congruent with that which was reported by Garbett (2011) regarding the relationship between confidence and constructivist pedagogy. She suggested an important prerequisite for constructivist teaching and learning is that educators should feel confident about their ability to answer any type of question regarding the plants they choose to incorporate into their teaching. Because the participants in this study had access the Pl@ntNet mobile applications, they felt more confident and empowered to facilitate learning experiences with plants with a sense of freedom and fearlessness. This positive impact on participant confidence is similar to what Goodwin (2008) found among primary school educators when they were challenged to teach about plants in the context of a school garden. Similar to this study, Goodwin found that participants became more confident about plants and gardening as a result of the training they had received, and this ultimately led them to start using plants more often during their lessons. In addition to the obvious access to information, some participants reported a renewed feeling of self-assurance as they started to teach about plants during the year of this intervention because they were convinced that their learners would respond positively to a fresh technological approach to their teaching.

5.5 POSITIVE FEEDBACK LOOP BETWEEN PARTICIPANTS AND LEARNER PERCEPTIONS

Some of the findings from this study can be considered as largely confirmatory of conclusions that have been made by previous studies in the context of plant blindness and education. Similar to what was found by Lombaard (2015) in the South African

context, this study found some plant blindness to be present in the educators that participated in this research. Additionally, it also found evidence that the negative perceptions educators harbour towards teaching about plants have their origins in two arenas. Firstly, the majority of the educators have an educational background wherein zoochauvinism and anthropocentrism characterised most of their learning. Some of the participants reported observing negative perceptions toward plants in their educators at school and universities and all the participants admitted to having some plant blindness themselves.

It is therefore one of the findings of this study that the background of an educator has a significant influence on whether they would end up with plant blindness themselves. Interestingly, not even the impact of strong plant mentors in the form of a relative who was involved with plants could mitigate the negative perceptions that participants were exposed to elsewhere, especially at school and university. It should be noted that this study found that, although there was evidence for some plant blindness in participants, the majority of findings point to plant neglect or lack of plant awareness. The reason for this neglect was the negative feedback that educators received from learners when they taught about plants. Previous studies have also found the influence of learner feedback to be instrumental to shaping educators' perception about certain topics (Lombaard, 2015).

Furthermore, this study also found anecdotal evidence from the participants that the perceptions of the learners they teach are influenced by the way they present certain content. Simply put, when educators are enthusiastic about content, learners tend to respond positively and when educators seem disinterested in content, the learners also mirror that perception. This finding confirms what has been proposed by various researchers in previous studies (Borsos et al., 2021; Lombaard, 2015; Strgar, 2007). This should not merely be regarded as a negative finding, because it holds the possibility of being used to combat plant blindness in a lasting and impactful manner. By drawing on the idea of the educator as a positive plant mentor, as proposed by Hershey (2002), Strgar (2007) suggested that plants can be presented to learners as intrinsically interesting if

educators with appropriate insights are able to share their own interest in plants with their learners from their place of influence. One way in which this relationship between educator and learners could be represented is in the form of a positive feedback loop, as shown in Figure 5.1. A positive feedback loop is a concept which is often used in the Life Sciences to describe a self-reinforcing system in which a stimulus causes an action, which in turn, results in an increase in the initial stimulus (Biology dictionary, 2021). Such a system, once initiated, can be self-amplifying and continue indefinitely, unless an external stimulus interrupts the feedback loop. In the case of learners and educators, the negative perceptions held by educators about plants perpetuates a negative perception among learners, and that further reinforces negative perceptions in educators.

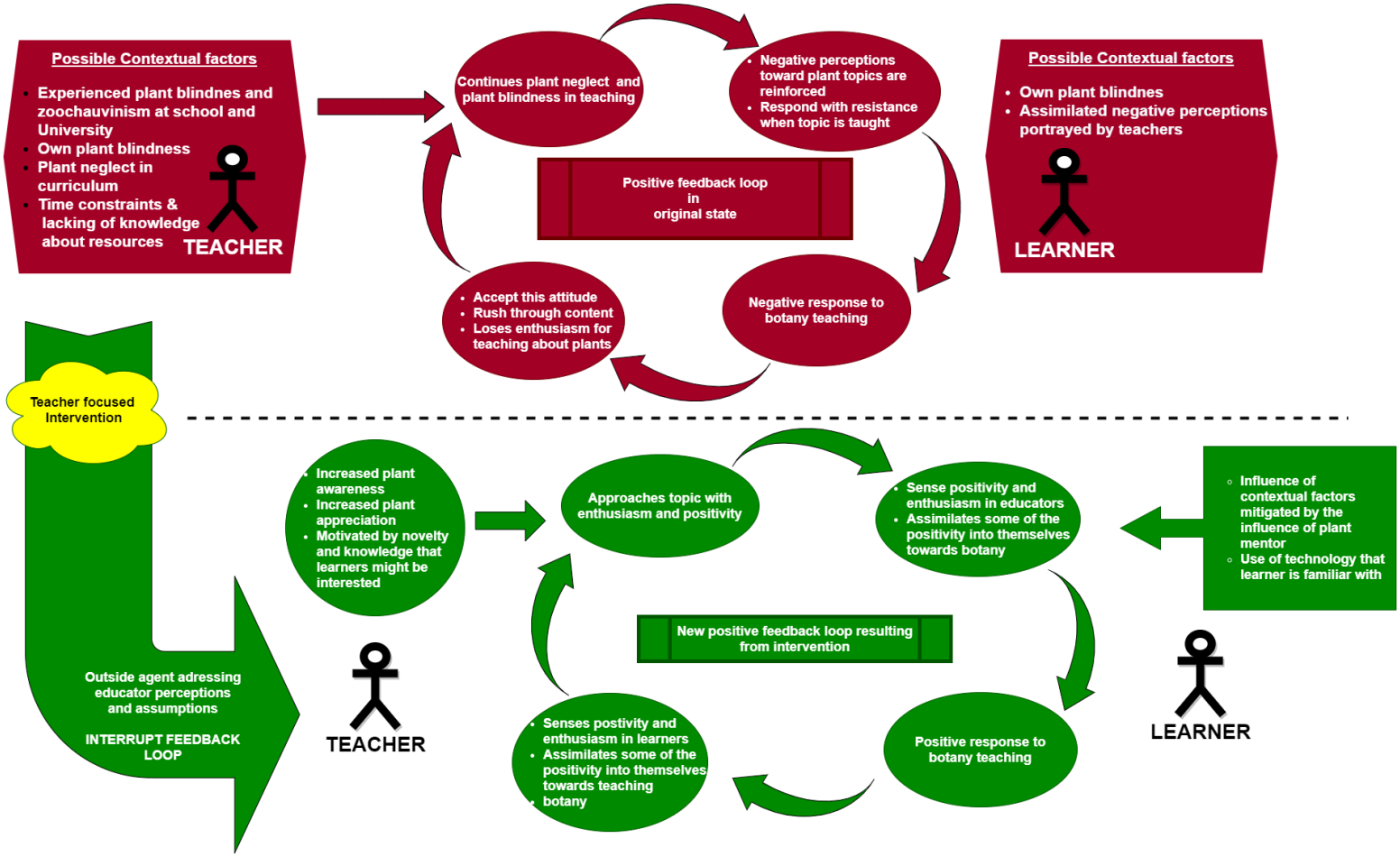

Figure 5.1: Positive feedback loop and the interrupting effect of an educator focused intervention

- *The top section of this diagram shows the positive feedback loop which takes place under normal circumstances in the absence of an external influence.*
- *The bottom section shows the alternate positive feedback loop which is initiated as a result of an external educator focused intervention.*

The diagram in Figure 5.1 shows that both educators and learners have contextual and background factors which impact the way they think about plants. In the case of educators, some of these factors include the influence of their educational background, their own plant blindness, plant neglect in the curriculum, time constraints and lack of knowledge about resources to teach about plants in exciting and engaging ways. In the case of learners, some important factors include their own plant blindness and the positive or negative perceptions which they adopted from previous educators who might have presented plants as a negative or unexciting topic. One of the participants in this study aptly summarised the experience of the learners as they progress through primary and secondary school. She explained that when the learners come into her classroom and see her admittedly negative perception regarding plant topics, it is probably not the first time they have encountered it. This is because there is a strong possibility that their previous educators also presented plants in a negative light during their teaching and that these learners have adopted some of those perceptions into their own frame of reference.

Multiple efforts have been made to address plant blindness in learners with varied outcomes (Stagg et al., 2020). This study, however, started with the assumption that educators have the opportunity to have a strong influence on learner perceptions regarding plants by taking up the role of plant mentor, as suggested by Hershey (2002). Based on this knowledge of an educator's influence on learners and their perceptions, it is likely the case that, unless there is a significant change in the perception of an educator with a negative perception toward teaching botany, no lasting change can be produced through learner-focused interventions. This assumption is based on the knowledge that learners are strongly influenced by their educators in terms of the way they teach about certain topics (Wubbels & Brekelmans, 2005). By following this logic, it seems obvious that the best place to start any endeavour at combatting plant blindness and fostering plant appreciation is by focusing on educators first.

During the course of this research project, an intervention was designed which was aimed at addressing plant blindness in a group of educators from differing contexts. This

intervention consisted of a one-day workshop and subsequent implementation phase which was coupled with weekly reflections by participants. The workshop constituted the most important part of the intervention, and its aims were twofold. Firstly, it attempted to inform the participants about plant blindness and its importance, after which a simple test was done to show participants how prevalent this phenomenon is and possibly even expose it amongst themselves. The second aim was to introduce a technological aid (the Pl@ntNet mobile application), which is freely accessible and easy to use. This mobile application was presented to the participants as a tool which could assist them in making their teaching more engaging and exciting to learners. This introduction was coupled with a demonstration of the application and an opportunity for participants to use it for themselves and see how it could be implemented in the classroom as well as outside with a plant-based treasure hunt. Participants were then encouraged to find creative ways to incorporate what they had learnt during the workshop in their own unique contexts and reflect on it weekly in their diaries.

As the study progressed, it became evident that the weekly diary was crucial to the success of the intervention. Most of the participants reported facing challenges and barriers during the implementation phase, but evidence was found that the mere fact that participants knew that they would have to write something in the diary, compelled them to press through the challenges and find creative solutions. Moreover, the prolonged implementation phase essentially extended the amount of time the educators spent on taking part in the intervention. The decision to strategically prolong the time of the intervention was based on suggestions from the two most notable studies regarding plant blindness, mobile learning and treasure hunts (Hartman et al., 2019; Kissi & Dreesmann, 2018). Both these groups of authors suggested that the impact of an intervention could be amplified if it was to be extended over a period of time which exceeds five days. This assertion was based on the earlier suggestion made by Dillon et al. (2006) with regards to the ideal length of an intervention.

Another aspect which set this study apart was the fact that it collected a large amount of rich data throughout the entire process. Data was collected before the intervention, during

the implementation and after its completion. This allowed the researcher to gain a global perspective of the influence that this intervention had on the participants' plant appreciation as well as that of their learners (as reported by the participants).

This study found that the intervention was able to successfully interrupt the positive feedback loop which perpetuated negative perceptions between educators and learners regarding botany teaching. Participants reported a renewed enthusiasm to teach botany with the use of the Pl@ntNet application after the intervention. In addition, many participants were eager to spot plant blindness in their learners and attempt to address the issue during their teaching. The data which were collected regarding the implementation of the intervention, showed that the technological factor (in the form of the Pl@ntNet mobile application) coupled with the renewed enthusiasm from the participants, had a noticeably positive impact on their learners. From the data collected, a strong correlation was found between the degree to which participants implemented what they had learnt during the workshop and the degree to which they observed a change in their learners' perceptions.

5.6 CONCLUSION

In this chapter, the findings of this study according to themes that pertain to each of the secondary research questions was presented. The findings were discussed in terms of their significance and their relation to previous research in the South African context as well as international research. I elaborated on the conceptualisation of the proposed positive feedback loop between educators and learners as a novel way to consider the ways that plant blindness can be addressed in classrooms. Additionally, a diagrammatic representation of the way that such a positive feedback loop manifests in typical classrooms was presented as well as the influence that an intervention could have to produce increased plant awareness and appreciation in educators and learners.

CHAPTER 6: CONCLUSION

6.1 INTRODUCTION

This chapter is the final chapter of this study and briefly describes the most important findings in relation to each of its research questions. A brief summary is provided of the main contributions of this study to the ongoing conversation about plant blindness in education, especially in the South African context.

6.2 CONCLUSIONS IN RELATION TO THE SECONDARY RESEARCH QUESTIONS:

RQ1: How much plant appreciation do educators show before they participate in an intervention aimed at improving plant appreciation?

The educators who participated in this study were found to have positive perceptions about plants in general, although the majority of participants had a pronounced lack of plant awareness. The data collected in this study uncovered plant blindness, zoochauvinism and anthropocentrism in each of the participant educators and the ways they chose to teach. These findings align with all other research which has inquired into plant blindness in educators, both internationally and in South African classrooms (Balding & Williams, 2016; Coetzer, 2019; Kinchin, 1999; Lombaard, 2015; Pany, 2014; Stagg et al., 2020). Many of the participants were found to have admittedly neglected plant topics and rushed to finish them because they did not find it enjoyable to teach botany. With regards to the reasons why the participants felt unexcited by the idea of teaching about plants, this study uncovered two main reasons for the dislike of plant-related content. The most prominent factor which caused the participants to dislike teaching about plants was the negative feedback they consistently received in previous years when they taught botany. The fact that these educators continually received negative responses from their learners resulted in them also adopting the negative perceptions toward plants, even if they liked plants in their private capacity. Therefore, a clear distinction was observed between educators' general perception about plants and the way they feel about teaching content pertaining to plants.

Although data were not collected directly from the learners who were taught by the participant educators, this study was able to formulate a reasonably clear picture of the way that the educators perceived learners to respond to plant topics in class. This study found that the educators unanimously agreed that the overwhelming majority of their learners did not like learning about plants. After re-enacting parts of the workshop presented during this study, multiple participants confirmed the presence of plant blindness in the learners whom they teach. An interesting finding in relation to the learners is that the participant educators seemed acutely aware of the fact that their own negative perceptions could be easily perceived and adopted by their learners. This notion that learner interest and attitudes are affected by what they perceive their educator's attitudes to be, supports earlier findings by Strgar (2007) and more recently findings from research conducted by Parsley (2021). In both these studies, it was concluded that learners tend to become invested in subjects in which their educators seem interested (Parsley, 2021).

This study corroborates the findings of Lombaard (2015) who focused on Natural Sciences educators and found plant blindness and zoochauvinism to be present among the majority of learners and educators. This is consistent with the international literature regarding plant blindness in education. Plant appreciation was lacking in all the participants in this study.

RQ2: How do educators utilise a designed intervention in their daily teaching to promote plant appreciation?

From the start of this study, participants were enthusiastic about the workshop and what they had learnt with regards to the way it would impact their teaching. This study found that the intervention was able to inform participant educators about plant blindness and guide those educators to become aware of plant blindness in themselves and their learners. Furthermore, the intervention was found to provide participants with a fresh perspective with regards to the way that they could teach plant topics in their own contexts. The Pl@ntNet mobile application was well received by the participants in this study and was perceived by the educators as a useful tool to assist them in teaching botany in more interesting and engaging ways. Consequently, most of the participants

found interesting ways to incorporate the use of the Pl@ntNet application into their teaching and reported significant improvements in their own perceptions about plant-related topics as well as the perceptions of their learners. This also speaks to the literature on interventions and the ways in which the idea of constructive, active learning could be used to address the lack of interest in learners (Aldya & Arifendi, 2021; Cerbin, 2018). Once the educators in this study became aware of the problem in themselves and their students, they responded in accordance with the suggested approach of addressing this phenomenon (Aldya & Arifendi, 2021; Bolkan & Griffin, 2018). These participants were therefore seen to implement novel teaching strategies and fresh approaches to give learners the opportunity to personally interact with the plants in their immediate surroundings.

None of the participants implemented a treasure hunt at their schools, citing challenges regarding class management and large group sizes as the main reasons. An important consideration that is needed with regards to the implementation of the treasure hunt idea is one of the fundamental differences between the two previous studies and this study (Hartman et al., 2019; Kissi & Dreesmann, 2018). In the previous two studies, the researchers designed a treasure hunt and facilitated it, compared to this study in which participants would have had to plan their own treasure hunt at their own school to replicate it. Taking into account the time constraints and other challenges that were reported by the participants of this study, it is not surprising that none found time for a treasure hunt. The participants did, however, use the Pl@ntNet application to identify plants and some guided their learners to use the application themselves as part of learner-centred teaching activities. Interestingly, many participants reported that they often used the Pl@ntNet mobile application in their private lives, which caused them to become more aware and interested in plants and develop more positive perceptions with regards to teaching botany.

It is also worth noting that the prolonged implementation of the intervention (spanning multiple weeks) was entirely driven by the individual participant educators. This, therefore confirmed that an intervention could have a lasting impact if it can successfully inform,

inspire, and empower educators to rethink the way they teach botany. Incidentally, the fact that the educators continued to rethink and reform their botany teaching meant that learners continued to reap the benefits thereof, thereby continuing the indirect impact of the intervention. This finding is not new to the literature about interventions relating to plant blindness as Aldya & Arifendi (2021) have recently described a similar progression. Once educators move away from using a traditional mode of teaching (PowerPoint presentations and textbooks) to utilising more engaging ways of teaching and learning, student interest invariably increases regarding the topic that is taught. Furthermore, studies have found that learners give attention to, and work harder in contexts where they are interested and stimulated by active participation and the usage of mobile technology to enrich the learning process (Aldya & Arifendi, 2021).

The use of the Pl@ntNet mobile application during this study to identify and acquire information about plants in the immediate environment found a similar impact on learner attitudes and interest. The general idea behind using technology as a means to spark learner interest is the fact that the current generation of school-going learners are very preoccupied with their mobile phones and prefer to spend their time interacting with it (Bureau of Market Research, 2015). In a sense, the use of mobile applications as portals through which a new generation of learners can learn about plants, extends their existing interest in an attempt to increase their receptiveness to learn about the educational content in which they are able to interact with their mobile devices. Recent studies have proved this to be a possible solution to the lack of learner interest in many classrooms, especially when botany and environmental studies are taught (Aldya & Arifendi, 2021; Hartman et al., 2019; Kissi & Dreesmann, 2018).

RQ3: How does an intervention influence the confidence that Life Sciences educators have and the knowledge base that they use when teaching toward fostering plant appreciation?

This study found that the participant educators were confident with regards to teaching plant-related content from textbooks and PowerPoint presentations, as prescribed by their respective school curricula. Initially, apprehension was observed regarding the idea of

taking learners outside the classroom or attempting to make use of the plant diversity on school premises to enrich teaching of botany and environmental studies. The main reason for the apprehension was the lack of training that the educators received regarding plants. The majority of the participants in this study only had limited exposure to plant-focused subjects during their tertiary education and none of them felt confident about their abilities to identify and acquire information about the plants in their surrounding environments. The Pl@ntNet mobile application was quite helpful in this regard, as it allowed educators to have instant access to information about any plants they encountered. This newfound access to information caused the participant educators to become more confident about using different plants in their teaching as they felt assured that they would be able to answer any questions that learners might ask about the plants used in the teaching.

6.3 CONCLUSIONS IN RELATION TO THE PRIMARY RESEARCH QUESTION:

What is the influence of an intervention on the plant appreciation in subsequent teaching of Grade 10 and 11 Life Sciences educators?

Much of the findings from this study confirms findings of previous research, both internationally and in the South African context. A novel contribution to the conversation surrounding plant blindness in education is the conceptualisation of a framework that posits a positive feedback loop between educators and learners which seems to be present in a large number of classrooms around the world. Although the findings of this study generally confirms what has been found in previous research regarding plant blindness in learners and educators, a framework was developed which combines all the relevant ideas about plant blindness and how it could be addressed (Lombaard, 2015; Parsley, 2021; Stagg et al., 2020). Based on the findings from this study and the plethora of research regarding the role of educators as plant mentors, this study proposes that the focus of combatting plant blindness should shift away from learners and onto educators. The reasoning behind this proposition is the fact that educators have a prolonged impact on learners which will outlast most attempts at combatting plant blindness in learners (Hershey, 2002). Therefore, if plant blindness and botanical illiteracy is not addressed in

educators first, any attempts at addressing plant blindness in learners could easily be undone by their educators.

This study found that an educator-focused intervention, such as the one that was designed for this study, could interrupt the positive feedback loop of negative perceptions about plants and kickstart an alternate positive feedback loop in which positive perceptions about plants are amplified and sustained. Moreover, this type of change in plant appreciation might have a better chance of being sustained over time as it is self-reinforcing.

By positing this new framework, the study does not propose to disregard previous efforts to combat plant blindness. Rather, it aims to provide a new perspective on the way that plant blindness can be addressed and possibly encourage more research into whether or not the positive impact that this study has observed, could be replicated by future endeavours.

6.4 LIMITATIONS OF THE STUDY

As this study was fundamentally exploratory and aimed to make a novel contribution to the field of Life Sciences education research, some limitations emerged. The first, most obvious limitation, is that of the relatively small sample size which this study considered. This is regarded as a limitation as small samples such as considered in this study, cannot be used to extrapolate findings and conclusion to wider, general groups of individuals. The findings of this study can therefore only speak with confidence about the contexts of the participants who participated in the research. It should however be noted that the data consisted of five different sources of rich data with thick descriptions of events and thought processes which were collected from participants in varying contexts, at different times during the duration of the study. It is therefore not implausible to assume that the conclusions drawn from this study would be representative of many other educators in similar contexts in the South African educational system. The reasoning behind justifying a smaller sample size in light of the depth and quantity of data collected is in keeping with Vasileiou, Barnett, Thorpe, & Young (2018) who suggested that the focus should shift

away from the number of participants in a study to rather consider data adequacy. According to Vasileiou et al., (2018), a small sample can still provide adequate amounts of data by considering a variety of data types and ensuring that the collected data is rich in meaning and contains thick descriptions of context in relation to the various ways that data is collected.

Another limitation of this study was that the data collected about the perceptions of learners were anecdotal and did not constitute proof of increased academic performance or feedback directly from the learners. The scope of this study did not allow for this additional type of data collection as the Covid-19 restrictions meant that no research directly involving learners was possible. The researcher did, however, consider this limitation during data analysis and made an effort to interpret the data regarding learner perception in light of other research which concurred with the findings of this study.

The fact that schools were required to maintain strict social distancing protocols meant that most of the participants in this study only saw their learners every second day, thus effectively causing them to lose fifty percent of contact time. This caused the educators in the affected schools to feel pressured to finish the curriculum in time, which made it challenging to find time to implement new and novel ways of teaching (especially constructivist-type teaching).

It should also be noted that the purpose of this study was merely exploratory, which means that the design of an infallible intervention was not one of its goals. Rather, this study merely inquired about the possible influences that an educator-focused intervention could have on developing educator plant appreciation as, at the time of this study, no other research has offered insight into this question in the South African context, with the exception of research conducted by Goodwin (2008).

6.5 FUTURE RECOMMENDATIONS

This study found that an educator-focused intervention could interrupt positive feedback loops that exist between educators and learners regarding plants and the teaching of

botany. Future pursuits which could follow from this study might endeavour a redesign of the intervention to find ways to make it more applicable to the South African classroom. One of the major challenges that needs to be addressed is the lack of cellular data which was reported by all participants. This challenge meant that many learners were not able to contribute to the learning activities themselves. Current developments of the Pl@ntNet mobile application seems to paint a hopeful picture with regards to the challenge of requiring mobile data for its use. Finding a solution to this challenge might prove to be crucial in ensuring the effectiveness of an intervention. At the time of this study, correspondence with the Pl@ntNet team revealed that they planned on releasing a version of their application which would allow for offline use. In addition, it might be fruitful to consider broadening the scope of data collection to involve both educators and learners. The implementation of an intervention focused on educators could yield new insights into the ways of influencing learners. When the participants of this study were asked for suggestions regarding possible future iterations of the interventions as was presented during this study, the most common proposition was that it should be introduced to other schools for the benefit of a larger number of educators. Therefore, it is plausible to consider the possibility of allowing a larger number of schools to participate in future interventions, especially once it has been refined and successfully aligned to the CAPS curriculum. Furthermore, this study found it to be quite necessary to inquire further into the relationship between the attitudes of educators and the attitudes of the learners they teach.

Although some research has been done in this regard in the international context, there is no study that has enquired specifically into such a relationship and its ramifications on the quality of learning that takes place in Life Sciences classrooms. This study, along with research by Lombaard (2015) confirmed that such a relationship exists in South African classrooms, although very little is known about its actual dynamics and to what degree the relationship is causal or correlational.

6.6 A FINAL WORD

The motivation to conduct this research arose from a personal struggle as a Life Sciences educators with plant blindness in myself and the learners I teach. Once I became aware of the pervasiveness of plant blindness and its detrimental impact on various spheres of society, I became passionate about becoming part of the solution. In this study, it was immensely encouraging to observe educators from differing backgrounds and contexts, who had struggled with plant blindness and lack of motivation to teach about plants, become excited about teaching botany for the first time in years. The need for the educational community to embrace technology, and especially mobile technology, more fully was reaffirmed during this study. Additionally, the need for creative ways to use mobile technology in schools that do not have access to mobile data was accentuated. This is an endeavour which is especially necessary in the South African context, as many schools do not have access to any form of mobile data or Wi-Fi. There is considerable potential for future research around the topic of this study. I am confident that the resilience of educators will triumph over plant blindness and that plants will once again regain their rightful place in the minds of learners and educators the world over.

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APPENDICES

Appendix A: Treasure hunt worksheet example

The Amazing Plant Treasure Hunt

Location 1

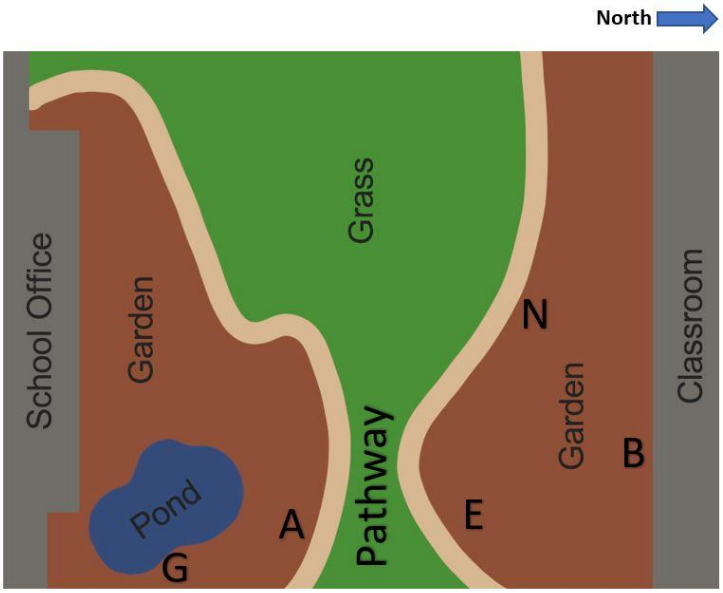
- A- *Philodendron bipinnatifidum* (Selloum)
  - Instruction: Search for a tree that looks like it has big eyes on its bark and big leaves with finger-like projections.
  - **Questions:1) What type of climate does this plant prefer to grow in?**
    2) What type of special roots do these plants produce?

- B– *Strelitzia reginae* (Birds of Paradise)
  - Instruction: Search for a plant with flowers that look like a colourful bird's head with longitudinal leaves containing parallel veins.
  - **Questions:1) What is the beak-like structure called from which the flower emerges?**
    2) What type of pollinators do these plants predominately attract?

- G– *Ruscus hypophyllum* (Spineless Butcher's broom)
  - Instruction:Search for a shrub-like plant with small dark green leaves which have small protrusions coming out of the top surface of the leaves.
  - **Questions:What plant structure will this protrusion eventually form into?**

- E– *Clivia miniata* (Bush lily)

- N– *Alocasia macrorrhizos* (Giant Taro)



Appendix B: Treasure hunt map and instructions

The Amazing Plant Treasure Hunt

Location 1

Answer Sheet

A *Philodendron bipinnatifidum* (Selloum)

1) Tropical, subtropical and warm temperate climates

2) Aerial roots

B *Strelitzia reginae* (Birds of Paradise)

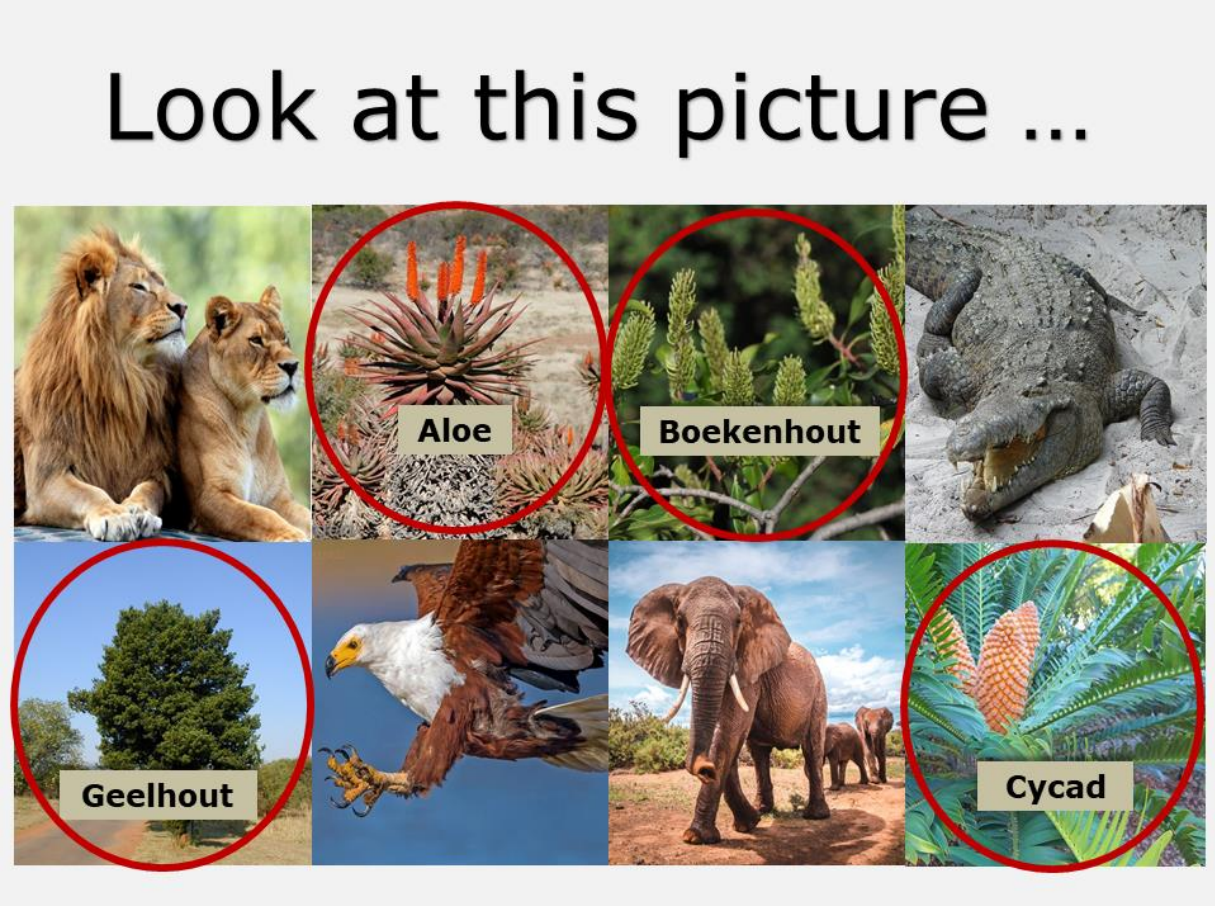
1) Spathe

2) Sunbirds

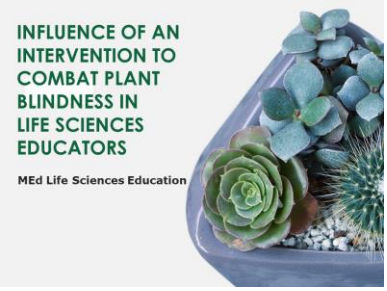
G *Ruscus hypophyllum* (Spineless Butcher's broom)

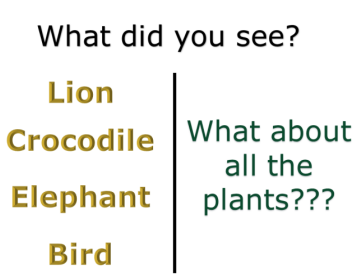
1) fruit

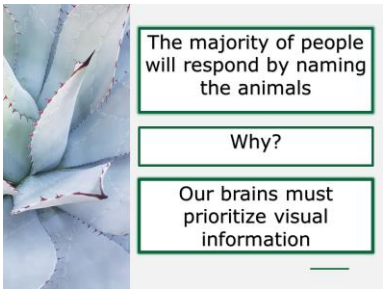
Appendix C: Image used to test for plant blindness

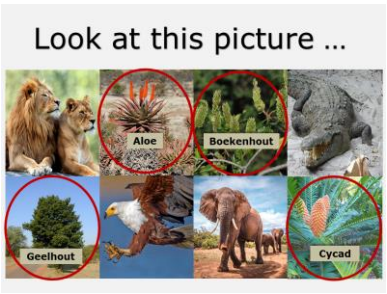


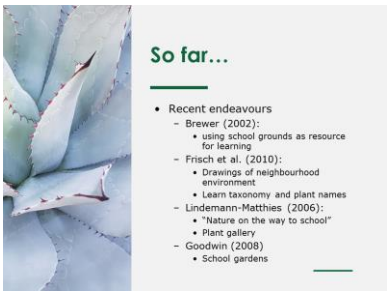
Appendix D: Presentation shown during workshop









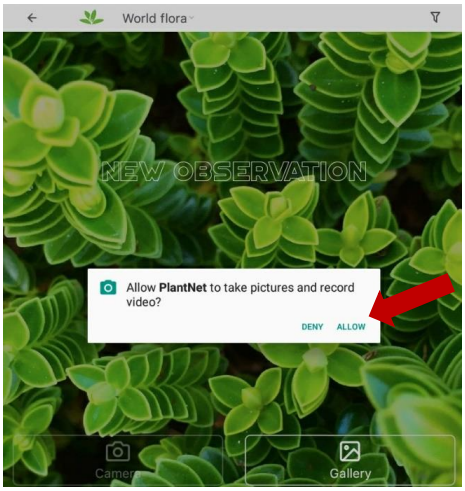


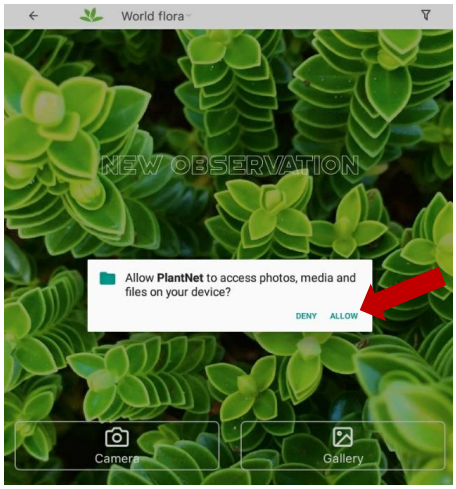
Appendix E: Instructions on the usage of the Pl@ntNet application

The following points are instructions on how to use the application to identify plants:

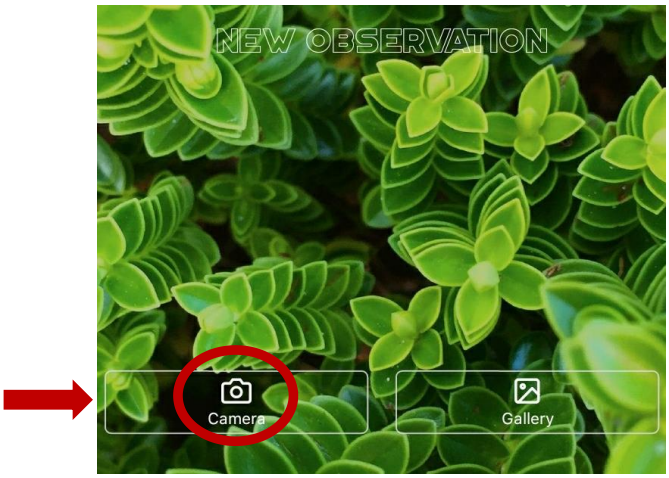
- The section which allows you to identify a plant by using your mobile device's camera is situated at the bottom centre of the home page in the application.
- When you want to identify a plant, click on the camera icon as shown below.

- Before you can use your camera, the application will ask you to allow it to use your camera as well as to allow access to your gallery to store the photos you take. Simply click on "allow" for both these options.

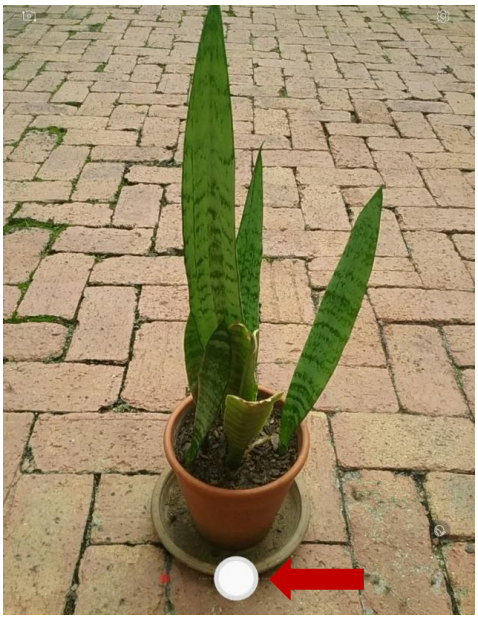




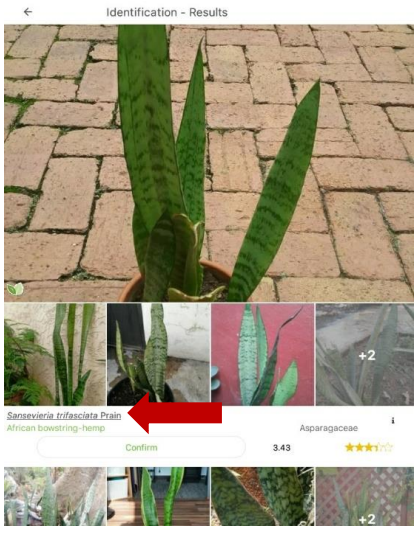
- Once you have allowed both these prompts, you will see the following screen.
- Click on the camera icon to start using your camera to identify a plant.



- The best way to identify a plant is to capture a picture of multiple parts of the plant.
- The way to capture a picture of a plant is to click on the circle at the bottom of the screen as shown on the screenshot (below left).
- Once you have taken a picture, select which plant organ you are focusing on.
- You can add pictures of more organs by clicking on the back button at the top left corner as shown below (below right), which will allow you to specify the different organs.

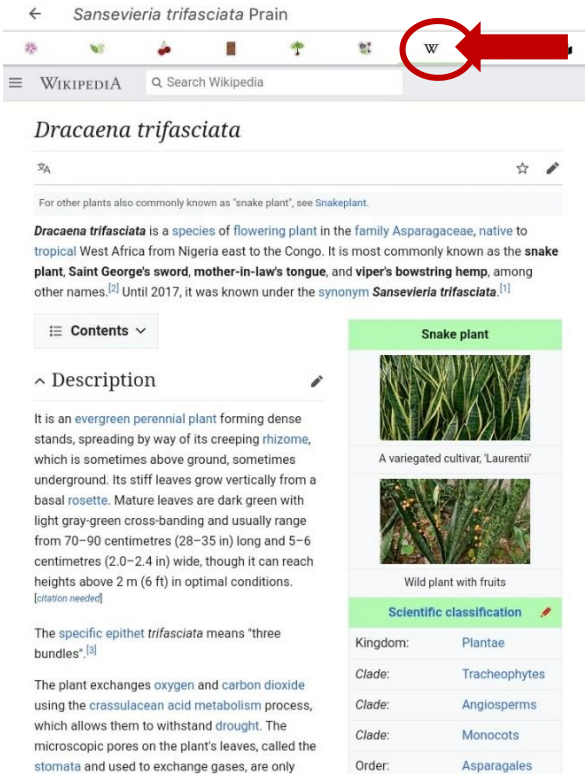


- Once you have taken pictures, you will be shown a screen with various suggestions of possible plants which match your pictures.
    - Note: If the application gives you a message which says that it cannot find any matches and suggests that you search in “World flora”, click on the word “**World flora”** to access the global database.
    - You should then be given possible matches for your photos.
- Look at the pictures of the possible matches to ensure that you get an accurate identification.

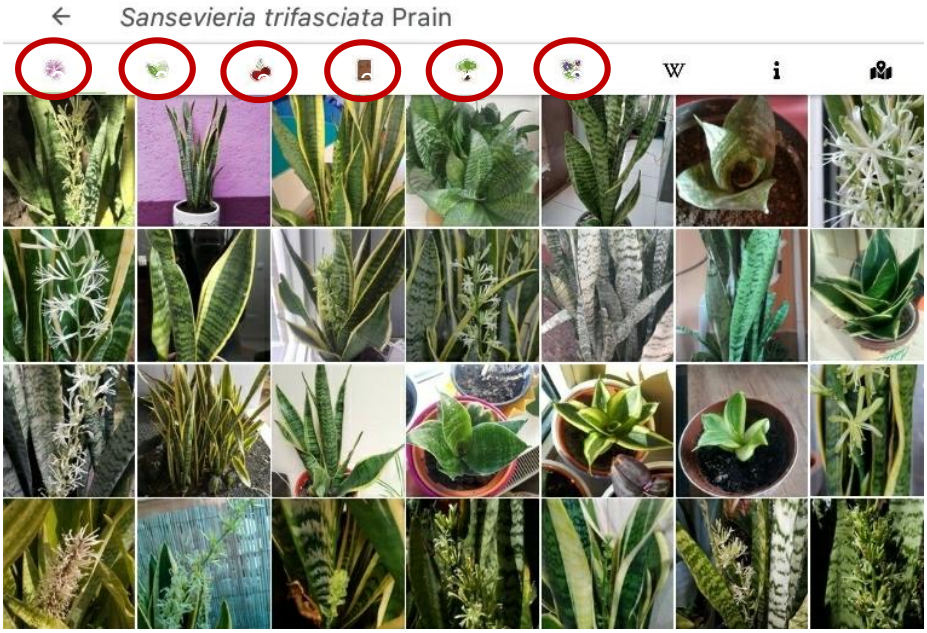


The following steps are a guide to find information about the plant which you identified:

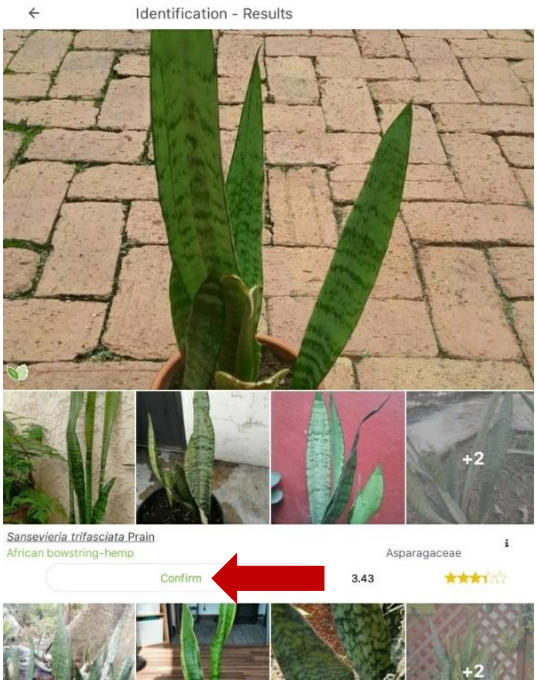
- There are two main sections where you can find information about plants as shown below.
- The screenshot on the left shows the link to Wikipedia where you can find information about the description, morphology, and various miscellaneous topics.
    - **Note: Most of the information necessary for the workshop will be found under this tab.**
- The screenshot on the right shows the tab that gives a breakdown of the classification of the plant, including scientific names and common names.

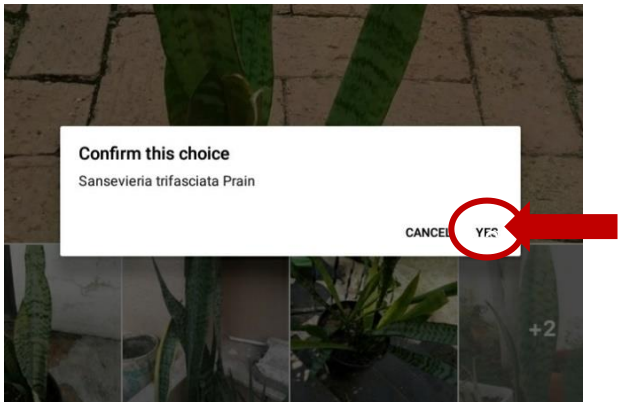


- If you are still unsure, you can click on the scientific name of the plant to see many other photos of its flowers, leaves, bark and fruit.
    - Click on the icons at the top of the screen to view the various parts of the plant.



- Once you are positive that you have correctly identified the plant species, click on the "confirm" tab and if you are asked again, simply say yes as shown below.





Appendix F: Plant perception questionnaire

PLANT PERCEPTION SURVEY

* Required

1. Email address *

2. How much experience do you have (years and months) of teaching Life Sciences? *

3. Which topic(s) in the Life Sciences do you enjoy teaching most? Explain why. *

4. Which topic(s) in the Life Sciences do you find least enjoyable to teach? Explain why. *

5. What is your perception of teaching topics relating to plants? *

6. In your opinion, how important are plant-related topics compared to other topics in the CAPS curriculum? Explain why you say this. *

7. In your own experience, what is the general perception of the learners whom you teach about plant-related topics? *

Educators confidence

8. How confident are you with regards to teaching topics related to plants? Explain why you say this. *

9. To what extent do you use the plants on your school grounds to facilitate teaching and learning about plants? Please give examples. *

10. Do you have plants in your classroom? If yes, do you use them to facilitate teaching and learning about plants?

11. How likely are you to take learners outside the classroom to learn about plants? Explain why you say this. *

12. Have you ever taught plant taxonomy or classification by using the plants on the school premises? Explain why or why not. *

13. What are some of the barriers which might make it difficult to use plants on the school premises to teach a topic like taxonomy or classification? Explain why you say this. *

14. Do you feel that your tertiary education has adequately prepared you to incorporate your school environment into teaching about plants? Explain why you say this. *

15. Are there any types of resources that might be helpful for you as a teacher to facilitate teaching and learning outside the classroom? Please give examples. *

Appendix G: Post workshop reflection

Post workshop reflection

Educators were asked to write a reflection after taking part in the intervention about its utility and significance

Questions:

1. Please comment on your experience of taking part in the intervention.
2. Are there aspects of the intervention which you found to be helpful or meaningful to you as an educator?
    . If yes, please elaborate on those aspects and explain why they were helpful or meaningful.
3. Do you foresee that you will be able to utilise what was gained from this intervention in your future teaching?
    . If yes, please explain in what way you plan to implement skills or knowledge gained during the intervention.
4. Do you have any suggestions about possible improvements which could be made to the intervention to increase its utility? Please explain.
5. Do you perceive this intervention to be effective in increasing the plant appreciation of Life Sciences educators?

Appendix H: Post hoc interview schedule

Educator Interview Schedule

The influence of an intervention to combat plant blindness in Grade 10 Life Sciences educators

Time of interview: Duration:

Date:

Place:

Interviewer:

Interviewee: Pseudonym:

Male/ Female:

Plants are the foundation of nearly all life on earth as they are one of the very few organisms on the planet that possess the ability to manufacture food from inorganic substances. The purpose of this study is to contribute to research of South African Life Sciences educators in the area of plant blindness and educator confidence. Plant blindness refers to the neglect and underemphasising of plants to the extent that they are often not really "seen". Pseudonyms will be utilized in the interviews, data analysis and the findings. The data collected in this study will serve in research purposes only and treated as confidential. Access to the data will be granted to the researcher and the supervisor only. Thank you for your participation.

Questions:

1. Have you ever heard about plant blindness before the intervention?
    - If Yes, please explain what your prior knowledge entailed.
2. Describe your past training with regards to botany (from school level to tertiary training).
3. Can you identify any of the characteristics or implications of plant blindness in yourself?
4. How do you feel about teaching topics relating to plants?
5. Based on your experience as an educator, to what extent do you perceive plant blindness to be a problem amongst the students you teach?
6. Did you perceive the intervention as useful?
7. Is there any part of the intervention which you think you will be able to use in your own teaching practice?
    - If Yes, please explain how you plan to implement what was gained from the intervention practically to improve teaching.
8. How do you think will this intervention influence your confidence when teaching about topics relating to plants?
9. How has this intervention impacted your perception about plants and ways in which it can be presented in in a classroom setting?

Appendix I: Weekly diary

Educator weekly diary questions

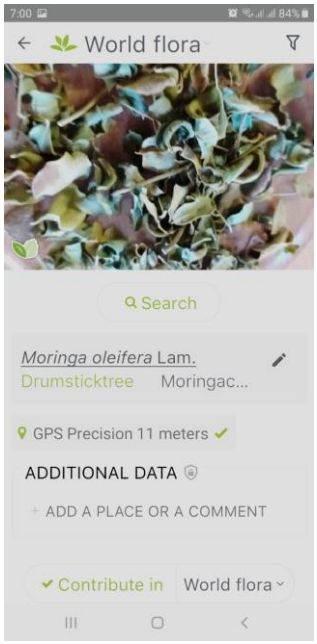
Educators were expected to complete a diary entry at the end of each week by using the following questions to reflect on their experiences in relation to the intervention and the teaching of plants.

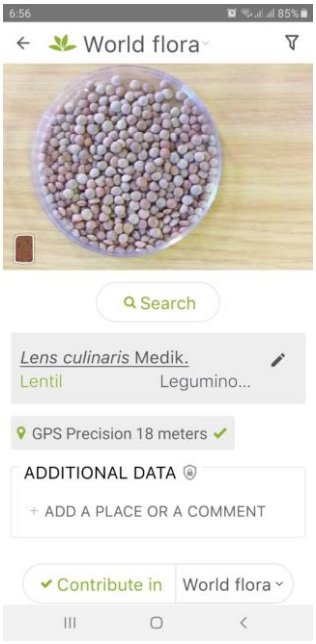
Questions:

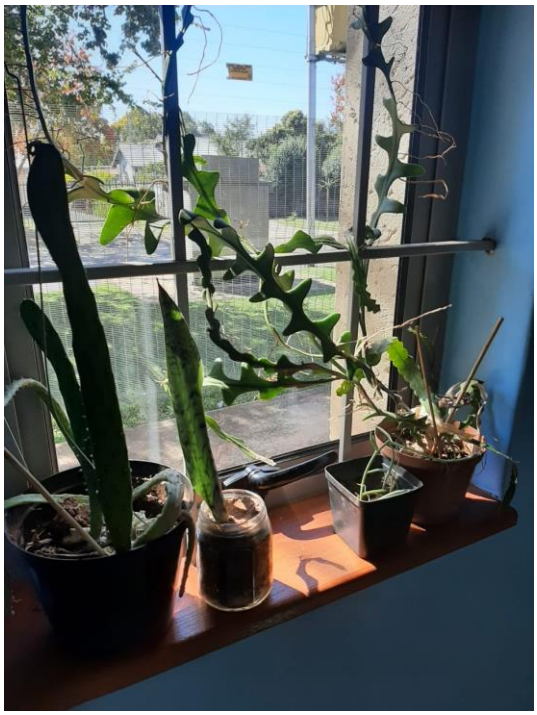
1. What content did you teach during this past week?
2. Did you find opportunities to incorporate plant-related information into your teaching? Give examples.
3. Were there any instances during this past week in which you were able to use knowledge or skills acquired from the intervention which you attended? Please explain.
4. While planning your lessons, did the knowledge which your acquired during the intervention have any influence on how you approached the teaching of certain topics? Please explain.
5. Did you make use of the Pl@ntNet application during this week (inside or outside the classroom)? If yes, how did you use it?
6. Were you able to use the plants outside your classroom to enhance the process of teaching and learning? Please explain.

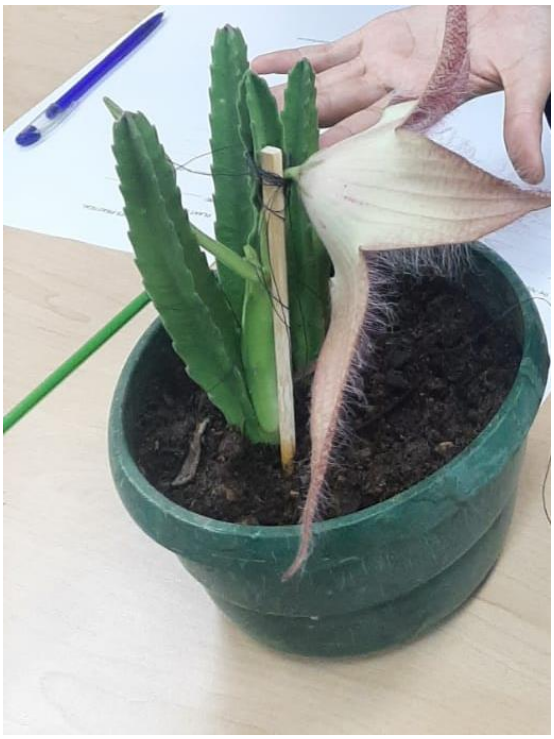
Appendix J: Photographic evidence of Pl@ntNet usage

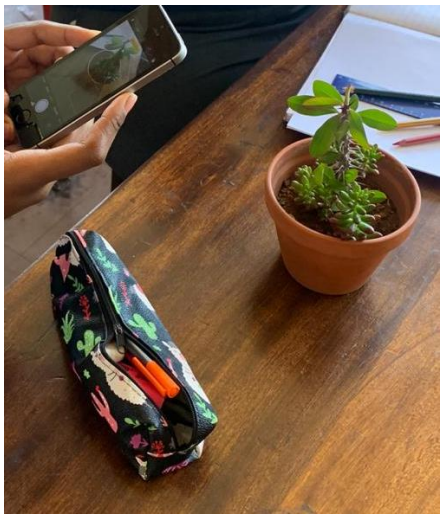
All screenshots and photos are used with permission from the participants who provided them.











Appendix K: Final reflection

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YUNIBESITHI YA PRETORIA

Educator final reflection

Educators were expected to give a final reflection about the influence of the intervention on their teaching and general perception about plants.

Questions:

1. Please provide feedback about whether this intervention was useful to you.
2. Do you foresee that you will be able to use the Pl@ntNet application and the knowledge gained during the intervention in your future teaching?
3. Did the intervention and the process of this research project have any influence your own plant appreciation?
4. Do you think that this intervention had an influence on the plant appreciation of the learners in your Life Sciences classes?
5. Do you have any recommendations about how future interventions can be improved?

Appendix L: Ethical clearance certificate

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YUNIBESITHI YA PRETORIA
Faculty of Education

RESEARCH ETHICS COMMITTEE

CLEARANCE CERTIFICATE	CLEARANCE NUMBER: **EDU070/20**
DEGREE AND PROJECT	MEd An intervention to combat plant blindness in Life Sciences educators
INVESTIGATOR	Mr Benjamin Alexander Coetzer
DEPARTMENT	Science, Mathematics and Technology Education
APPROVAL TO COMMENCE STUDY	10 June 2020
DATE OF CLEARANCE CERTIFICATE	19 August 2021

CHAIRPERSON OF ETHICS COMMITTEE: Prof Funke Omidire

CC Ms Thandi Mngomezulu
Dr A.L. Abrie

This Ethics Clearance Certificate should be read in conjunction with the Integrated Declaration Form (D08) which specifies details regarding:

- Compliance with approved research protocol,
- No significant changes,
- Informed consent/assent,
- Adverse experience or undue risk,
- Registered title, and
- Data storage requirements.

Appendix M: GDE permission to conduct research

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	26 November 2020
Validity of Research Approval:	08 February 2021 – 30 September 2021
	2019/505A
Name of Researcher:	Coetzer BA
Address of Researcher:	
Telephone Number:	
Email address:	
Research Topic:	Influence of an intervention to combat plant blindness in Grade 10 ,Life science Educators
Type of qualification	
Number and type of schools:	
District/s/HO	

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

26/11/2020

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

1. *Letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*

Making education a societal priority

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

Appendix N: Letter of notification to school governing body

Faculty of Education

FACULTY OF EDUCATION
DEPARTMENT OF SCIENCE, MATHEMATICS AND TECHNOLOGY EDUCATION
Groenkloof Campus
Pretoria 0002
Republic of South Africa
Tel: +27 12 420 –5572
Fax: +27 12 420-5621
http://www.up.ac.za
4 May 2020

LETTER OF NOTIFICATION: SCHOOL GOVERNING BODY

Dear Chairperson of the SGB

I Benjamin Alexander Coetzer, am a Master of Education Student studying through the University of Pretoria and would like to collect data at your school for a research project titled *Influence of an intervention to combat plant blindness in grade 10 Life Sciences educators*.

The purpose of this study is to investigate the influence that a designed intervention has on Grade 10 Life Sciences educators with regard to plant blindness and their confidence in teaching to address the phenomenon both inside and outside the classroom context. Plant blindness is a phenomenon which is one of the key challenges facing the teaching and learning of Life Sciences as it causes teachers and learners alike to underemphasize and very often dislike topics relating to plants. Furthermore, various studies have confirmed that plant blindness is currently having detrimental effects on other areas of society like tertiary institutions and conservation efforts. Although many studies aim to address plant blindness in learners, very few focuses on empowering educators and giving them resources to address it in their daily teaching. This study proposes to address that shortfall through an intervention.

An intervention will be designed based on models used in previous studies and refined by consulting with subject experts. This project will be implemented in two phases. The first phase will start with a structured survey administered to 10-15 educators via email, after which the intervention will be presented to these participant educators at a venue and time that will be convenient to all the participants and the researcher. The intervention will take place outside school hours and will be concluded with a written reflection from each participant. During the second phase, the researcher will collect the rest of the data by means of a semi-structured interview, weekly diary, screenshots and a final reflection from 4-6 participants who choose to participate in the subsequent research. The diary and screenshots can be completed and submitted at participants' own time. The interview and the final reflection will take place at a time and place convenient to the participant and the researcher. Both will be audio-recorded, whether they are conducted in person or via electronic means (telephonically or on-line).

The results of this study may be presented at conferences or published in scientific journals. If it is required, the researcher will be available to provide short presentations on the purpose, findings and recommendations of their research to both GDE officials and the school concerned. The teachers will be provided with letters that will elicit their informed consent and the researcher will only commence with data gathering once all these have been granted. Pseudonyms will be used to ensure confidentiality of educators.

Appendix O: Letter of permission to school principals

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Faculty of Education

FACULTY OF EDUCATION
DEPARTMENT OF SCIENCE, MATHEMATICS AND TECHNOLOGY EDUCATION
Groenkloof Campus
Pretoria 0002
Republic of South Africa
Tel: +27 12 420 –5572
Fax: +27 12 420-5621
http://www.up.ac.za
4 May 2020

LETTER OF PERMISSION: PRINCIPAL

Dear Principal,

I Benjamin Alexander Coetzer, am a Master of Education Student studying through the University of Pretoria and would like to collect data at your school for a research project titled *Influence of an intervention to combat plant blindness in Life Sciences educators*.

The purpose of this study is to investigate the influence that a designed intervention has on Grade 10 and 11 Life Sciences educators with regards to plant blindness and their confidence in teaching to address the phenomenon both inside and outside the classroom context. Plant blindness is a phenomenon which is one of the key challenges facing the teaching and learning of Life Sciences as it causes teachers and learners alike to underemphasize and very often dislike topics relating to plants. Furthermore, various studies have confirmed that plant blindness is currently having detrimental effects on other areas of society like tertiary institutions and conservation efforts. Although many studies aim to address plant blindness in learners, very few focuses on empowering educators and giving them resources to address it in their daily teaching. This study proposes to address that shortfall through an intervention.

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The results of this study may be presented at conferences or published in scientific journals. If it is required, the researcher will be available to provide short presentations on the purpose, findings and recommendations of their research to both GDE officials and the school concerned. The teachers will be provided with letters that will elicit their informed consent and the researcher will only commence with data gathering once all these have been granted. Pseudonyms will be used to ensure confidentiality of educators.

Participation is subject to the Ethics Committee of the Faculty of Education at the University of Pretoria's regulations, and the following will apply:

1. The names of the school and identities of the participants will be treated confidentially and will not be disclosed. All participants and schools will remain anonymous.
2. The surveys, diaries, reflections and interview transcripts will be treated confidentially. Only the researcher (B.A. Coetzer) and the supervisor (Dr A.L. Abrie) will have access to the diaries, screenshots, surveys as well as all audio recordings and transcribed data.
3. Only the researcher (B.A. Coetzer) will know the real identity of the teachers who agree to participate in the study.
4. Pseudonyms for schools and the teachers will be used in all spoken and written reports.
5. The information provided by the teacher will be used for academic purposes only.
6. Participation in this project is entirely voluntary. Participants have the right to withdraw at any time, and without any prejudice.
7. The teachers will not be exposed to acts of deception at any point in the research study.
8. The teachers will not be placed at risk of any kind.
9. No incentives will be offered to any of the research participants.
10. The decision to accept or decline the invitation will **not** have any adverse effect on the school or the educators.

The Gauteng Department of Education, the Faculty of Education and the Ethics Committee at the University of Pretoria have approved this study. For any further queries, you are more than welcome to contact the researcher or their supervisor.

Your support in this matter will be appreciated.

Mr. B.A. Coetzer (researcher)
083 610 0327
U14175267@tuks.co.za

Dr. Mia Abrie (supervisor)
(012) 420 5569
mia.abrie@up.ac.za

If you are willing to allow me to do the surveys, interviews and other specified data collection, please kindly sign the attached form as a declaration of your permission. I would also like to request your permission to use the data, confidentially and anonymously, for further research purposes, as the data sets are the intellectual property of the University of Pretoria. Further research may include secondary data analysis and using the data for teaching purposes. Thank you for taking time to read this letter

I, _____(your name only), hereby grant permission to the researcher to interview and collect data from Life Sciences educators at my school and use the data as specified in this letter.

…… ……
Signature Date

Appendix P: Informed consent form given to participants.

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Faculty of Education

FACULTY OF EDUCATION
DEPARTMENT OF SCIENCE, MATHEMATICS AND TECHNOLOGY EDUCATION
Groenkloof Campus
Pretoria 0002
Republic of South Africa
Tel: +27 12 420 –5572
Fax: +27 12 420-5621
http://www.up.ac.za
4 May 2020

LETTER OF CONSENT: EDUCATOR

Dear Educator,

I Benjamin Alexander Coetzer, am a Master of Education Student studying through the University of Pretoria and would like to collect data at your school for a research project titled *Influence of an intervention to combat plant blindness in Life Sciences educators*.

The purpose of this study is to investigate the influence that a designed intervention has on Grade 10 and 11 Life Sciences educators with regard to plant blindness and their confidence in teaching to address the phenomenon both inside and outside the classroom context. Plant blindness is a phenomenon which is one of the key challenges facing the teaching and learning of Life Sciences as it causes teachers and learners alike to underemphasize and very often dislike topics relating to plants. Furthermore, various studies have confirmed that plant blindness is currently having detrimental effects on other areas of society like tertiary institutions and conservation efforts. Although many studies aim to address plant blindness in learners, very few focuses on empowering educators and giving them resources to address it in their daily teaching. This study proposes to address that shortfall through an intervention.

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The results of this study may be presented at conferences or published in scientific journals. If it is required, the researcher will be available to provide short presentations on the purpose, findings and recommendations of their research to both GDE officials and the school concerned. The teachers will be provided with letters that will elicit their informed consent and the researcher will only commence with data gathering once all these have been granted. Pseudonyms will be used to ensure confidentiality of educators.

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2. The surveys, diaries, reflections and interview transcripts will be treated confidentially. Only the researcher (B.A. Coetzer) and the supervisor (Dr A.L. Abrie) will have access to the diaries, screenshots, surveys as well as all audio recordings and transcribed data.
3. Only the researcher (B.A. Coetzer) will know the real identity of the teachers who agree to participate in the study.
4. Pseudonyms for schools and the teachers will be used in all spoken and written reports.
5. The information provided by the teacher will be used for academic purposes only.
6. Participation in this project is entirely voluntary. Participants have the right to withdraw at any time, and without any prejudice.
7. The teachers will not be exposed to acts of deception at any point in the research study.
8. The teachers will not be placed at risk of any kind.
9. No incentives will be offered to any of the research participants.
10. The decision to accept or decline the invitation will **not** have any adverse effect on the school or the educators.

The Gauteng Department of Education, the Faculty of Education and the Ethics Committee at the University of Pretoria have approved this study. For any further queries, you are more than welcome to contact the researcher or their supervisor.

Your support in this matter will be appreciated.

Mr. B.A. Coetzer (researcher)
083 610 0327
U14175267@tuks.co.za

Dr. Mia Abrie (supervisor)
(012) 420 5569
mia.abrie@up.ac.za

If you are willing to allow me to do the surveys, interviews and other specified data collection, please kindly sign the attached form as a declaration of your consent. I would also like to request your permission to use your data, confidentially and anonymously, for further research purposes, as the data sets are the intellectual property of the University of Pretoria. Further research may include secondary data analysis and using the data for teaching purposes. Thank you for taking time to read this letter.

I, _____(your name only), hereby grant consent and permission to the researcher to collect data from me pertaining to the scope of the abovementioned research and to use it as specified in this letter.

Please indicate with an X whether you are interested in participating in the second phase of the study.

☐ Yes, I want to participate in the second phase of the study.
☐ No, I am not interested in participating in the second phase of the study.

…… ……
Signature Date

Appendix Q: Correspondence with Pl@ntNet

Gmail Benjamin Coetzer <bcoetzer.research@gmail.com>

Requesting to make reference to Pl@nt Net in Masters of Education study
4 messages

Benjamin Coetzer <bcoetzer.research@gmail.com> Wed, Aug 11, 2021 at 12:17 PM
To: contact@plantnet-project.org

Good Day

I am a Masters of Education student at the University of Pretoria in South Africa. I am also a Life Sciences educator at a public secondary school.

I discovered the Pl@nt Net application while searching for creative and interesting ways to enrich my Botany teaching. I found it to be of great use to facilitate meaningful plant interactions with the learners whom I teach.

I am also currently busy with a Masters's degree in Life Sciences education with the focus of addressing plant blindness in the educational sector. Once I found the Pl@nt Net application, I realized that the application could be useful to many other educators who also want to address plant blindness in their own context. I, therefore, decided to incorporate the Pl@nt Net application into my research by introducing educators to it and looking for ways that they use it and how its use affects their plant appreciation.

The results were very positive and the educators were unanimous about the fact that they planned to continue using the Pl@nt Net application and introduce their learners and families to it as well.

I would like to request permission to use screenshots taken by me and some of these educators while using the Pl@nt Net application and mention the name of your application in my dissertation.

Kind Regards

Benjamin Coetzer

Masters of Education Student
University of Pretoria

Hugo Gresse <contact@plantnet-project.org> Wed, Aug 11, 2021 at 1:57 PM
To: Benjamin Coetzer <bcoetzer.research@gmail.com>

Hi Benjamin,

That's great!

Feel free to use any screenshots of the app with Pl@ntNet mention/logo.

Also, let us know if you can share some feedbacks to us and what we can improve in the app.

BTW, we are also working on an offline version which should be available for beta testers in October and may be useful for you.

Best,

[Quoted text hidden]
--
Hugo Gresse
Mobile engineer for Pl@ntNet at INRIA / UMR AMAP
Montpellier, FRANCE
Pl@ntNet
Donate / Don
Discuss with us on Discord (English)

Benjamin Coetzer <bcoetzer.research@gmail.com> Thu, Aug 12, 2021 at 10:45 PM
To: Hugo Gresse <contact@plantnet-project.org>

Hugo

Thank you very much for your email and for allowing me to reference your application in my study.

I am truly thankful!

With regards to the offline beta version, I am very interested in participating in the testing of such a version of the application. There is a good possibility that I will continue with a Doctorate study which might make use of Pl@nt net once again to adress plant blindness in eductors.

Offline access would be very useful for that purpose as cellular data is one of the biggest challenges faced by educators and learners in the educational system in South Africa.

Please advise about how I can apply to be part of the beta group.

Kind Regards
Benjamin Coetzer
[Quoted text hidden]

Hugo Gresse <contact@plantnet-project.org> Fri, Aug 13, 2021 at 10:06 AM
To: Benjamin Coetzer <bcoetzer.research@gmail.com>

Hi Benjamin,

You should be able to join the beta program on the Google Play Store on your device directly, if you scroll a little on PlantNet app screen.

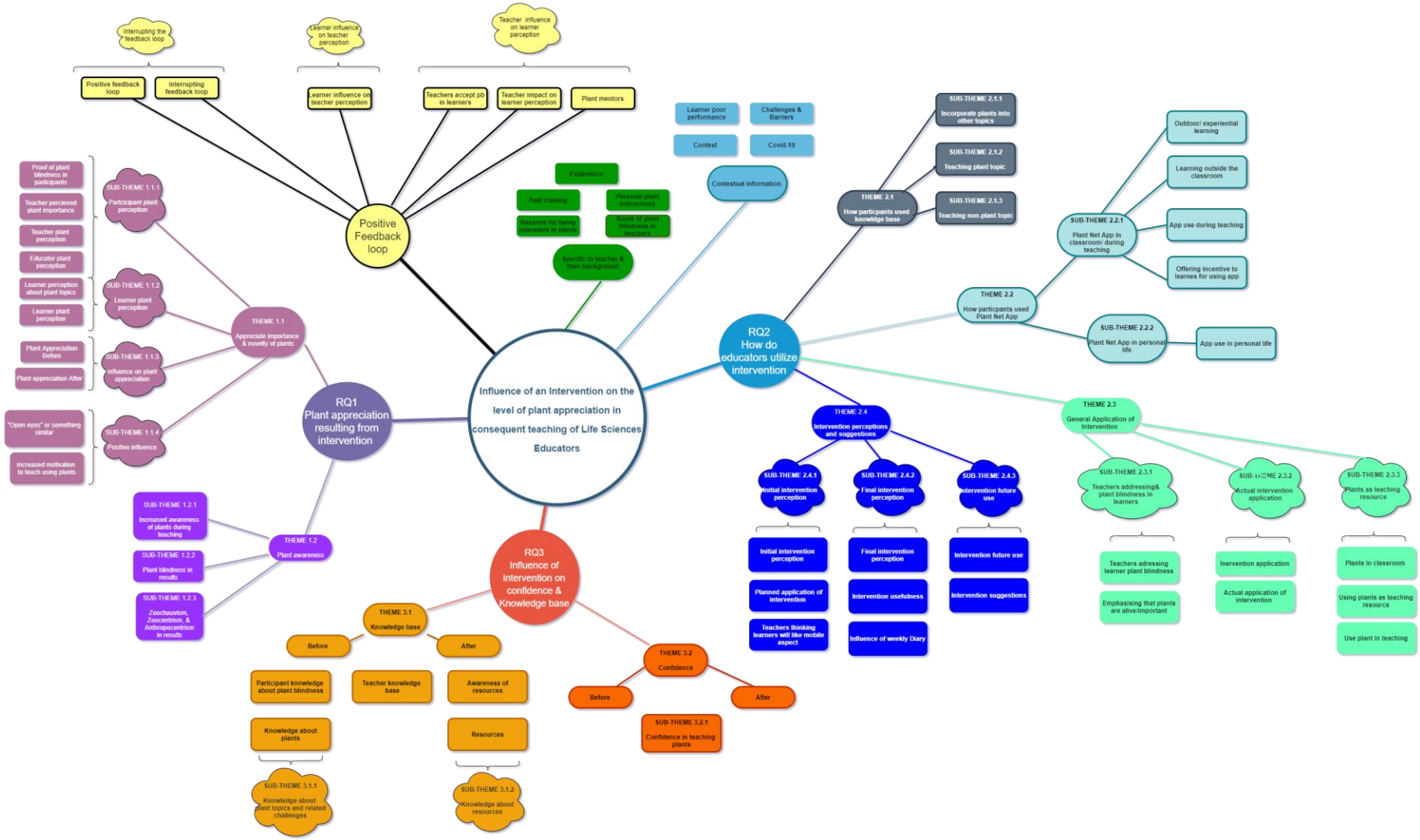
If this is not the case, let me know.

The beta version also include the group (starting this afternoon).

Best

[Quoted text hidden]

Appendix R: Mind map showing themes and sub-themes



Appendix S: Plant perception questionnaire answers

Answers participants gave to Plant Perception survey questions					
	Participant 1	**Participant 2**	**Participant 3**	**Participant 4**	**Participant 5**
How much *experience* do you have (years and months) of teaching Life Sciences?	3 years and two months	10 Years	20 Years and 2 months	10 Years	10 Years
Which topic(s) in the Life Sciences do you *enjoy* teaching most? Explain why.	Genetics and blood circulation Genetics has a wide variety of applications in our modern day and it keeps learners interested during the entire duration of the lesson. Although some concepts of genetics are difficult for learners but it is worthwhile for me as a teacher at the end of the day to see them get it. The circulatory system is also interesting and difficult for learners as well, but I just love it in all its complexity.	Life processes and molecules to organs	Genetics. Many new developments with GMO's en interesting scenario's.	Ear, Eye and Skeleton Learners can relate to these topics and they can do practical activities which they enjoy thoroughly!	Skeleton heart kidney
Which topic(s) in the Life Sciences do you *find least enjoyable* to teach?	The history of life. It's just plain right boring and kids don't enjoy it as well	Environmental studies	Photosynthesis and respiration. Learners struggle to grasp chemical reactions involved in these processes.	Plants! Learners find it boring.	Plants
What is your *perception* of teaching topics relating to *plants*?	I'm indifferent to it actually. There are days when I enjoy them and days when I don't.	Not really my favorite	Many learners do not like the topics related to plants. I find that I must motivate learners more to get them interested in these topics.	The Learners find it boring! Also not enough time.	Kids don't find it interesting and they don't relate
In your opinion, how important are plant-related topics compared to other topics in the *CAPS* curriculum?	Equally important. Firstly plants are producers so most food chains start there. Also it relates to the kid's identity on topics such as IKS (recognized traditional medicine)	Equally important, because we need diversity in life	Not very important. The content of the life cycle of plants was scaled down from the previous curriculum.	Not enough time given and they could make it more interesting, by giving more info on more medicinal plants	Not so much
In your own experience, what is the general *perception* of the *learners* whom you teach about plant-related topics?	In their words " it's boring and plant tissues have difficult terminology"	Learners normally enjoy what the teachers shows a lot enthusiasm in	They usually do not look forward to these topics. Allthough they usually enjoy it while we are busy with these topics.	They are not interested get confused with the terminology,, they do not want to study.	Children don't find the topic interesting
How *confident* are you with regards to teaching topics related to plants?	Very confident. Varsity made me an expert in my subject content.	Comfortable, but not enthusiastic	Quite confident. Botany was one of my University subjects.	Confident, know the contents.	Good
To what extent do you *use* the *plants* on your *school grounds* to facilitate teaching and learning about plants?	Only when I teach plants I use plants as LTSM, for example when I teach types of roots, it is easy to just pick any small plant from the school premises.	Sometimes	I use it a lot. We have beautiful gardens at our School. We usually collect flowers from the garden for dissection. I also collect plant from the garden for the learners to identify as monocotyledon or dicotyledon plants. We use these plants for practicals to investigate transpiration.	Not on school ground but we go to the Botanical Gardens.	Examples
Do you have *plants* in your *classroom*? If yes, do you use them to facilitate teaching and learning about plants?	No	No	Yes. I have a few plants including xerophytes. I use them to illustrate adaptations of plants to their habitats.	I have started with succulent plants in my class, take plants and leaves to class when teaching the topic.	No
How likely are you to take *learners outside* the *classroom* to learn about plants?	Not likely	Rarely	I like to do it. But is may be difficult if it is a big class.	Do not take Learners classes outside because they run around and disturb other classes.	Botanical gardens
Have you ever taught plant taxonomy or *classification* by using the *plants* on the school *premises*? Explain why or why not.	No. It would be time consuming, usually we are working against time	Yes, it makes it easier and practical	Yes. The learners like this 'outing' and or gardens have a wide variety of plants.	No, learner discipline problem.	Yes
What are some of the *barriers* which might make it difficult to use plants on the school premises to teach a topic like taxonomy or classification?	Time. ATP puts us under pressure to cover content in a stipulated time	School is new, there'snt diversity	Big classes may be difficult to control and to bring the content over.	As above mentioned!	Not enough examples
Do you feel that your *tertiary education* has adequately prepared you to incorporate your school environment into teaching about plants?	They tried, but what you learn in theory at varsity level is sometimes difficult to implement at school level depending on the type of school you find yourself in and the resources provided	No. Lack of interest in plant production disadvantaged me	Yes. We visited the Botanical gardens during practical session.	No, not enough plants and trees around the school.	No
Are there any types of *resources* that might be helpful for you as a teacher to facilitate teaching and learning outside the classroom?	Can't think of any	Internet helps	Not to my knowledge.	Smaller classes.	Don't know

Appendix T: Worksheet created by Participant 3 to use in conjunction with Pl@ntNet application

GRADE 11: LIFE SCIENCES PRACTICAL

PLANT IDENTIFICATION

NAME: .....

Use the Application to identify your plant.

FAMILY: .....

Genus: .....

Species: .....

Common name: .....

Area of origin:

Habitat/optimum growth conditions:

Uses of part of this plant:

Interesting information/features: