Investigating Situational Interest and Learning of Biodiversity: A case study of students' experience of a visit to a nature reserve

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Declaration

I, Bhamini Kamudu Applasawmy (student ID: 1533512) declare that this thesis is my own unaided work, except where otherwise acknowledged. This thesis is submitted in fulfilment for the requirements for the degree of Doctor in Philosophy at the University of Witwatersrand, Johannesburg, South Africa. It has not been submitted before for any degree or examination at any other University.

Bhamini Kamudu Applasawmy
April 2021

Dedicated to my son Gyanesh

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Abstract

This case study investigated the experiences of 13 students (13-15 years), from three Scout groups, who participated in a one and a half-hour guided tour to Ile aux Aigrettes nature reserve, Mauritius. It identified the factors that triggered Situational Interest (SI), what students learnt about biodiversity and how their learning relates to the triggers of SI. SI is the psychological state triggered by environmental stimuli that causes emotional arousal, directs the attention of an individual towards content and motivates the desire for further discovery. Hence, SI promotes learning. One cannot predict visitors' prior interest and knowledge of biodiversity as they enter a nature reserve. However, their SI may be triggered through factors that stimulate interest and ultimately enhance the learning of biodiversity regarded as a multi-dimensional complex concept.

The study was theoretically framed using the Contextual Model of Learning for studying informal learning experiences, the Four-Phase Model of Interest Development (FPMID) for interest development and the Human Constructivist (HC) and affective learning frameworks for conceptual change, based on the premise that learning is meaningful. Data collection consisted of field observation and pre- and post-visit interviews. Students also drew Personal Meaning Maps (PMM) about their conception of biodiversity before each interview. Visual data collection techniques such as auto-photography and photo-elicitation were introduced.

Exhibits such as the tortoises, bronze models of extinct animals and endemic plants and animals as well as biodiversity-related concepts were aspects of the tour that contributed to SI due to both affective and cognitive situational factors. The affective factors that triggered SI were strong emotional arousal, bodily experiences and aesthetic experiences felt by students. The cognitive factors comprised impressive information and size/numbers which contributed to learning. The novelty of the information and of the experiences appeared to be a critical trigger of SI as it was influenced by both affect and cognition. Furthermore, the factors that ignited SI were intricately linked. The study showed that interest can be triggered both towards the discontinuous event of exhibit encounters and the continuous events of the context of the visit, such that the triggering process was not a once-off event; rather interest was being triggered and maintained continually.

I proposed three lenses to analyse what students learnt about biodiversity namely: 'ecological literacy', 'biodiversity and society' and 'nature and self'. After the visit, students' understanding of the term biodiversity and the importance of conservation increased. There was also increased knowledge of extinct and endemic species. Similarly, students were better able to formulate relevant opinions about biodiversity and society issues and display emotional concern for nature. Collectively, students were more likely to deepen their existing conceptions rather than making new conceptual additions. Most students remembered and understood incremental pieces of information rather than synthesizing information to gain a holistic picture. Individually all students exited the trip with more knowledge. However, the net gain in the new knowledge was independent of their prior knowledge. Thus, a student's ability to grasp and assimilate new information as a result of the tour remains limited, irrespective of prior knowledge. Students who had higher prior knowledge also had higher affective learning episodes as they found the learning material personally relevant and salient.

The study showed that weak forms of knowledge restructuring by incremental addition of knowledge were by far the most common form of learning. However, in some cases, they formed the basis for stronger knowledge restructuring which occurred less frequently. Independently, the affective triggers of SI resulted in superficial learning. Cognitive triggers of SI always led to more significant knowledge restructuring and co-occurred with affective learning episodes due to wonder, bodily experience or emotions as well as affective triggers of SI. Therefore affect enriches cognition by co-occurring with cognitive triggers of SI which in turn leads to strong forms of knowledge restructuring.

This study provides evidence that learning in informal settings is not insignificant. Practitioners should aim to present new discrepant information that impresses and creates strong emotional arousal among visitors to promote learning through a strong restructuring of knowledge. I suggest a refinement of the FPMID to consider that one may move iteratively, instead of sequentially, from Triggered SI towards Maintained SI and the time factor may be as little as a one-hour intervention. I also propose that biodiversity education be modelled around three aspects: ecological literacy, society and emotional connectedness. Finally, I recommend that auto-photography and photo-elicitation could be further explored in informal learning studies and science education, to promote affect and cognition.

Keywords: Situational Interest, biodiversity education, Human Constructivism, affective learning, Four-Phase Model of Interest Development, informal learning, nature reserve, Mauritius

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List of abbreviations

CBD:	Convention on Biological Diversity
CCM:	Conceptual Change Model
CML:	Contextual Model of Learning
EII:	Emerging Individual Interest
EES:	Environmental Education for Sustainability
FPMID:	Four-Phase Model of Interest Development
HC:	Human Constructivist
HSC:	Higher School Certificate
IAA:	Ile aux Aigrettes
ILS:	Informal Learning Settings
IUCN:	International Union for the Conservation of Nature
MSI:	Maintained Situational Interest
MWF:	Mauritian Wildlife Foundation
NGO:	Non-Governmental Organisation
PMM:	Personal Meaning Maps
Pre int:	Pre-visit interview
Post int:	Post-visit interview
S&T:	Science and Technology
SC:	School Certificate
SDG 14:	Sustainable Development Goal 14 – Life below water
SDG 15:	Sustainable Development Goal 15 – Life on land
SDG 4:	Sustainable Development Goal 4 – Quality education
SDG:	Sustainable Development Goals
SI:	Situational Interest
STEAM:	Science Technology Engineering Arts and Mathematics
STEM:	Science Technology Engineering and Mathematics
TSI:	Triggered Situational Interest
UN:	United Nations
WDII:	Well-developed Individual Interest

1. Chapter 1: Introduction

1.1 Introduction

This study aimed to investigate the nature of the development of Situational Interest (SI) and learning of biodiversity among students aged 13 to 15 years, during and after a visit to a nature reserve, Ile aux Aigrettes (IAA), a small islet situated in the south eastern coast of Mauritius. SI is the momentary spike in an individual's attention and affective response to 'environmental stimuli' that 'catch' and direct attention towards a content; in this case biodiversity. The nature of the physical settings, encounter with novelty and the possibility of social interaction have been found to trigger SI among students visiting a zoo and an aquarium (Dohn, 2010; 2013). From an educational point of view, one might want students' interest to be triggered, developed and maintained for a longer time since interest motivates learning, and is therefore desirable for education.

The essence of interest with respect to learning is that interest towards a content (in this case, biodiversity) may be triggered by environmental stimuli. While nature reserve practitioners cannot predict the extent of interest each learner has in entering a learning situation, they can aim to impart SI among visitors and hence influence the learning of biodiversity. Studying how SI may be ignited is therefore a starting point to investigate interest with respect to learning about biodiversity in the context of a visit to a nature reserve. Thus, an area for further research is identifying what aspects of the visit might trigger interest among visitors: is it the visitors' motivations, the guide or the environment? Another question is: does interest influence learning about biodiversity? Through this research, I address these central questions. This thesis, therefore, investigated the experiences of students as they visited Ile aux Aigrettes nature reserve in Mauritius. I investigated the aspects of the visit that triggered the interest of the students and what they learnt about biodiversity. I also investigated SI and its link to learning.

1.2 Context

Biodiversity comprises all life on earth. One of the main objectives of the United Nations Decade of Biodiversity (2011-2020) was to promote public awareness of the value of biodiversity especially targeting young people. Biodiversity education is particularly important since biodiversity has been described as a topic about which different stakeholders (society, politicians, scientists and citizens) have different agendas (Gayford, 2000). Biodiversity involves science, equity and distribution of a country's resources such that all individuals are deeply concerned. I believe that quality education implies that young people need to understand how these agendas come into play to be able to position biodiversity within the realms of education about and for sustainable development. Therefore young people who will inherit today's environmental management practices should be targets of biodiversity education so that they develop knowledge, concern and interest in biodiversity.

Interest is a construct falling within the affective domain of learning and has been recognised as a central concept in education (Hidi, 1990). People with high levels of interest tend to adopt effective learning strategies such as questioning driven by curiosity and perseverance usually expressed through positive affect (Hidi & Renninger, 2006). Interest in biodiversity may result in motivation to learn and deeper engagement with the subject. Citizens may thus become empowered to take part in decisions concerning biodiversity. Therefore, interest in and learning of biodiversity are desirable.

One way of being exposed to biodiversity is through a visit to a nature reserve. Nature reserves form part of informal learning settings which also comprise museums, science, centres, aquariums and botanical gardens whose primary aim is to entertain and educate visitors (Bell et al., 2009). As students visit a nature reserve, the novel environment is likely to create curiosity, delight and other emotional reactions during interaction with exhibits which might influence their learning. Hence, a visit to a nature reserve presents several affective learning opportunities which have been described as being poorly understood compared to cognitive learning (Alsop & Watts, 2003). In this thesis, I address this gap by investigating situational interest with respect to learning of biodiversity.

There is no doubt that learning happens when a student visits an informal learning setting such as a nature reserve (Bell et al., 2009). What and how students learn from these places has been referred to as informal learning, out-of-school learning (Braund & Reiss, 2006) or free-choice learning (Falk, 2005). This kind of learning is characterised by being learner-driven, usually devoid of structure, focusing on fostering delight, interest and curiosity among visitors as well as is entertaining and enjoyable (Bell et al., 2009). In this direction, one might think that entertainment takes the lead over learning which is more likely to be superficial. However, Stocklmayer and colleagues (2010) have refuted this argument with the following justification: The fact that informal learning is internally rather than externally driven makes the learning more constructive and longer lasting since it builds on a learner's existing knowledge. I think that the personalised nature of learning might be also be linked to the individual's interest towards a content since interest motivates further exploration and discovery. Thus, if interest is triggered during a visit to a nature reserve it might be a starting point for an intrinsically motivated learning of biodiversity even after the visit. Furthermore, Bell et al. (2009) in a publication of the National Academy of Science (USA) have advanced that "further research is required to understand how learners develop interest during informal learning experiences". This gap has also motivated my research on studying SI and its link to learning.

1.3 Background

A large body of research on situational interest (SI) in education has emanated from experimental studies where variables are carefully controlled to determine text characteristics that are favourable to learning (Ainley et al., 2002). These variables have been termed as situational factors of the environment that trigger SI; for example, text containing elements of surprise, novelty, challenge etc. Exhibitions and programmes in informal contexts are usually designed to instil interest, curiosity and surprise among visitors (Bell et al., 2009). However, little research has addressed SI in an informal context; e.g. Dohn (2010, 2013) who identified that different factors elicit SI such as hands-on, surprise, novelty and social involvement. Nevertheless, in informal settings, it is unlikely that these factors would occur independently (Renninger & Bachrach, 2015). Dohn's research may further be explored by investigating how these situational factors interact with one another and link to learning. It would also be opportune to investigate which exhibits trigger SI, especially in the context of a visit to a guided tour where the visitors are not able to move around freely.

SI has been described as having content specificity, that is, SI is directed towards specific content also termed as an object of interest (Krapp, 2002). However, the sparse studies on SI in informal settings did not address the object or content of the visits that trigger SI. Yet, exhibits and their content as well as their layout are determinants of the visitor experience which demand the attention of practitioners (Bell et al., 2009). Furthermore, scholars have called for innovative data collection methods to study visitor experiences in the least disruptive way. In this direction, I explored auto-photography as data to investigate the feelings and experiences of visitors to identify the exhibits that caught their attention during the guided tour.

SI is linked to learning since it channels attention towards content. A trip to a nature reserve presents learning opportunities about biodiversity. Biodiversity has been described as a broad and complex concept that is not easily understood by the public. In 1998, a survey of awareness and public attitude towards the environment among the Mauritian population revealed that out of a sample of 1000, only 42.7% have heard of the term 'biodiversity' and only 29.6% claimed to know what "biodiversity" means (Ministry of Environment, 1998). It is still unknown whether public awareness and understanding of biodiversity have changed since 1998. Yet public and students' understanding of biodiversity is important given the intricate link between biodiversity and society. Time and again Mauritius, like other small islands, is likely to face the serious biodiversity-related question: to safeguard, exploit or destroy biodiversity resources? Interest and knowledge of biodiversity are important since the public and young people are regularly challenged to understand and accept policies and decisions related to biodiversity worldwide, for example: seasonal closure of fishing. Since 2015, there have been diverging public opinions following the government's decision to authorize the mass culls of large numbers of the last species of flying fox (*Pteropus sp*) surviving in Mauritius. The decision was maintained even though the species has been assessed by the International Union for the Conservation of Nature (IUCN) as threatened with extinction (Vincenot et al., 2017). The flying fox is being blamed for destroying fruit plantations leading to economic loss. Scientists were fervently against this decision which puts the flying fox population at risk (Vincenot et al., 2017). This is a clear example of conflicting agendas regarding a biodiversity-related issue: economic profit or species protection. Thus, in this research, I addressed the question of what students knew about biodiversity and how their knowledge changed as a result of the visit to IAA.

Another important consideration is that science learning is not restricted to school learning and that an individual navigates through different roles during his/her lifetime and encounters learning opportunities, for example Scout groups (Bell et al., 2009). Scout activities including visits to nature reserves present science learning opportunities that are understudied (Jarmann, 2015). In this direction, my study explored how and what students learnt about biodiversity in their role as Scout members and not under the influence of schools.

1.4 Research Problem

Despite the potential of informal learning places to elicit interest and spark curiosity among visitors, in-depth research on interest and learning in informal contexts is sparse. A few researchers have addressed how participation in activities of informal settings succeeded in developing pro-environmental behaviour and connectedness with nature (Kossack & Bogner, 2012). Others have investigated the prior interest and motivation of visitors and found that botanical gardens and national parks visitors were more interested in restoration rather than learning as a purpose of their visit (Ballantyne et al., 2008). However, research on interest or the extent of interest development as triggered by the experience of a visit to a nature reserve is lacking. Similarly, there is a dearth of research linking interest and learning about biodiversity. This, even though the United Nations has placed education for sustainable development and global citizenship within Sustainable Development Goal (SDG4) which targets quality education to be reached by 2030. Furthermore, the SDGs also highlight the need to conserve, protect and sustainably use biodiversity resources, through SDG 14 which deals with the conservation and protection of life under water and SDG 15 which speaks of conservation and protection of life on land (UN report, 2020). As of 2020, the world is still falling short of the targets to reduce biodiversity loss and reversing this trend demands that societies need to be better educated about biodiversity (UN report, 2020).

The affective outcomes of field trips including increased interest, excitement, sparking curiosity, motivation or improved attitudes towards a topic, have been documented in informal settings (Bell et al., 2009). According to DeWitt and Storksdieck (2008), field trips that provoke interest and learning seem to be a valuable supplement to classroom instruction and motivate future learning. Bell et al. (2009) called for further investigation into how interest, future learning and learners' identity develop through informal science learning experiences and recommend further research on interest and learning as part of the six avenues that should guide research in informal learning. In this direction, I have investigated students' experience of a visit to a nature reserve, emphasising interest and learning of biodiversity.

A large body of research in environmental education offered by natural environments has focused on imparting knowledge, developing environmental attitudes and behaviours among visitors (Ardoin et al., 2020), thereby failing to address affect. Yet, these studies have addressed what happens as a result of the visit and on the *product* of learning rather than *how* the *process* of learning occurs. The underlying mechanism of *how* informal settings are stimulating interest and affect among students is still poorly researched. Dierking et al. (2003) and Bell et al. (2009) appealed for studying more of the *process* of learning in informal settings and Dierking and Falk (2016) called for research paradigms that holistically reflect questions of the ''what, when, where, why, how and with whom'' of STEM learning. Therefore, this research investigates both the process of learning and how interest is connected to learning.

Research on interest in the field of education has been addressed using reading and expository text and it has been recorded that both individual interest and interesting text have facilitative effects on cognitive functioning and learning (Hidi, 1990; Ainley et al., 2002). However, investigations on interest in science and informal settings and how they inform learning are sparse with few studies such as those of Dohn (2010) and Vainikainen et al. (2015). Such studies demand further attention and replication. Considering that the investigations of the latter authors were conducted in developed countries, it would be worthwhile to investigate whether these findings hold true for Mauritius, a Small Island Developing State, where research on biodiversity education is sparse.

A large body of research on visitor experiences has emanated from museums (Kirchberg & Tröndle, 2012). According to Braund and Reiss (2006), zoos, aquarium, museums and science centres allow one to engage with science through a *presented* world; meaning the place and set up is artificially created by humans and portrayed in a pre-determined fashion. Nature reserves, on the contrary, enable one to witness and experience nature in an authentic context, the *actual world* about which little research has been conducted (Braund & Reiss, 2006). The natural world possesses the advantage of acting like a natural laboratory portraying *in situ* conservation of biodiversity. The nature of the visitors' experience of encountering flora and fauna in their natural habitats might enable visitors to have a unique experience, possibly different from a museum visit. Investigating a visitor's experiences of a visit to a nature reserve with respect to interest and learning of biodiversity will contribute to our knowledge of visitor experience of biodiversity conservation *in situ.* The knowledge gained might help promote trips to nature reserves as valuable biodiversity learning resources for Mauritius and other developing countries.

1.5 Aim and research questions

This study aimed to investigate the extent to which a visit to a nature reserve influenced the development of interest and learning of biodiversity among students aged 13 to 15 years. The students were in the role of Scout members as they visited Ile aux Aigrettes nature reserve, Mauritius.

The research was guided by the following questions:

1. What are the situational factors of a visit to a nature reserve that trigger interest among students?
2. What do students learn about biodiversity as a result of their visit to a nature reserve?
3. To what extent do the situational factors of the visit identified in (1) influence the learning of biodiversity among students?

1.6 Conceptual Framework

This study was informed by research on situational interest (SI) and learning as they might occur in nature reserves which form part of informal learning settings. I used the Contextual Model of Learning (CML) (Falk & Dierking, 2013) to study how an individual's experiences in the informal learning context were influenced by the social, physical and socio-cultural context. I also used Hidi and Renninger's (2006) Four-Phase Model of Interest Development (FPMID) to frame my conception on the triggering and development of SI. I integrated the Contextual Model of Learning with the Four-Phase Model of Interest Development to investigate how interest was linked to learning in informal contexts. For studying how students learn, I used the concept of Human Constructivism from Mintzes et al. (1997) and Alsop and Watts's (2003) position on affective learning to demonstrate conceptual changes and meaningful learning. SI has been shown to influence conceptual change and correct misconceptions (Thomas & Kirby, 2020). Therefore, the learning process which operated together with SI was analysed by considering meaningful learning and conceptual change as described in the theoretical framework section in Chapter 2. A combination of the three frameworks informed the conceptual framework adding value to the study of interest and learning.

The study is based on constructivism (discussed in Chapter 2) which takes the view that students learn by actively restructuring their existing knowledge in response to their contextual environments. Therefore, the reality is socially constructed by students. Critiques of constructivism in the field of science education posit that learners need to acknowledge that science has a well-established methodology and that reality exists indifferent to our interpretations (Osborne, 1996). Thus, I adopt a 'modest realist' stance (Osborne, 1996) in studying learning, merging the affordances of constructivism by identifying how students construct their knowledge. Nevertheless, I acknowledge that there is an ontological reality about biodiversity, comprising of established theories produced through replicated experimental foundations. It is about this reality that students would be learning during their visit to IAA.

1.7 Researcher positionality

In Chapter 3, I explain that this research is interpretivist in nature and relies on qualitative methodologies. Holmes (2020) advances that qualitative researchers need to declare their positionality; that is, the researchers' world view and the position they adopt about a research task, its social and political context. The reason is that positionality might influence how the researcher approaches the research, its outcomes and results. I describe how my positionality may have influenced the research in this section.

I am a Mauritian woman, who was born and grew up on the island of Mauritius. As a Mauritian, I embrace the values of living in unity in diversity. Mauritius is a multi-ethnic and multi-cultural society. Despite being of Hindu faith and having Indian ancestral roots, I easily befriend and work with people of various origins. I developed these values from my upbringing, my social environment and my formal education in state schools, especially social studies and history classes which teach tolerance in diversity.

During my secondary school years, I won first prize in a quiz competition that focused on the protection of animals and I believe that this, coupled with the influences of dynamic biology teachers, instilled in me my passion for biology. I earned an Honours undergraduate degree in Biology at the University of Mauritius in 2006. For my dissertation, I studied the germination rates of native and invasive plants in Mauritian upland forests. This entailed tedious and physically demanding fieldwork in the dense forests in the Black River Gorges nature reserve and enjoyable overnight stays in field camps for scientists, far from the comfort of my home. I got the opportunity to interact with staff of the Mauritian Wildlife Foundation, the National Parks and Conservation Service of Mauritius and the Mauritius Herbarium. They worked on various projects such as the establishment of Conservation Management Areas, controlling invasive species and conservation of native forests. Having witnessed the heavy degradation of the Mauritian forests and influenced by the passion and groundbreaking work of my thesis advisers and peers, I always desired to make my contribution to the conservation of biodiversity.

As a young graduate, the job scarcity in the area of conservation biology led me to take up a temporary position as a guide at the Natural History Museum and subsequently a teaching job in a secondary school for about one year. I was then attracted to the job profile of my current position as Resource Officer/Senior Resource Officer in the education department of the Rajiv Gandhi Science Centre, Mauritius. In the meantime, I studied for a Masters Degree in Research Methodology, at the University of Mauritius on a part-time basis, I believe that this training contributed to my ability to embrace a PhD in science education despite having an undergraduate degree in the Natural Sciences.

I have thus spent almost 13 years in the field of informal science education, engaged in the promotion and communication of science. My main responsibilities include the development of informal science education programmes and content for science kits and exhibitions. I am also trained to conduct science shows during which I take special care to demonstrate experiments while introducing humour and fun to an audience. Thus, I believe that learning and enjoyment may be paired. While leading these programmes I usually adopt a constructivist stance, favouring audience involvement and interaction, scaffolding the information so that learning becomes easier for the audience.

During my years at the science centre, I have attended and presented at various international conferences in informal learning. While I was undertaking this research during 2017, I received a fellowship for training in science centre leadership at the Australian National University and during 2018, I was part of the training programme on Women in Science Technology, Engineering, Arts and Mathematics (STEAM) in the USA. These training programmes strengthened my passion for learning STEAM in informal environments. To date, I have visited more than 25 museums and science centres in different countries illustrating my passion and recognition of museums and science centres as educational institutions. I strongly believe that informal learning settings may contribute significantly to science education, having experienced and read about success stories of partnerships between schools and science centres and museums. This might represent a personal bias that I might have and in several parts of the thesis, I highlight the value of informal learning settings as vehicles for science education without undermining the importance of formal education. However, such claims are backed up with references and the findings of this thesis adds to the body of literature in informal settings.

My education, training and work environment has shaped me into a realist whereby as a scientist, I believe that there is an objective reality with tested and replicated scientific foundations. Being a female of Hindu faith who espouses Mauritian values such as tolerance in diversity and inter-culturalism, I had no personal bias during the data collection. For example, I could easily access the Christian Church premises and Chinese clubs to access the participants who were, in the majority, Christian. I do not consider that students viewed me as an authority figure or somebody different from them since most Mauritian students are born and brought up with similar values.

I also chose not to study the influence of religion and culture on the learning of biodiversity but instead objectively investigated how the individual experienced the visit to IAA, searching for the 'truth'. This means, I objectively and rigorously analysed the data with minimum personal bias as I described in Chapter 3. However, while studying how people learn in informal settings which are rich in emotions and sensations (similar to the ones I experienced while on field camp 17 years ago), I believe that I needed to obtain rich data and a thick description of students' ideas and feelings. Thus, I chose qualitative instead of quantitative methodologies. My experience as a science centre practitioner has shown me that the experiences of two students will never be the same and each student constructs his/her learning experience based on his/her prior knowledge and interest and in this direction I espoused constructivist philosophies.

Having highlighted my positionality as a researcher, I have drawn the attention of the reader to some aspects of my values and experience which might have influenced or not influenced my research given the context of this research. However, despite these bias or personal preference that I might have, I remained objective throughout the research and I consider that I have been able to bring to the forefront some insights into how students experience their visit to a nature reserve concerning interest and learning.

1.8 Conclusion

In this Chapter, I have highlighted how informal learning environments present affective learning opportunities for visitors and I point out that the affective domain of learning which comprises interest is poorly understood. Interest is desirable in education since it motivates learning. Public interest and knowledge of biodiversity are required since biodiversity is a socio-scientific issue which influences our life. Nature reserves comprise plants and animals conserved in a natural ecosystem and hence present learning opportunities about biodiversity. In this line, it would be opportune to study whether a guided tour to a nature reserve contributes to stimulating interest and learning of biodiversity. In this research, I investigate students' experiences of a guided tour to Ile aux Aigrettes nature reserve.

1.9 Structure of the thesis

This thesis consists of 8 Chapters as follows:

Chapter 1 is an introduction to the research where I describe the background and rationale of the research and developed the research questions.

Chapter 2 is the literature review where I survey the literature on biodiversity education, informal learning, interest research and learning.

Chapter 3 is the research design and methodology section where I describe and justify the steps that I undertook in designing and conducting the study. I describe the case study design, research instruments used namely photographs, personal meaning maps, observations and interviews and the theoretical underpinnings of this case study.

In Chapter 4, I describe the context of this research walking the reader to Ile aux Aigrettes nature reserve through the eyes of a participant using a narrative description. I highlight the exhibits and biodiversity explanation that one is likely to encounter during the guided tour under study.

In Chapter 5, I analyse the data that was collected from photographs and interviews to determine the factors that triggered SI among students. This Chapter highlights the affordances of visual methods of data collection to study participant experiences.

In Chapter 6, I analyse what students learnt about biodiversity by proposing and analysing a framework to guide the teaching and learning of biodiversity. I describe what students learnt collectively and also show a portrait of four students based on their prior knowledge.

In Chapter 7, I use the Human Constructivist framework to show how students learnt and use the findings to link how they learnt with the factors that triggered their SI.

In Chapter 8, I summarise the findings, discuss the results and highlight the implications for theory and practice.

2 Chapter 2: Literature review

This research focuses on Situational Interest (SI) and learning of biodiversity. The literature review draws on research about interest in education, situational interest, and learning in informal settings, including natural places and biodiversity education. In this Chapter, I first enlarge upon the construct 'interest', discuss research on interest with respect to learning, focusing on SI and identifying the factors that are known to trigger SI (situational factors). I also discuss the experience of learning in an informal setting and the theoretical frameworks that underpin this research. Since this research is also about the learning of biodiversity, I also expand on debates around biodiversity education and associated pedagogical implications before presenting the gaps in literature relating to studies on biodiversity education in real-life settings.

2.1 Interest in education

The importance of interest both as a goal and outcome of education has been recognised since the early 20th century through the works of scholars like John Dewey (1913). Much focus has gone into studies on attention, curiosity or motivation, which informed vocational career decisions before the 1980s (Krapp & Prenzel, 2011). However, it is more important to recognise the role of interest in describing and explaining learning processes and outcomes in various education settings. Thus, the theorisation of the 'interest' construct becomes crucial and has been later explored by scholars based largely on studies where participants' interest was assessed while they read expository texts (e.g. Hidi, 1990). Nevertheless, their findings might be relevant for studying interest in informal learning environments such as nature reserves, whose success in achieving their mission may be determined by their capacity to elicit visitors' interest in biodiversity.

'Interest' as a construct has been categorised as an emotion, a motivational variable and a psychological state[1] (Hidi & Renninger, 2006). I investigated how students experience interest as a motivational variable and as emotion as per Hidi and Renniger's (2006) definition, rather than a physiological/neurological state. This meaning of interest makes the precise definition of interest a difficult task (Harackiewitcz et al., 2016), but points out the richness of the interest concept. This indicates that one must have several considerations, including affect and motivation while studying 'interest' concerning learning.

Note[1] Renninger & Hidi, (2016) claim that interest as a psychological state is basically the physiological/neurological reactions experienced by an individual to objects, people and situations. That is what happens in the brain and the body and it may be displayed through facial expressions. The physiological reactions, however are not within the scope of this research.

The emotional component of interest

Firstly, as an emotion, interest has been described as a 'feeling of wanting to investigate, become involved or expand the self by incorporating new information and having new experiences with the person or object that has stimulated interest' (Izard, 1977, p.216). There are two key elements in this definition: interest has a feeling-related component, and secondly, this feeling motivates the desire for further exploration. The nature of the feeling is mostly manifested as a positive affect illustrated through curiosity or fascination towards a content that drives one's intention to investigate, seek information and explore related ideas (Ainley et al., 2002). However, negative feelings such as disgust have also been noted. Izard (2007) specifies that this feeling of interest creates new emotions, cognitions and ultimately motivations. This is why Silvia (2008) advanced that interest forms part of 'knowledge emotions' together with other emotions such as confusion, surprise and awe. Therefore, interest is closely related to learning, and this thesis investigates the nature of this relationship.

Since interest produces positive experiential states, Schraw and Lehman (2001) draw attention to the fact that interest should not be exclusively equated to enjoyment: interest catches attention and pushes one to explore something new and intriguing while enjoyment results in satisfaction, rewards and joy. Nevertheless, since enjoyment and positive affect represent signs that interest has been triggered, both interest and enjoyment are intricately linked. Critics have often claimed that in informal learning settings, including nature reserves, enjoyment takes the forefront over learning. Yet, Rennie and Stocklmayer (2003) have refuted these critiques by proposing that enjoyment does not prevent but rather enhances learning. Thus, affective learning outcomes of informal learning experiences should be considered. One such affective outcome is interest, which enables visitors to remain curious and therefore willing to pursue science (Bell et al., 2009). This represents a motivation for further engagement with science.

The motivational component of interest

Motivation is the second aspect of interest. A person in a state of interest will display increased attention, effort and affect towards the content of interest and will be pre-disposed to re-engage with the content over time (Harackiewicz et al., 2016). Since attention and effort represent a sign of interest, the latter construct has been closely related to intrinsic motivation theories. Deci (1992) conceptualised interest from the "self-determination theory perspective" whereby an individual engages in an activity with a full sense of wanting, choosing, and personal endorsement in a learning activity that produces enjoyment as illustrative of intrinsic motivation. Therefore interest may sometimes produce enjoyment of learning that becomes a desirable outcome of the learning that occurs in informal learning places. In such places, visitors are likely to experience excitement, curiosity, and to seek fun and entertainment while receiving educational information (Bell et al., 2009). Thus, learning becomes a pleasurable, rewarding and intrinsically motivating experience. When people are intrinsically motivated, they experience a state where they are completely immersed in an activity and experience what has been described as 'flow' in museum environments (Csikszentmihalyi & Hermanson (1999). This state can be thought of as being a state of interest (Deci, 1992). Therefore, interest is deeply connected with the intrinsic motivation to learn. It helps generate actions or emotions desired for learning, for example, actively seeking new knowledge to become further interested and engaged in a topic such as biodiversity.

2.1.1 Defining interest for this research

Irrespective of whether interest is considered a motivational variable or psychological state or a feeling, it is a central concept in science education. This is because, in science education, there is a need to investigate, acquire, use new information and ultimately become motivated to learn and act. For my research, I will define *interest with respect to learning as an emotional and experiential state characterised by affective reactions such as curiosity, enjoyment and increased attention that motivates further action and desire to learn more over time*. In this definition, the emotional state relates to the feeling-related aspect of interest, while the experiential state is related to the motivational component of interest that drives learning. However, I remain open to the notion of time in the sense that 'time' may be weeks, days, months or simply over hours.

2.1.2 The person-object theory of interest

Interest is a relational construct, meaning that an individual's interest is directed towards 'something' specific, termed as an 'object or content of interest' (Hidi & Renninger, 2006). The object of interest is the content towards which interest is directed, for example, endemic plants or tropical forest ecosystems or simply biology. This "special" and "distinguished" relationship between the person and the object/content of interest has been termed as the person-object theory of interest (Krapp, 2002). The relationship between an individual and his/her object of interest has also been referred to as content specificity of interest (Harackiewicz et al., 2016).

In light of the person-object theory of interest, Krapp and Prenzel (2011) emphasise the need to investigate better the structure of the object towards which interest is directed: interest towards an object (e.g. an exhibit), a topic (e.g. biodiversity), subject/domain (biology), an activity (dissection) or a context (a visit to a museum). Recently, while reporting studies of interest towards science, scholars have specified the object of interest under investigation. For example, Potvin and Hasni (2014) specified that they discussed Science and Technology concerning how it is taught at school. Furthermore, there has been an improvement in the measurement of STEM (Science, Technology, Engineering and Mathematics) interest. Staus et al. (2019) proposed a validation instrument to measure STEM interest by clearly asking a set of questions each falling under specific STEM domains such as earth and space science, life science, technology and engineering, and mathematics. These two studies (Staus et al., 2019; Potvin & Hasni, 2014) highlight the importance of defining the object of interest to identify which aspect of the science subject or topic causes interest among students. Therefore, while investigating how interest is triggered and manifested during a nature reserve visit, it is important to consider the object of interest, e.g. an exhibit, since it might indicate how and why an individual’s attention has been directed towards that specific exhibit. The object of interest is crucial for my study since I intend to identify the factors that trigger students' SI. These factors might be the exhibits, the guide, the content of the guide’s elocution, the presence of social groups or simply the context of the visit. In Chapter 5, I identify the objects towards which interest was directed during the guided tour.

2.2 Situational Interest

Two types of interest have been the primary focus of educational research: situational and individual interest (also referred to as personal interest). Situational interest (SI) is the immediate momentary affective reaction to certain environmental “stimuli” and, with time and support, it may develop into individual interest (Hidi & Renninger, 2006). On the other hand, individual interest is the relatively stable motivational orientation towards an object of interest illustrated through persistence and positive affect, resulting in increased learning (Ainley et al., 2002). SI refers to current engagements. It is a psychological state triggered by stimuli from the environment (Schraw & Lehman, 2001). It causes an individual to momentarily focus his/her attention and effort on the object of interest (or content) during an activity (Krapp, 2002). In theorising interest, Hidi and Renniger (2006) and Krapp (2002) advance that interest may be developed sequentially from the ‘fleeting’ SI towards a longer-lasting individual interest which becomes part of an individual’s identity. Identity formation, especially regarding biodiversity conservation, is desirable for environmental education programmes whose primary aims are to empower individuals to protect the environment (Ardoin et al., 2020). Considering that SI can also be triggered during a biodiversity-related field trip (Dohn, 2010; 2013), it might be a starting point for further interest in biodiversity and identity formation in individuals.

From the above discussion, it can be found that SI has the following attributes. First, SI may be triggered. Second, this triggering is determined by the learning environment (physical or social); third, SI catches and directs attention towards an object of interest and fourth, SI produces affect. Therefore, interest may be triggered and leads me to my first research question: what are the situational factors of a visit to a nature reserve that trigger SI among students? I discuss the situational factors that trigger SI (triggers of SI) hereunder.

2.2.1 The situational factors that trigger Situational Interest (SI)

If learning situations aim at imparting SI, identifying the factors that cause or trigger SI is required. A short term spike in a person's attention and participation in a learning activity would represent a state of SI. Elements in the learning environment that ignite SI are often referred to in the literature as triggers of SI or situational factors (Renninger & Hidi, 2016). A large body of research on interest and SI triggers has emanated from studies on reading an expository text where researchers identified the text's characteristics that evoke SI (Hidi & Renninger, 2006; Ainley et al., 2002; Schraw & Lehman, 2001). Early work in this area by Hidi (1990) and Ainley et al. (2002) found that text characteristics such as novel, unexpected or unusual information, the ability of the reader to identify with the character, text related to life themes, texts involving high activity level and structural aspects of the text such as coherence and completeness contribute to SI and opportunities for further learning. Other aspects are suspense, engagement and complexity of information (Schraw & Lehman, 2001). These factors appear to be similar to what happens to a visitor during an informal learning experience, for example, encounters with novel and unexpected information, suspense, personal relevance of the content and ease of navigation into exhibition space as reported by Falk and Dierking (2013). This leads to the consideration of whether the factors that have been found to trigger SI during text reading apply to informal learning experiences. However, studies on SI on the reading text were largely experimental. The researcher controls specific variables and uses mathematical modelling, making inferences and correlations (Förtsch et al., 2017). Often, recall of text after reading was considered learning and interest such that a high recall would mean a high SI. However, recall might not be appropriate to measure learning from nature reserve visits as I describe in section 2.4. This highlights that SI concerning learning during these visits is poorly understood.

More recently researchers have attempted to decode whether findings from text reading are relevant to other learning situations such as during biology and science lessons (Förtsch et al., 2017; Huann-shyang et al., 2013; Chen et al., 1999) and visits to informal learning settings (Vainikainen et al., 2015). In physical education classes, Chen et al. (1999) found that SI can be manifested through exploration intention and instant enjoyment. When taken together, novelty, challenge, exploration intention, instant enjoyment, and attention demand influence total interest, indicating that SI generated is more pronounced when several factors occur together. Still, the study was limited in not finding which of these five features were best able to trigger SI. Contrary to Chen et al.'s (1999) study which was positivist in nature and relied on correlations to make claims, Dohn (2013) adopted a situative approach, observing and interviewing students during school field trips to zoos and aquarium. He found situational factors of the visits that triggered SI: (i) surprise related to encounters with unexpected discrepant information, (ii) social involvement by being in a group, (iii) hands-on activities by engaging with experiments, (iv) novelty of aspects which were different from daily practice and

(v) knowledge acquisition by learning something new based on prior knowledge. This means observation studies are likely to reveal triggers of SI not identified during reading text, such as social involvement and hands-on activities.

The effect of hands-on activities on eliciting SI in learning situations was also documented by Vainikainen et al. (2015), Dairianathan and Subramaniam (2011) and Huann-shyang et al. (2013). The gap in these studies was that authors either failed to distinguish between SI and individual interest or addressed classroom learning following visits to science exhibitions (e.g. Vainikainen et al., 2015). SI, as it might occur during purely informal experiences or nature reserves, is poorly understood. Furthermore, from Dohn's (2010,2013) and Huann-shyang et al.'s (2013) studies, it appears that triggers of SI are occurring simultaneously. Still, the authors did not adequately report on the nature of these co-occurrences, nor did they identify the factor that was more impactful at triggering SI. Further studies on how the triggers of SI operate in conjunction might shed light on identifying the determinant triggers of SI, which might be further incorporated in education intervention programmes. Dohn (2010, 2013) was also sceptical in confirming the generalisability of his findings due to the small sample of participants studied. Thus, a deeper investigation on how the triggers of SI co-occur might be important especially in nature reserves and other informal learning settings whose mission would be to develop curiosity and interest for science among visitors (Bell et al., 2009). Thus, in this study, I could also identify the linkages between different factors that trigger SI during a visit to a nature reserve.

From the studies described above, I find that these triggers of SI could be categorised into two groups: affective and cognitive triggers of SI. The affective triggers of SI englobe aspects of the learning environment that evoke feelings in the individual, such as surprise, unexpectedness, the novelty of the situation, suspense, and the ability of the individual to find personal relevance to the information. The cognitive triggers of SI would be related to aspects such as the complexity of the information, cognitive activation, and challenge to prior knowledge described by scholars. Studying interest and learning enables an investigation of both the affective and cognitive triggers of SI simultaneously. Renninger and Bachrach (2015) advocate for wider use of observational methods in interest research. In my study, I address this by adopting field observation and visual data collection methods described in Chapter 3.

Another type of situational factor has been documented: seductive details (Hidi, 1990; Schraw & Lehman, 2001). Seductive details refer to the extent that highly interesting but unimportant text segments distract readers from more important text segments. They influence memory or recall of the learning situation. Seductive details abound during an informal learning experience and are, therefore, useful to study. Falk and Dierking (2013) emphasise the importance of the infrastructure in museum environments that is not related to exhibition content but shape visitor experiences for example décor, cafeteria, parking facilities, etc. DeWitt and Storksdieck (2008) report how the novelty of being in a new place, bus rides to reach the place, and the social context of a visit influence students' affective experiences. In a guided tour, seductive details might constitute visitors' comfort or the novel environment contributing to affective experiences and hence the SI.

It also appears that there is a blurred boundary between the aspects of the learning situation that cause SI and how SI is manifested. These two aspects are not distinguished. According to Hidi and Renninger (2006), SI results in short term affective and cognitive processing. Affective processing has been documented when participants describe feelings such as being surprised, awed, or having fun (Dohn, 2010) or catching individuals' attention. Therefore, if one claims to have experienced surprise in the wake of unexpected information, a SI event is assumed to have occurred. Cognitive processing is related to knowledge acquisition, especially when students make connections to existing knowledge and find relevance or value to the content.

Furthermore, it has been reported that SI is likely to be produced when individuals attribute value and usefulness to a learning content (Harackiewicz et al., 2016). I consider that this might be because learners enter learning situations full of prior knowledge and experience. Value and usefulness (Harackiewicz et al., 2016) possibly intersect with affective dimension of learning which contribute to conceptual change through learning materials which are germane and salient (Alsop & Watts, 2003). Affective learning is further elaborated in section 2.5.2. Thus, it would be useful to study SI concerning learning by identifying how students learn. The second aspect would be how the factors that trigger SI relate to knowledge acquisition. Therefore, subsequent research questions are: What do students learn due to their visit to a nature reserve? And to what extent do the triggers of interest influence the learning of biodiversity among students? Given that my research questions address interest with respect to learning, in the next section, I survey the literature on what learning in informal settings such as nature reserves would mean.

2.3 Learning in informal settings such as nature reserves

The goal of science education nowadays is not only for students to know, use and generate scientific explanations and evidence but also to understand the nature of scientific knowledge, become value-centred, and participate productively in scientific practices and discourse (Pedretti & Nazir, 2011). Discourse on science includes biodiversity, the multi-dimensional issue, related to science, society, economics and politics (Dreyfus et al., 1999). An individual who is value-centred is likely to develop a connection between the self and nature (Weelie & Wals, 2002). However, the formal education system has been criticised for being de-contextualised in terms of its inadequacies to cater for the cognitive, affective, social, and cultural dynamics of learning which are mutually supportive of one another and intertwined (Braund & Reiss, 2006). Learning in informal contexts possesses several affordances that might address the affective, cognitive and sociocultural learning (Falk & Dierking, 2013). Stocklmayer et al. (2010) advance that informal learning is 'internally rather than externally' driven, full of affective experiences, more constructive and longer lasting since it builds on learners' existing knowledge. This would imply learning is intrinsically motivating and might result from SI. Furthermore, visitors experience heightened curiosity, delight and enjoyment during interaction with exhibits, enabling them to remain curious and willing to pursue science (Bell et al., 2009). Curiosity, delight and enjoyment are affective reactions known to be manifestations of SI while learners' prior knowledge and new knowledge constructions form part of individual learning such that learning in an informal context is likely to be more of an experience which I discuss below.

2.3.1 The experience of learning

Since the learning process in informal settings is different from structured formal learning, there is a need to define what learning in an informal setting would mean. There is a general agreement regarding the complexity that learning science in informal settings entails. Braund and Reiss (2004) state that it is almost impossible to define learning since there is a high dependency on the researchers' context, perspectives, and intentions. They criticise definitions that focused only on measurable outcomes and adopt a wider view of learning as follows:

Learning is a process of active engagement with experience. It is what people do when they want to make sense of the world. It may involve the development or deepening of skills, knowledge, understanding, awareness, values, ideas and feelings or an increase in the capacity to reflect. Effective learning leads to change, development and the desire to learn more (Braund & Reiss, 2004, p. 5).

From the definition of Braund and Reiss (2004), learning appears to be more of a life-long endeavour where learners continuously make sense of their world cognitively through knowledge acquisition, affectively and experientially under the influence of environmental, cultural and social factors. Thus, learning science from the real world does not result from a single experience. Dierking et al. (2003) advance that

Learning is cumulative, emerging over time, through a myriad of experiences …that dynamically interact to influence how individuals construct scientific knowledge, attitudes and understanding… Learning is an organic, dynamic, never-ending, and holistic phenomenon of constructing personal meaning… (Dierking et al., 2003, p. 109)

From Dierking et al.'s (2003) and Braund and Reiss's (2004) work, it appears that emphasis is laid upon the fact that learning is more of an experience resulting from one's interaction with a diversity of social and physical contexts. Falk and Dierking (2013) advance that experiences are cumulatively built on others because there are many variables (e.g. prior knowledge and experiences, time, presence of other people, interest, etc.) that ultimately shape the learning experience. Therefore, the attribution of one-to-one causal effects of the variables on how visitors learn in museum environments would be problematic. Therefore, investigating learning experiences demands a thorough consideration of cognitive, affective and socio-cultural factors that operate over time. Thus, the feelings that may be evoked and students' experiences during a nature reserve visit would influence what they learn about biodiversity.

The above definitions suggest that emphasis is laid on the interplay between cognitive and affective components of learning. This calls for further consideration of affective learning in informal learning situations, which has received little attention from researchers (Alsop & Watts, 2003). Stocklmayer et al. (2010) identify a set of affective attributes that underpin the voluntary and intrinsically motivated nature of learning in informal learning settings. They highlight how informal learning settings aim to create wonder, surprise, delight and excitement, and eliciting learners' interest in science. Since surprise has been found to cause SI, and delight and excitement are signs of manifestations of SI, affective experiences during visits to informal spaces appear closely linked to interest.

Affect has been investigated in environmental education research such as on nature connectedness (Liefländer et al., 2013), appreciation for nature (Kaiser et al., 2014) and environmental values (Schneiderhan-Opel & Bogner, 2020). However, these studies have relied largely on self-reported questionnaires, focusing on attitudes and behavioural intentions, and it appears the construct of 'interest' or 'emotions' is not deeply investigated. Furthermore, investigating learners' interest has been recommended as one of the six strands that informal learning research could address (Bell et al., 2009). Interest is important since science education's ultimate goal is to enthuse students and permit them to develop an appreciation of the crucial role of science in society (Stocklmayer et al., 2010). More studies on how informal learning settings might support interest development among visitors is required. For this to happen the construct of 'interest' as applied by scholars in interest research (Hidi & Renninger, 2006) may be investigated in the context of learning in nature reserves.

In light of the above discussion, for my research, I adapt Anderson et al.'s (2003) definition of learning in informal settings:

the process of '*gradual, incremental and assimilative growth in knowledge* (Anderson et al., 2003), *resulting from an emotional and/or social experience of interacting with the environment*'.

The definition of learning illustrates the complexity of learning in an informal context. It englobes the personal, physical and social context of Falk and Dierking (2013) and the affective, social and cognitive aspects. At the same time, it highlights that learning is an experience that cuts across place and time. Furthermore, by stressing the emotional experience, I also meet the 'people-centred' lens of Bell et al. (2009) that refers to the purposes and outcomes of science learning in informal environments such as the development of interest and motives, knowledge and affective responses. Besides, in Bell et al.'s (2009) National Research Council report, the appeal was made to integrate theoretical perspectives in studying learning experiences in the informal context which I discuss below.

2.4 The frameworks for studying learning in informal settings

As discussed in Chapter 1, I chose the Contextual Model of Learning (CML) as an overarching framework for studying learning experiences in an informal context. The CML has roots in socio-cultural and constructivist theories (Falk & Dierking, 2013). In the next two sections, I first briefly discuss the frameworks widely used for studying learning in informal settings.

The recognition and understanding of learning in informal contexts imply that research on learning should be theoretically grounded. The use of a coherent conceptual framework in informal learning gained momentum only from the mid-1990s (Phipps, 2010). This means that studying learning experiences has not always been theoretically grounded even if this is required to mainstream informal learning within science education as proposed by Rahm (2014). In several research articles published from 1995 to 2005, authors highlight how theory may become ingrained into research on informal learning (Dierking et al., 2003; Martin, 2004; Phipps, 2010; Anderson et al., 2003). The socio-cultural and constructivists theories have dominated research in the area (Phipps, 2010). I discuss the relevance of these frameworks to a study like mine hereunder.

2.4.1 Socio-cultural theories

The sociocultural approach has viewed learning as a collaborative activity among social groups, through tools, people, language and actions and stems from the work of Vygotsky (Ashgar, 2012). The importance of scaffolding is manifold through verbal and non-verbal guidance provided to children through adults in their environment (parents, teachers and museum docents). In a guided tour, the adults include the guides or the group leaders. Dierking et al. (2003) call for the exploration of the social and cultural mediating factors in shaping learning experiences as one of the six avenues that could inform informal learning research. However, Martin (2004) highlights some challenges associated with the socio-cultural theory, which could be addressed through a clear definition of the unit of analysis (family discourses, participant group structures and institutional dynamics). In this line, Tunnicliffe et al. (1997) studied discourse among family groups to identify learning processes that take place in museums settings. A guided tour would be full of elocution from the guide, which determines what information visitors receive about the nature reserve. Thus, socio-cultural theories might have informed my research. Still, the nature of the guided tour under study prevented me from relying on the socio-cultural theory for the following reason: the socio-cultural theories of learning is more concerned about how the adults and students would exchange information rather than the delivery and transmission mode adopted by the guides who led the groups in my study. In my study, conversations with the guide and other students remained limited. Nevertheless, I recognise that there are no labels associated with exhibits during the tour to Ile aux Aigrettes and the guide plays a crucial role in delivering biodiversity related information to visitors. Therefore, I acknowledge that all the new knowledge gained as result of the trip could be attributed to the guide's elocution. However, I examined how individuals made changes in their cognitive structures based on their prior knowledge and this irrespective of their social interaction, and this aspect is better addressed by the constructivist framework.

2.4.2 Constructivism

Kim and Dopico (2016) highlight how the depth of scientific information in exhibitions is sometimes too abstract. Visitors who are not acquainted with the topic might find it difficult to understand. This may be particularly true for somebody learning about biodiversity during a first-time visit to a nature reserve. Using constructivist thinking, Hein (1995) considers that the learner in a museum environment (or nature reserve) is not a 'passive vessel' into which information is poured but rather undergoes the process of learning as an active restructuring of the mind. He conceives learning in museums as a blend of how visitors make meanings out of museums' exhibits and how this is influenced by visitors' culture, previous personal experience, and visit conditions. Thus, the focus is on individual learners' mental construction of meaning and knowledge, in response to their social, contextual environments. Hence, the importance of prior knowledge and experience become crucial in shaping future learning. A 15-year-old student is likely to enter a nature reserve with his/her prior knowledge of biodiversity; some may be correct or incorrect. From the visit, new knowledge will be incrementally developed by expanding one's existing mental representations (assimilation) or modifying their mental schemas to achieve equilibration by resolving the discrepancies between the external reality and their internal representations of that reality (accommodation) (Asghar, 2012). Therefore, learning would mean how knowledge is constructed at the individual level.

Research approaching informal learning from the constructivist perspective examined evidence of changes in learners' conceptual models (e.g., Anderson et al., 2003). Focus is on individual learners, sometimes through an inquiry-based approach (Ashgar, 2012). The concept of meaning-making, which emerged from Ausubel's theory of meaningful learning, was thus embraced by the field of informal learning (Silverman, 1995). Meaning-making became incorporated in the exhibition and programme design to make museum experiences more relevant to the visitors who assimilate and accommodate new information. For meaningful learning to occur, learners consciously connect new information to their prior knowledge of personally relevant content. Therefore, the constructivist framework is more concerned about an individual assimilates new information into existing knowledge structures.

In further considering the dynamic and personal nature of learning, Anderson et al. (2003) propose that learning in informal contexts should be approached from a Human Constructivist (HC) perspective. They suggest that Human Constructivism recognizes that learning can be gradual, assimilative, implying a conceptual change in understanding, or sometimes rapid and significant, and resulting in a restructuring of knowledge. Human

Constructivism is relevant to informal learning as it acknowledges that a visitor's prior knowledge can impact the nature and quality of what they learn due to their visit. It also involves the knowledge change and restructuring that take place in an individual following a museum experience. I further discuss HC in the theoretical framework section.

2.5 Theoretical framework

This research falls within the realms of informal learning because nature reserves are part of informal learning settings. There seems to be a consensus that learning in informal learning environments is complex, involving the cognitive, affective and social aspects of learning (Bell et al., 2009). Since this thesis is about interest and learning, I choose to be guided by the Contextual Model of Learning (Falk & Dierking, 2013), how students learn is theoretically framed within conceptual change and Human Constructivism (HC) (Mintzes et al., 1997; Mintzes & Wandersee, 2005) while for SI, I adopt the Four-Phase Model of Interest Development (Hidi & Renninger, 2006).

2.5.1 The Contextual Model of Learning

As discussed in the literature review, learning in informal contexts is a complex and ongoing process where the individual's experience matters more than his/her ability to recall facts. This experience is influenced by a never-ending dialogue between the environment, the person and his/her socio-cultural influences. In this light, Falk and Dierking (2013) put forward the Contextual Model of Learning (CML) shown in Figure 2.1 below, as a guiding framework to study the complex nature of learning in informal environments. The CML draws from constructivist, cognitive and sociocultural theories of learning and describes learning in informal settings as a product or dynamic process of interaction between an individual's personal, sociocultural, and physical contexts. The intersection of the three contexts results in engagement which is the desired outcome of science education (Mckinnon & Vos, 2015). The CML caters for the complexities and wide array of factors that influence learning experiences in informal settings and has been widely embraced by researchers (Rennie, 2015; Phipps, 2010).

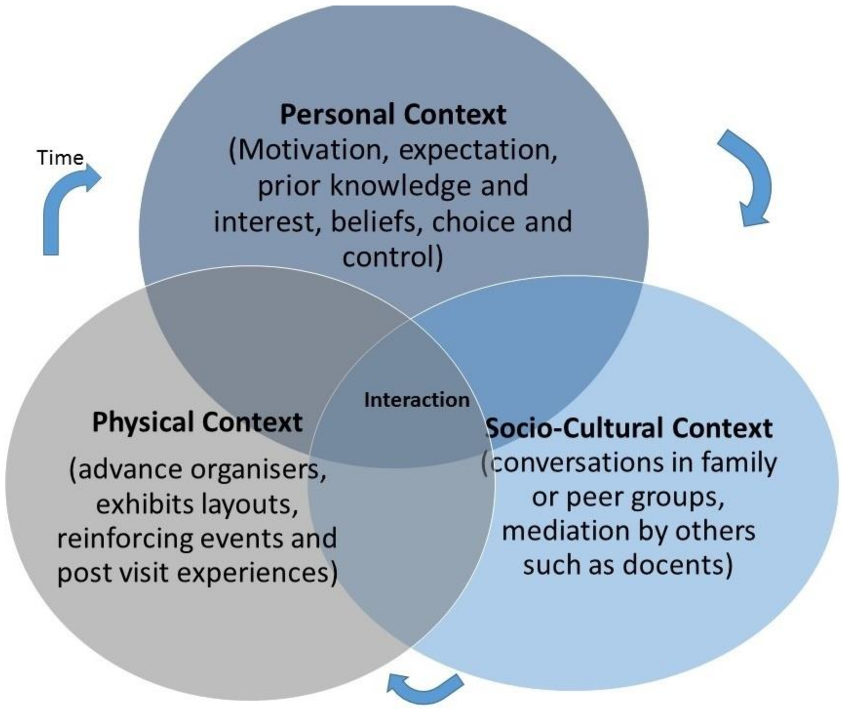

Figure 2.1: The Contextual Model of Learning (adapted from Falk & Dierking, 2013)

The CML guides researchers into framing their research into either one or all three contexts: personal, socio-cultural, and physical. The personal context represents what an individual carries into a learning situation such as visit motivation, expectations, prior knowledge, interests and experiences; the socio-cultural context speaks of the social and cultural interactions that a visitor has within and outside his/her group while the physical context represents the dialogue of the individual with the physical environment of the visit such as the orientation of exhibits in space, architecture, designs and programmes etc. (Falk & Storksdieck, 2005). The personal context is deeply rooted within the constructivist framework, emphasising prior knowledge and interest while the socio-cultural frameworks have influenced the social context of the CML. The interaction between the physical,socio-cultural and personal context of the learner occur in a dynamic interaction that progresses through time as the learner navigates through different roles and settings during his/her lifetime.

Dohn (2010; 2013) shows that the physical context plays a role in arousing SI on a field trip during which social interaction abound. The social context would be considered in terms of group interaction among students, the guides and Scout leaders. The physical context will identify what physical attributes of the field trip (e.g. what learners see and touch) have an impact on learning experiences. The individual's personal experiences constitute their interest and learning that occur during the field trip and are dependent upon their prior knowledge. Falk and Storksdieck (2005) acknowledge that the CML is a large framework with many interconnected factors, and it is challenging to investigate all factors. Therefore my focus is on the personal and physical context of the visit and I do not investigate the socio-cultural context in depth since my research questions aim at investigating individual learners. However, I did not overlook the social influences on individual experiences. I remained open to observations or records of any social interaction during the visit which might influence the experiences of individuals. For example, I noted any interaction that the individual had with the guide, group leaders and other students. The guided tour was heavily driven and directed by the guide, who played a critical role in transmitting information to students. By using the CML as an overarching framework, I shed light on how interest (which forms part of the personal context) is related to learning and how other aspects of the CML (prior knowledge, physical space, interaction with physical space) interact with interest. This will be equivalent to 'what kind of connection' exists between the physical and personal contexts (interest).

2.5.2 Human Constructivism and affective learning

My research question 2, 'what students learned about biodiversity', and 3, 'how the situational factors of the visit influence how students learned about biodiversity', are deeply connected to learning. As per the definition of learning that I embraced: the process of '*gradual, incremental and assimilative growth in knowledge (Anderson et al., 2003), resulting from an emotional and/or social experience of interacting with the environment'*, both the cognitive and affective side of learning are investigated. This suggests that some form of conceptual change might be appropriate to investigate learning in individual students. I decided to espouse the constructivist school of thoughts whereby new knowledge is constructed following interaction with the environment (the trip) and more specifically Human Constructivism and the conceptual change model put forward by Alsop and Watts (2003) which is an extension of Conceptual Change Model (Posner et al., 1982).

Conceptual change and Human Constructivism

Learners are likely to enter the nature reserve together with their prior knowledge and conceptions of biodiversity, some of which may not match established scientific views. The roots of conceptual change during learning have been established by Piaget's terms *assimilation*, which is a modification of new information to fit what we already know and *accommodation* which represents a restructuring of our existing knowledge to fit a new one (Duit & Treagust, 2003). Thus, acquisition of knowledge is seen as a process of knowledge extension and exchange of misconceptions with meaningful knowledge (Duit & Treagust, 2003). Hewson (1992) further describes that change in prior conceptions may take the following forms (i) addition or extension whereby the learner adds new information to his/her existing conception, (ii) extinction where the initial concepts are abandoned and (iii) exchange where prior knowledge is replaced with new ones. A widely embraced model for conceptual change is the Conceptual Change Model (CCM) put forward by Posner et al. (1982). The CCM has two components: (i) firstly the learners need to be dissatisfied with their prior conceptions (ii) secondly, to learn a new concept the learner must understand it, accept it, and see it as useful. Conceptual change occurs when learners undergo 'weak' knowledge restructuring through moderate changes in his/her knowledge structures or a conceptual exchange (a stronger form of knowledge restructuring) through the abandonment of prior conceptions.

Much work on conceptual change has gone into identifying how learners' prior conceptions are resistant to change and have proposed solutions for teachers to help students embrace new conceptions over their existing ones (alternative conceptions) (Özdemir & Clark, 2007). The Conceptual Change Model might be relevant to learning during the nature reserve visit. In this environment, learning is learner-driven rather than teacher-driven. It would be more appropriate to study how learners construct their new knowledge of biodiversity upon existing ones through meaningful interaction with the context of the visit. This implies meaningful learning, where the learner conscientiously integrates new knowledge into his/her existing knowledge (Novak, 2002).

I find that the Human Constructivist (HC) framework developed by Novak, Mintzes and colleagues (Mintzes & Wandersee, 2005; Mintzes et al., 1997; Novak, 2002) might be relevant to investigate the learning of biodiversity during the tour to the nature reserve. HC has its roots in Ausubel's theory of meaningful learning and considers conceptual change through the basic idea that new knowledge and meaning is constructed and reconstructed following a modification of prior conceptions. The Human Constructivist framework is grounded on the premise that knowledge is stored hierarchically in our brains consisting of concepts and propositions. As meaningful learning proceeds, new concept meanings are integrated into our cognitive structure to a greater or lesser extent based on the quality and quantity of prior existing cognitive structures (Novak, 2002). Mintzes et al. (1997) describe concepts as perceived regularities between words/objects designated by objects, symbols or labels while propositions are the link words that describe the relationships between objects and symbols. Hence, much of Novak and colleagues' work has been based on practical tools such as concept maps representing 'mental models' that exist in a similar form in the brain.

The Human Constructivist view of learning recognizes that individuals' present conceptions are products of diverse personal experiences, observations of objects and events, culture, language, and teachers' explanations (Anderson et al., 2003). Such conceptions are not necessarily consistent with academic knowledge structures and therefore appropriate for informal learning. A small number of studies in informal learning settings have used concept mapping to determine the students' understanding of concepts (e.g. Anderson et al., 2003). The variant of concept mapping, the Personal Meaning Maps (PMM) situated within the constructivist paradigms, have started to become more widespread since it was proposed by Falk (2003). For example, Faria et al. (2019) and Lelliott (2009) found that Personal Meaning

Mapping was a useful technique to gather data on learning during school visits to a planetarium. In Chapter 3, I elaborate on PMMs which I used as a data collection instrument.

I encountered only two studies that used Human Constructivism as a theoretical framework to study learning in informal settings: that of Anderson et al. (2003) who studied knowledge transformations in three students who participated in a class visit to a science museum and follow-up classroom activities and that of Lelliott (2007) who assessed learning of astronomy following class-visits to a science centre and an observatory. Both studies have proved that Human Constructivism is an appropriate framework for studying learning in museum environments, yet, this theoretical framework is largely unutilised, making it appropriate for me to adopt. Figure 2.2 below presents a concept map adapted from Mintzes et al. (1997) to illustrate how Human Constructivism is linked to meaningful learning and knowledge.

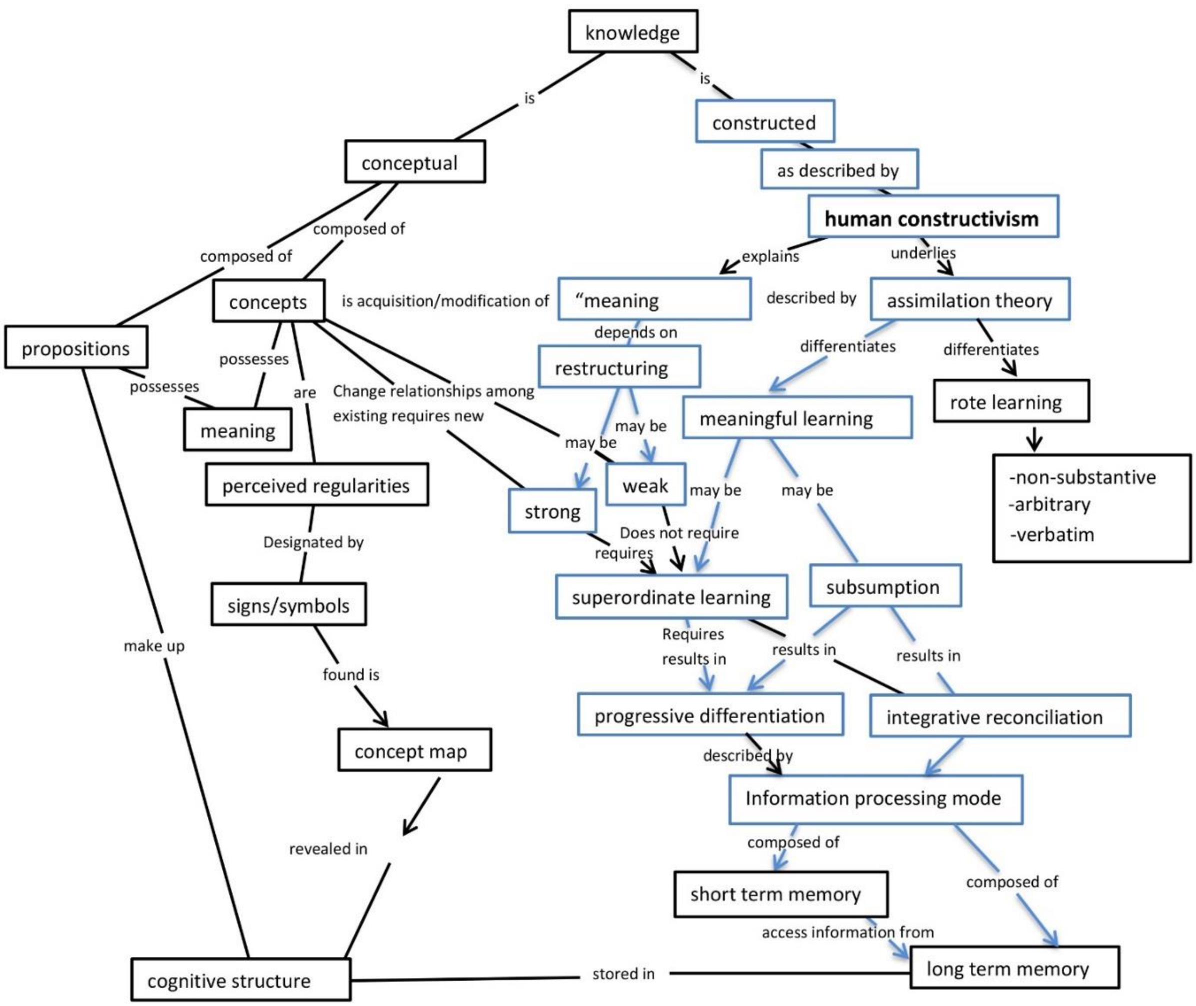

Figure 2.2: A concept map of the Human Constructivist framework (adapted from Mintzes et al., 1997)

The view of learning as per Human Constructivism summarised in Figure 2.2 above shows the relationship among four cognitive processes from meaningful learning which I describe below: subsumption, superordinate learning, progressive differentiation and integrative reconciliation. I describe each of these main processes as I use them in subsequent analysis.

(i) Subsumption

Subsumption occurs when new and less-inclusive concepts are linked to more general, higher-order concepts present in the learner's cognitive structure; for example, when students learn that certain unicellular organisms may be classified as "animals", the latter concept assumes substantively new meaning (Mintzes & Wandersee, 2005). Originally Ausubel distinguishes two types of subsumption: (i) derivative subsumption where the new learning material is simply understood as an example or illustrative of a previously learnt concept-e.g. the giant skink (*newly learnt material*) is an example of extinct animals (*previously learnt concept*) (ii) correlative subsumption whereby the new material is an elaboration, modification or extension of previously learned knowledge - e.g. extinct animals (*previous knowledge*) including the giant skink (*newly learnt material*) meaning it is gone forever and will not be seen alive again (*elaboration of the prior knowledge of extinct animals*).

Anderson et al. (2003) used the term 'addition', instead of subsumption, to categorise knowledge transformations that included adding new, less inclusive concepts that could be both derivative and correlative subsumption. They went further into their categorisation to introduce the terms 'recontextualisation' which they defined as the understanding of a concept modified by a changed context, but 'with no significant clarification of meaning' (Anderson et al., 2003). Recontextualisation appears to be more related to correlative subsumption and to Hewson's (1992) idea of 'addition or extension' whereby the learner adds new information to his/her existing conception. I find that subsumption would be what Duit and Treagust (2003) describe as 'conceptual capture' or weak restructuring' of knowledge structures. It represents an addition of new less-inclusive concepts which is a moderate change to the prior conceptions.

(ii) Superordinate learning

In superordinate learning, a new, more general and inclusive concept is linked to more specific concepts already a part of the learner's cognitive structure representing a significant reordering of cognitive structure (Mintzes et al., 1997). One such example could be when a learner learns about the concept of endemic species (species uniquely present naturally in a place and not introduced by man) and shows an understanding that endemic species are also native/indigenous (species naturally present in one country or place but also naturally present in other countries or place). Besides, they might recognise that native species might not necessarily be endangered. The ability to integrate and logically link these different concepts (endemic, native, endangered) together might represent an example of superordinate learning. Mintzes et al. (1997) advance that superordinate learning is typical of insightful moments. Since the learning experience in informal settings is characterised by eliciting curiosity and marvel among visitors, it implies that there are opportunities for superordinate learning. Yet they note that 'unfortunately superordinate learning is characteristic of only a small proportion of what goes on in education'. Insightful moments might be indicative of SI and while investigating how students learn in Chapter 7, I show that superordinate learning episodes indeed occur.

(iii) Progressive differentiation

Mintzes and colleagues describe progressive differentiation as the gradual elaboration and clarification of concept meanings during subsumption and superordinate learning. Learners delineate similarities and differences among existing concepts resulting in a more cohesive and integrated knowledge framework. Thus, progressive differentiation is more related to how knowledge structures are stored in increasing hierarchy levels and might be represented in concept maps through branching of central concepts that Mintzes and colleagues call 'dendritic structures' composed of many hierarchy levels. One example would the fauna (level 1 in the hierarchy) which branches into native species (level 2) which branches into endemic species (level 3). Endemic species branches into two dendritic structures: pink pigeon and Mauritius fody (level 4). Thus, there is an increased elaboration and clarification of the different concepts and how they are related (e.g. endemic species are a subset of native species).

(iv) Integrative reconciliation

Integrative reconciliation occurs when one explicitly delineates similarities and/or differences between related concepts, for example, the characteristics of mammals, birds, reptiles and fish and amphibians recognising that both birds and reptiles lay eggs to reproduce but reptiles are characterised by scales on their body and birds by feathers. Thus, the learner makes cross-connections between related concepts and eventually develops well-integrated, highly cohesive knowledge structures that enable them to engage in the inferential and analogical reasoning required for success in the natural sciences (Mintzes & Wandersee, 2005). Anderson et al. (2003) used the term *merging* to illustrate integrative reconciliation and used an illustrative example of copper and zinc that are similar because they form part of 'metals'.

Lelliott (2007) identifies that some authors found that integrative reconciliation has resulted from subsumption and superordinate learning while Ausubel's original theory refers to integrative reconciliation as a result of superordinate learning. This points out that during meaningful learning as per the constructivist framework, the four types of conceptual changes identified are linked, and the nature of these linkages have not been well defined especially regarding how subsumption, the 'weak forms of knowledge restructuring', evolve as the learner's knowledge structures become progressively refined. In light of this, Anderson et al. (2003) has used other terms consistent with Human Constructivism such as *emergence, disassociation and recontextualisation*. *Emergence* occurs when concepts that may have been stored in the students' memory are retrieved following a museum visit, and *recontextualisation* is when a change in a learners' conception is directly attributed to the visit's context. Anderson et al. (2003) used *disassociation* when the student abandons a previous conception for a new one due to a science centre visit. While recontextualisation may represent an extension or extinction of initial concepts, disassociation would be more of exchanging concepts. In Chapter 7, I produce an analytical framework, synthesising the types of conceptual change proposed by Anderson et al. (2003) and Mintzes and Colleagues based on the work of Lelliot (2007) to analyse how students learnt by the Human Constructivist framework.

Affective Dimension of learning as an extension of the Conceptual Change Model

Human Constructivism focuses on the cognitive domain of learning. However, the growth of knowledge that constitutes learning also results from emotional experiences as per the definition of learning that I adopted. The Conceptual Change Model (CCM) (Posner et al., 1982) suggests that conceptual change will only take place through assimilation or accommodation when the learner perceives the subject matter as intelligible (clear enough), plausible (reasonably true) and fruitful (potentially useful), thereby overlooking the importance of affective learning.

Recognising that the revisions of the original CCM were still largely cognitively emphasized, Alsop and Watts (1997) built on the work of Posner et al. (1982) and Treagust and colleagues (2003) to propose that CCM should also include issues of affect, conation and self-esteem. Since affect is considered, Alsop and Watts's work might be appropriate for studying the interaction between interest and how students learn. The advantage of Alsop and Watts's proposition is that the model was built upon a series of studies within the informal learning context under the assumption that during informal learning experiences, individuals construct scientific knowledge from multiple sources and that learners' attitudes and feelings towards science influence their capacities to act on the knowledge they construct. This makes Alsop and Watts's extension of the CCM appropriate for my research on interest and learning.

In addition to the cognitive aspects of the original CCM, Alsop and Watts argue for three ingredients that enhance learning about a science content: how 'salient', how 'germane' and how 'palatable' (Alsop & Watts, 1997). They stress the importance of the affective lens in influencing learning. Watts and Alsop (1997) describe 'salient' as features of a 'piece of knowledge' that the individual sees as conspicuous, astounding, striking and stunning, and may have either positive or negative influences in the individual by being either stimulating or disturbing. The aspect of salience appear closely related to the affective factors that trigger SI as identified in literature such as emotions of surprise or striking text (Dohn, 2010; Hidi &

Renninger, 2006). ‘Germane’ considers how the learner perceives the new knowledge as being personally relevant in terms of its applicability and appropriateness in the sense of how the learning material will be useful to the learner. Rahm (2014) and Potvin and Hasni (2014) found that teaching methods that show the relevance of school science in everyday life are more likely to develop students interest in science and technology. These studies support a close link between relevance and interest. The ‘germane’ aspect represents how the teaching of science, especially in informal settings, might become more contextualised to address issues of equity and diversity instead of proposing a westernised view of science to visitors.

Since germane considers the usefulness of the learning material, it also joins the utility-value of interest described by Harackiewicz et al. (2016) who perceived that one would be interested in a content if the latter is perceived as useful and valuable. The utility-value of interest thus, intricately ties with ‘fruitfulness’ of learning material described in the CCM. Finally, Watts and Alsop (1997) describe the ‘palatable’ lens of affective learning regarding how agreeable to the mind or savoury the learning material is. The palatable component refers largely to the feelings learners develop towards how happy or unhappy they are to learn about the content. Watts and Alsop (1997) refer to an interview with a student who mentioned that she dreaded to learn about radioactivity. Similarly, Hidi and Renninger (2016) refer to these positive and negative feelings about a learning content that captures interest, but while Hidi and Renninger consider the negative feelings as potential triggers of SI, Alsop and Watts (1997) consider the negative feelings as distasteful and a deterrent to learning. Thus, feelings about a learning material might influence both interest and learning up to a certain point beyond which affect and cognition need not necessarily be indissociable.

In addition to the affective lens, Alsop and Watts (1997) also describe a *conative* dimension of learning that might favour conceptual change, meaning how actionable the learner perceives a learning content. This implies how the new learning material will lead the learner to take further action and apply it to practical problems. Acting on knowledge might mean changed behaviours or behavioural intentions. Behavioural change has gained attention in biodiversity education research (e.g. Schneiderhan-Opel & Bogner, 2020) and environmental education research (Ballantyne et al., 2008), implying that the conative dimensions of learning might become a goal of biodiversity education programmes. Furthermore, Alsop and Watts (1997) describe the self-esteem dimension of learning which consists of an image (how the learners perceive themselves about science), confidence (the sense of self-belief that drives the learner to persist in the challenge) and autonomy (individual’s capacity to pursue the scientific endeavour and find answers). The self-esteem aspect seems more related to individual interest, learners’ identity and their ability to persist without support in the face of difficulties and thus, not within the scope of this research.

The descriptions of salience, palatable, germane and conative dimensions of learning provided by Alsop and Watts (1997), suggest several meeting points between SI and affective learning. Therefore, the affective and conative dimension of learning act as a reasonable theoretical ground to study whether SI influences learning. The four dimensions of affective learning become suitable for studying learning in informal settings where affective experiences abound, and visitors have fun. While the Human Constructivist framework provides the theoretical grounds for identifying cognitive learning, the CCM extended by Alsop and Watts (1997) considers the affective and conative dimensions to study learning. In Chapter 7, I adapt these two frameworks to analyse my data on how students learn and then link SI and learning using deductive coding.

2.5.3 The Four-Phase Model of Interest Development (FPMID)

I investigate how students' experiences influence situational interest in biodiversity-related content (object of interest) presented to them during the IAA visit using the Four-Phase Model of Interest Development (Hidi & Renninger, 2006). The essence of the model is that the momentary SI, which can be triggered, may ultimately develop into long-standing individual interest; hence interest may undergo a development process. However, the research focuses on SI rather than individual interest.

Hidi and Renninger (2006) put forward the Four-Phase Model of Interest Development (FPMID) based on previous studies that have measured, characterised and described the phases in the emergence and deepening of interest with respect to learning. The model probes further into the description of situational and individual interest and presents a development continuum from *Phase 1 - Triggered Situational Interest, Phase 2- Maintained Situational Interest, Phase 3 - Emerging Individual Interest and Phase 4 - Well-developed Individual Interest*. It characterises the development of interest across contexts and both in-school and out of school settings (Renninger & Hidi, 2016). Each phase occurs sequentially as described hereunder, but individuals may either progress from Phase 1 to 4 or regress in the absence of adequate support (Hidi & Renninger, 2006):

1. Phase 1: Triggered Situational Interest (TSI)

Triggered Situational Interest is activated due to specific features of the environment or content. This has been referred to as interestingness (Krapp, 2002) of content, for example, inconsistent, surprising or striking information, which may be manifested through a short term spike in a person’s attention towards a content. TSI is usually, though not always, supported by external stimuli, the individual is usually unaware of his interest. He/she may experience positive affect such as being in awe, curious or happy. Suppose interest in a topic/content (biodiversity) is absent in an individual, it can be triggered by characteristics of the learning environment, for example, the setting, the exhibits and interaction with others. On the whole, TSI is a psychological state that results in short term affective and cognitive processing. If people are encouraged to make connections between the object of interest and their skills, knowledge and prior experience, they will go into the second phase of interest development.

2 Phase 2: Maintained Situational Interest (MSI)

In this phase, individuals are in a state of focused attention to previously encountered content. If TSI catches attention, MSI is more likely to hold the person's attention towards a content. During MSI, individuals reengage with content to which they attribute value and develop knowledge. The individual will make connections to existing knowledge and content and likely to have positive feelings. At this stage, the individual cannot independently probe further to engage more and may not invest in more effort without encouragement. I consider that MSI is an important phase that determines whether an individual will progress towards the individual interest phase or not.

3 Phase 3: Emerging Individual interest (EII)

At this stage of interest development, individuals are in the beginning phase of lasting individual interest. The individual attributes value and positive feelings to the act of being able to reengage in tasks related to the object of interest, if the opportunity is presented. The individual will choose to reengage. The individual becomes curious and asks his questions, independently of major external support. However, the individual encouragement from others is still needed, when faced with a challenge or difficulty to preserve and invest more effort. This phase may or may not lead to a well-developed phase of interest.

4 Phase 4: Well-developed individual interest (WDII)

This phase of interest development refers to both a psychological state of interest and to the relatively enduring predisposition to reengage with a particular content over time. This state is characterised by stored knowledge, value and positive feelings. Students will intentionally choose to get involved with tasks related to the object of interest when given a choice. Difficult tasks will feel effortless and students will be reflective of the content of interest. Students can persevere despite frustrations and challenges to meet set goals. They actively seek the opinion of others to validate their work and for feedback. External support is not necessary to sustain interest at this stage, but it is desirable.

Table 2.1 below summarises the Four-Phase Model of Interest Development highlighting the different characteristics of each phase.

Table 2.1: The Four-Phase Model of Interest Development (adapted from Hidi & Renninger, 2006)

	The FOUR PHASE model OF INTEREST DEVELOPMENT Development Continuum over time			
Characteristics of each Phase	**Phase 1: Triggered Situational Interest**	**Phase 2: Maintained Situational Interest**	**Phase 3: Emerging Individual Interest**	**Phase 4: Well Developed Individual Interest**
Occurrence	It is the first occurrence of SI, triggered by external stimuli	It is the re-engagement with previously encountered content	Individuals choose to reengage with content if given the opportunity	It is the enduring pre-disposition of an individual to reengage in content over time
What happens during this phase?	Individuals' attention is caught	Individuals' attention is held	Individuals become curious, asks their questions without support	Individuals intentionally choose to engage with a content
Caused by	Surprise, novelty, personal relevance	Meaningful tasks, personal involvement	typically but not exclusively self-generated	Self-generated
Support of other people (external support)	Usually required but not always	Required for example opportunity to reengage	Required when faced with difficulty	Not required but desirable
Results/outcomes	Short term affective and cognitive processing in individuals	Individuals make connections to existing knowledge, develop positive feelings, knowledge and attribute value to the content	Individuals develop value and positive feelings, invest more effort towards a content	Difficult tasks feel effortless; individuals become reflective of the content. They seek feedback to validate their work

The Table illustrates the progress from Triggered Situational Interest, Maintained Situational Interest, Emerging Individual Interest and Well-Developed Individual Interest. The characteristics of each phase are described. Each phase may progress to the subsequent stage or regress to the previous phase depending on whether the individual gets the opportunity and support required (Hidi & Renninger, 2006).

I find that Four-Phase Model of Interest Development has certain key features: (i) first interest if absent in an individual can be made to develop (ii) the aspect of adequate or external 'support' seems crucial for MSI and EII through subsequent encounters with the content or support from others (iii) Situational Interest is distinguished from Individual interest in the sense that in a state of SI, the individual is dependent on the environment which 'catches' and 'holds' his/her attention. While having individual interest, the person engages with the content of interest more independently and perseveres in light of difficulty with a task gaining intrinsic satisfaction (iv) the model has not specified the aspect of time taken for the transition between one phase to the next as time can be days, weeks, months. This aspect is yet to be investigated. Chapter 8 proposes a refinement of this model in light of the transition from TSI to MSI.

One critical aspect of using this model is to identify the object towards which interest was directed as per the Person-Object theory of interest (Hidi & Renninger, 2006) which posits that one can only be interested in an object of interest or content (something/someone/a situation, etc.); interest is a relationship between a person and an object/content. In this study, the object of interest is the biodiversity-related content which could be a concept, an exhibit, or information that the student encountered during the guided tour. Phase 3 and Phase 4 of the FPMID model relates to the individual interest which was not within the scope of this research since these phases are concerned with individual interest that becomes established within the person over time. I was more concerned about the Triggered Situational Interest Phase (Phase 1). The key is to identify aspects of the visit that 'caught' students' attention and resulted in short-term affective and cognitive processing. However, I also remained aware of any signs of Maintained Situational Interest (Phase 2). For example, if the individuals showed signs that their attention towards a content was being sustained and manifested through positive feelings while making connections with existing knowledge. Phase 1 and Phase 2 of the Four-Phase Model of Interest Development helped me answer the following research questions: What are the situational factors of the visit that trigger SI and how these situational factors contribute to learning about biodiversity.

2.6 Interest and Learning

Recently, there have been some debates into which of the phases of interest development predict learning, specifically by authors such as Rotgans and Schmidt (2014, 2017). The FPMID appear to support the idea that independent learning occurs during the individual interest phase. Rotgans and Schmidt (2014) point out that some studies fail to make the distinction between SI and individual interest as these propose that individual interest is positively related to increased knowledge while SI is a 'fleeting' phenomenon, triggered momentarily and disappearing when the need for knowledge is satisfied. Rotgans and Schmidt (2017) stress that 'SI only arises if the person becomes consciously aware that he/she lacks the necessary knowledge'. They found that participants who had knowledge deficits reported significantly higher levels of SI, such that SI predicts learning. They further point out that the SI of somebody who already has an individual interest may further be triggered by providing new learning opportunities. This finding is important in studying the role of knowledge acquisition on interest development since it differs from what other authors have advanced. For example, Schraw and Lehman (2001) account for a positive linear relationship between interest and learning; interest increases with increasing knowledge. In this line, Rotgans and Schmidt (2017) suggest a review of the Four-Phase Model of Interest Development (Hidi & Renninger, 2006), conceived as developing sequentially from situational to individual interest.

The advances of Rotgans and Schmidt about the FPMID have been refuted by Hidi and Renninger (2017) and this was in turn answered by (Schmidt & Rotgans, 2017) in a commentary in support of their original paper. They reinforce their suggestions that learners enter a learning situation with a certain degree of individual interest and interest development in an individual does not start from scratch in the face of a learning situation. However, their conclusion is based on experimental studies where the researchers carefully chose the texts to arouse SI. Based on their findings, the authors advance that SI is mostly cognitive rather than affective. They focused on investigating the effect of knowledge on SI and did not consider other possible triggers of SI. Therefore, further investigation is needed in authentic settings on the role of affect or prior knowledge on SI. This debate in the literature stresses that the role of knowledge or learning in interest development is still not well understood or agreed upon by scholars, thereby highlighting the need to investigate this area.

In light of the theoretical frameworks discussed above, I integrated the Contextual Model of Learning (CML) with the Four-Phase Model of Interest Development to investigate how interest is linked to learning in informal contexts. The Human Constructivist and affective learning conceptual framework guided my investigation regarding how students learnt. This integration of the frameworks is one important aspect that adds value to this study about interest and learning of biodiversity. A schematic integration of the three frameworks is proposed in Figure 2.3 below.

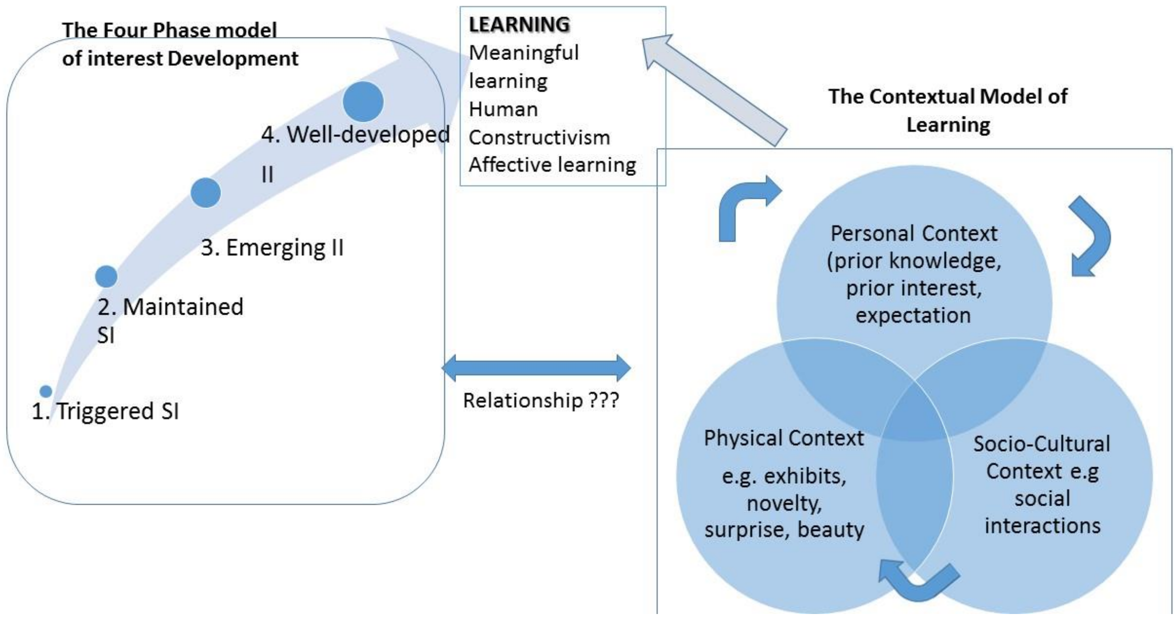

Figure 2.3: Schematic integration of the three frameworks used for this research

The relationship between the frameworks in Figure 2.3 above may be explained as follows:

1. The FPMID suggests that interest may be developed by factors of a learning situation that are external to an individual.
2. As FPMID, Situational Interest may be triggered by features of the environment such as thenovelty and beauty ofexhibits which form part of the physical context of a visit to a nature reserve described by the Contextual Model of Learning (CML). Surprising information is related to both the exhibits and the information provided about the exhibits through social interaction with the guide. Furthermore, prior interest and expectation which form part of the personal context of the learner may determine how SI is triggered. During a learning situation, interest may be triggered by various factors which interact and co-occur but the nature of this interaction is still blurry. Thus, there is a link between the FPMID and the CML.
3. The SI manifested through positive affect, catching the attention of individuals and motivational behaviours such as willingness to reengage with a content. This may lead to both cognitive and affective learning and ultimately meaningful learning.

The understanding of interest is largely based on research on reading expository text. Interest generated in the authentic context of visits to nature reserves is still poorly understood, especially regarding interest in the biodiversity content. In the next section of the literature review, I discuss literature about biodiversity learning.

2.7 Biodiversity Learning

My research aimed to study learning and interest in biodiversity during a visit to a a nature reserve. This thesis considers that biodiversity education falls within environmental education, a concept that has evolved and is now considered Environmental Education for Sustainability (EES) (Weelie & Wals, 2002; Sauvé, 2005). Therefore, this section of the literature review will give an overview of debates around biodiversity education.

2.7.1 Defining Biodiversity

According to the Convention on Biodiversity[2] (CBD), biodiversity or 'biological diversity' means 'the variability among living organisms from all sources including, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.' (United Nations, 1992, p.3). This implies diversity at all levels from genes, populations, communities and ecosystems, and can encompass the evolutionary, ecological and cultural processes that sustain life. The convention on biodiversity emphasizes issues of equity and sustainable use implying that people from different and diverging backgrounds are also concerned about biodiversity. Therefore, biodiversity is intricately linked to society.

The various concerns related to biodiversity have given rise to 'symbolic' or 'political' definitions of biodiversity that should be distinguished from scientific ones (Dreyfus et al; 1999). Symbolic definitions of biodiversity refer to the environmental problem of decreasing variation of life and to the normative demand that we should do something about it. Scientific definitions help understand what is being lost while the symbolic definition considers what needs to be done by human societies to prevent biodiversity loss. These varied angles through which biodiversity has been defined implies that for a 15-year-old student, it might be challenging, yet important, to grasp and understand the interplay between different factors impacting biodiversity (society, politics, economics etc.). Moreover, the national curriculum framework of the Mauritius Institute of Education and the Ministry of Education, Mauritius, for grades 9 (14-15year old) about biodiversity specifies that learners should be able to '*show understanding of biodiversity, its importance to humankind and how it can be protected*' and to '*discuss the natural and human-induced factors that negatively impact biodiversity*'. Thus, as per the curriculum, the student should understand diversity in terms of characteristics of living things, variability among living

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Note[2] The Convention on Biodiversity has been signed by 150 government leaders at the 1992 Rio Earth Summit of the UN. It is dedicated to promoting sustainable development. It recognizes that biological diversity is about more than plants, animals and micro organisms and their ecosystems – it is about people and our need for food security, medicines, fresh air and water, shelter, and a clean and healthy environment in which to live. Source: https://www.cbd.int/convention/

things living in a habitat, threats to biodiversity and the importance of a balanced ecosystem. This implies diversity at the species and ecosystem level and the recognition of the societal role in biodiversity.

'Biodiversity' remains a complex multi-disciplinary concept with links to society, politics, economics and ecology. This complexity might become opportune for education as it helps learners understand the plurality of viewpoints, analyse different meanings and dimensions, and develop critical thinking about conservation (Navarro-perez & Tidball, 2012). It also helps to join Pedretti and Nazir's (2011) views that science education (which includes biodiversity education) should enable students to critique and solve social and ecological problems, guided by values and empirical evidence. Thus, by learning about biodiversity, students are likely to develop logical, moral and ethical reasoning and understand issues of socio-scientific importance. A starting point in teaching and learning biodiversity is to understand the reason for the conservation of biodiversity as advocated by Meinard et al. (2014). This would enable learners to understand the importance of biodiversity for society and the environment. Meinard and colleagues (2014) proposed defining biodiversity through a constructivist approach, starting from the usefulness of biodiversity from an economic and ecological perspective. In similar lines, Berry et al. (2018) highlight the following common arguments for conserving the diversity of all life on earth: (i) biodiversity provides important ecosystem services of benefit to humans such as provisioning of food and materials, temperature regulation, clean air, recreation and cultural services (ii) biodiversity provides actual and future potential material and economic benefits to people (iii) it is morally wrong to destroy nature. These three reasons boil down to three crucial factors of biodiversity: firstly biodiversity is important for its ecosystem services provided to mankind in the form of regulation and the provision of current and future social and economic services which is a utilitarian perspective. Thus, it affects economics and society. Secondly, preserving biodiversity is important to maintain a balanced ecosystem needed for the planet's sustainability, which concerns an ecological perspective. Thirdly, biodiversity has the moral right to exist, which is a moral and ethical stance. Biodiversity entails a plurality of viewpoints that encompass scientific definitions and equity and sustainable use of natural resources.

Biodiversity is an example of what Rennie and Stocklmayer (2003) describe as the 'public do not understand science on science's terms, but on their terms'. This would mean that the public constructs their meanings based on what is relevant to them. Dreyfus et al. (1999) agree that public opinion of biodiversity is important. Research in environmental education should focus more on *how* people learn and what they *want* to learn rather than what they *should* learn. However, the complex inter-relationships that underlie concepts like biodiversity do not easily 'transfer' to people's minds (Weelie & Wals, 2002). This means it is not easy for civil society and students to understand a holistic picture of biodiversity and its related issues.

For this reason, some researchers have referred to biodiversity and biodiversity education as "ill-defined" multi-dimensional concepts which may have various interpretations (Dreyfus et al., 1999; Weelie & Wals, 2002; Navarro-perez & Tidball, 2012). This multi-dimensionality of the concept of biodiversity has several pedagogical implications. I discuss these next as they impact the analysis of *what* students learn about biodiversity, given that biodiversity is a broad concept.

2.7.2 Pedagogical implications

In light of the multi-dimensional complexity of the concept of biodiversity, there have been debates in the literature concerning what the teaching and learning of biodiversity should entail or from what perspective biodiversity curricula should be approached. From a post-modernist pedagogical perspective, the ill-defined nature of the concept of 'biodiversity' could become a strength for education (Weelie & Wals, 2002) as it offers the possibility of a learner-centred pedagogical approach: the learner may derive his/her meanings, interpretation and assessment of a situation, resulting in greater involvement in the learning process. This would imply meaningful learning, where the learner consciously integrates new knowledge to his/her existing knowledge structures (Novak, 2002). For example, the biodiversity concept raises socio-scientific debates and provides an opportunity to learn about a highly relevant, controversial, emotionally charged and debatable topic linking science and society. This can become the 'bedrock' foundation for future actions (Dreyfus et al., 1999).

Moreover, biodiversity education helps students recognize that science is not an isolated affair; it also involves people, the environment, ethics and economics. Thus, engaging in diverse viewpoints and discussion about biodiversity might help a learner become value-centred, develop logical reasoning and civic responsibility which are goals of science education as advocated by Pedretti and Nazir (2011). One example of a biodiversity issue that concerns society and ecology is the introduction of a closing season for octopus fishing in Mauritius and Rodrigues to give time for growth and reproduction. This scientific and policy decision puts the livelihood of fishermen at stake. Teaching biodiversity using such examples might be a starting point to introduce students to the different aspects concerning biodiversity and its conservation. Informal learning settings such as nature reserves may play a key role in igniting and directing students' thoughts in this aspect. Yet, there is still a lack of guidelines to drive biodiversity education in a specific direction.

Various authors have put forward different but somehow converging perspectives/arguments regarding what biodiversity education should address (Lude, 2010; Yli-Panula et al., 2018; Weelie & Wals, 2009). From their recommendations which I discuss below, there seems to be an agreement that biodiversity education could be framed around three main aspects: (i) the development of ecological literacy whereby learners learn about the scientific definition of biodiversity, ecosystem processes and the role of humans within the ecosystem (ii) knowledge about how human societies influence biodiversity concerning the utilization of biological resources and (iii) the development of an emotional connectedness of the individual with nature and taking a moral or ethical stance regarding the need to preserve species. I briefly discuss each of these three aspects hereunder as they guided me in answering the research question 'what do students learn about biodiversity during the visit to the nature reserve?', described in Chapter 6.

The development of ecological literacy – Ecological literacy lens

The ecological literacy lens describes how learners could develop knowledge about the intricate relationships between species in ecosystems and raise discussions on humans' role within the ecosystem (Weelie & Wals, 2002). Therefore a starting point would be understanding variability among living things at species, ecosystem and genetic level. A few studies have attempted to address how students understand the definition of biodiversity based on the United Nations Convention on biodiversity. Nevertheless, biodiversity has been largely erroneously conceived as analogous to species diversity (variety of animals and plants) in countries such as Chili and Germany (Menzel & Bögeholz, 2009). There is less recognition of ecosystem diversity, neglecting genetic diversity. Menzel and Bogeholz (2009) found that out of 24 students, only three indirectly referred to genetic diversity in their study. The situation is reflected even among Turkish student teachers, whereby biodiversity was largely associated with species and ecosystem diversity (Dikmenli, 2010). If teachers tend to overlook genetic diversity, it could be problematic for the teaching of biodiversity, thereby highlighting the need for biodiversity education to emphasize that biodiversity concerns species, ecosystem and genetic levels.

While considering species, the phenomenon of plant-blindness has been noted (Yorek et al., 2008). Plant blindness is a phenomenon where people tend to think of plants as a backdrop to animal life and overlook the importance of plants in our daily life (Bermudez et al., 2018). Thus, both Yorek et al. (2008) and Bermudez et al. (2018) noted that students fail to connect plants and animals. Furthermore, students are more likely to name domestic and exotic animals than local or native species (Yorek et al., 2008). However, it appears that students from industrialised and developed countries know less about local species compared to those coming from developing countries (Menzel & Bögeholz, 2009). The latter authors found that students (more particularly those of higher socioeconomic status) were more likely to name exotic and invasive plants than native ones. Neglect of native species among students is alarming since invasive species cause much damage to native flora and fauna in several countries. Therefore, one aspect that the ecological literacy perspective of biodiversity education could incorporate is knowledge of locally endemic species and the threat they face to extinction.

Recent research papers on biodiversity education have called for the inclusion of an understanding of conservation measures in biodiversity curricula (Yli-Panula et al., 2018). The involvement of communities in the conservation of biodiversity is very common in several countries through local non-governmental organisations and community-based organisations as is the case in Costa Rica (Jiménez et al., 2017) and in Mauritius. I point out the work of the Mauritius Wildlife Foundation in managing Ile aux Aigrettes nature reserve on which the current research was based. Decision making in biodiversity conservation frequently requires the participation of different stakeholders, who may or may not possess an educational background in conservation. One example of community involvement was the speedy containment of oil spills in the lagoon near Ile aux Aigrettes nature reserve following a shipwreck during the year 2020. Thus, multiple stakeholder involvement in this process is frequently necessary to improve conservation effectiveness (Yli-Panula et al., 2018). For example, Souza and Bernard (2018) found that Brazilian students, recent graduates and managers have different priorities regarding conservation actions depending on their educational backgrounds. However, the reduction in habitat loss, overexploitation and *in situ* protection were considered top priorities among most participants compared to *ex-situ* conservation measures. This points to the importance of including an understanding of conservation measures as a priority for educational trips to nature reserves and even in formal education systems so that students may make informed decisions regarding biodiversity.

Therefore while investigating what students learn about biodiversity from an ecological literacy lens, I investigated how students understand the concept, its importance, threats to endemic species towards extinction, and conservation measures.

The influence of human societies on biodiversity – The biodiversity and society lens

As discussed above, human societies have been impacted and influenced by biodiversity for ages. For example, historical resource depletion, habitat destruction, and the introduction of invasive alien species have changed ecosystem dynamics in several countries, including Mauritius, leading to significant biodiversity loss. This indicates that biodiversity has economic, social and cultural value and needs to be preserved (Berry et al., 2018). The argument joins the 'political' or 'symbolic' definition of biodiversity (Dreyfus et al., 1999), which refers to the environmental problem of decreasing life variation and the normative demand that we should do something about it. Researchers have called for increased links between environmental education and tangible outcomes, for example an increased eradication of invasive species eradication to conserve biodiversity (Ardoin et al., 2020). Such actions would only be possible if biodiversity is situated within a societal context. Here, Kilinc et al. (2013) found that students propose conservation actions as a societal role where environmental groups in the community are involved in protecting species. Therefore biodiversity is intricately linked to society and learners should be able to recognize the anthropological activities that contribute to the loss of biodiversity (for example the extinction of the dodo in Mauritius following colonization). This will enable learners to situate biodiversity within the social context and recognise societal influences on biodiversity including the role of politicians, decision makers, scientists and the community. Therefore, in investigating what students learn about biodiversity, I find it important to consider what students learn about biodiversity concerning society.

One example from Mauritius regarding biodiversity and society is the controversy around the authorisation of mass culling of endemic fruit bats by the government, a species protected by law, but whose large population is causing damage to fruit plantations (Tollington et al., 2019). This decision has been vehemently condemned by the scientific community as mass culling puts a vulnerable endemic species at risk. The issue was debated in the media before the culls of more than 50 000 individuals during 2015, 2016 and 2017. The bat debate is a brilliant example of diverse and controversial stakeholder interest in a Mauritian context. It is opportune to investigate how students formulate an opinion about this biodiversity issue with socio-economic implications.

The 'biodiversity and society' lens of biodiversity thus, enables learners to recognize the historical and socio-cultural embeddedness of science and scientific ideas, as suggested by Pedretti and Nazir (2011). Therefore, in Chapter 6, I decided to examine what students learn about biodiversity in terms of their awareness of the negative impact of anthropological activities on ecosystems, their awareness of the current debates surrounding the culling of the endemic bats of Mauritius and the factors leading to the extinction of the dodo.

Emotional connection with nature – The nature and self lens

Littledyke (2008) and Weelie and Wals (2002) argue for more direct integration of the affective and cognitive domains of learning into a science education that informs environmental education to enable students to develop a sense of relationship with the environment. On similar lines, authors from the informal learning sector have recognized the role of emotions in fostering learning and behavioural intentions following an informal learning experience (Ballantyne & Packer, 2005). Empathy among school students has resulted from observing and experiencing wildlife in the natural environment (Ballantyne & Packer, 2005). Some visitors to an aquarium have described challenges to their attitudes and emotional involvement (Packer, 2006). The essence of these studies is that they highlight the importance of developing an emotional connection with nature which is crucial in shaping how individuals value nature which forms part of their ability to learn. For example, Schneiderhan-Opel and Bogner (2020) showed that students who developed a higher appreciation for nature positively developed knowledge gain during a biodiversity module. Kossack and Bogner (2012) show an increased connectedness with nature among participants in a one-day environmental education programme. Therefore, the 'nature and self lens' (adapted from Weelie & Wals, 2002) is concerned with how individuals value biodiversity and nature.

I consider that what students learn about biodiversity could also be approached from a nature and self lens which is highly related to the emotional and ethical argument for learning about biodiversity described by scholars such as Weelie and Wals (2002) and Navarro-perez and Tidball (2012). This lens addresses emotions, first-hand experience and a sense of wonder which aim to encourage students to develop interest and to value biodiversity, which is highly relevant to informal learning settings. A value-centred approach has been advocated by Pedretti and Nazir (2011) as one of the six main currents that science education should address, dealing with ethics and morality of socio-scientific issues. It seeks to understand what meaning the individual makes with nature. Through valuing and feeling personally concerned for the natural environment, they will be motivated to take part in counteracting environmental problems (Liefländer et al., 2013). It is concerned with how individuals have a connectedness with nature (Kossack & Bogner, 2012) in terms of their appreciation for biodiversity, whether they enjoy experiencing the natural environment and their stance on the ethics and morality on protecting all life forms. This aspect of learning, enables learners to appreciate biodiversity for its intrinsic value, as Berry et al. (2018) advocated. This lens also assesses where the participants position human beings in the biodiversity debate regarding humans' moral duty to preserve life.

Using the three main aspects discussed above based on recommendations of scholars, I develop an analytical framework in Chapter 6 to analyse what students learn about biodiversity. I propose that biodiversity education be situated around three main lenses: (i) the ecological literacy lens where learners should develop knowledge about the intricate relationships between species in ecosystems and raise discussions on the role of humans within the ecosystem. (ii) the biodiversity and society lens which is concerned with how human societies have impacted or continue to impact biodiversity through cultural, historical, economic and legal decisions (iii) nature and self lens which encourages learners to acknowledge the intrinsic value of biodiversity and the morality of conserving species who have their right to exist.

2.7.3 Studies on biodiversity education in informal learning settings

In this section, I survey the literature on studies on biodiversity education conducted in informal learning settings, including zoos, outdoor experiences and nature reserves.

Out-of-school contexts can make key contributions to school-based learning through a more contextualized learning-based approach especially with regard to the opportunities afforded by the presented world (such as zoos, aquarium, museums and science centres) and the actual world (such as nature reserves and natural parks) (Braund & Reiss, 2004). Steele (2014) proposes that exploring the natural environment and how humans should interact with it, through outdoor experiences and sensory experiences, should become an addition to Pedretti and Nazir (2011) six ideological orientations that should underpin science education. The nature reserves and natural parks worldwide provide several environmental education programmes as a conservation strategy, and these programmes might help students learn about biodiversity in an authentic context. However, these education programmes are largely run with the goal of producing tangible education outcomes through evidence like a decrease in the spread of invasive species or an increased population of threatened species (Burnett et al., 2015). Therefore, a large body of research has evaluated programme impact (Ardoin et al., 2020) in botanical gardens, zoos and nature parks. These include evaluating the effectiveness of guided tours in natural places to pass on the message of conservation to visitors (Armstrong & Weiler, 2002). Thus, many environmental education programmes were largely based on transmission models indicating that our understanding of the learning process during guided tours to natural parks remains limited.

Despite the opportunities presented by biodiversity education to foster constructive learning where the students actively derive meaning from the environmental context, much of the environmental education approach has been developed considering the 'attitude-behaviour models in mind' (Weelie & Wals, 2002; Dreyfus et al., 1999). These include looking for the desirable attitude and knowledge gain resulting from an environmental education intervention programme (Farmer, et al., 2007; Sellmann & Bogner, 2013). Farmer et al. (2007) found that students can recall the information presented by the ranger on ecosystems and pollution and had developed a perceived pro-environmental attitude even after one year. Similarly, Sellman and Bogner (2013) quantitatively assessed the impact of a climate change intervention programme of a botanical garden on students' cognitive achievement and found significant knowledge gain sustained over weeks. Their intervention programme focused on providing opportunities for social interaction, recall of information and attitudes among participants but they did not investigate the emotional aspect of the visit. Such studies contribute to the literature showing that educational programmes run in natural settings are impactful in fostering learning about biodiversity and promoting pro-environmental conservation attitudes. However, these studies are mostly investigating the outcomes of a transmission model of learning, assessing learners' ability to grasp information delivered to them; they do not investigate the learning process and what meaning learners make out of debatable environmental education topics as has been highlighted by Dreyfus et al. (1999), Weelie and Wals (2002) and (Rickinson, 2001). Therefore, my research partly addresses this gap by investigating how students learn and how interest in biodiversity is generated.

Education programmes in natural places also focus on value transmission, but Kossack and Bogner (2012) consider it futile if people do not feel close to nature. Several investigations on programme impacts on students' connectedness with nature and knowledge acquisition were conducted (e.g. Schneiderhan-Opel & Bogner, 2020). The role of emotions and values in fostering learning and behavioural intentions is therefore important. Schneiderhan-Opel and Bogner (2020) explored self-reported questionnaires using instruments called the 'inclusion of nature with self' which miss the in-depth, rich description of students' emotions thereby calling for more observational methods and interpretive studies. The emotion of empathy and environmentally sustainable attitudes were reported among students who observed and experienced wildlife in natural environments (Ballantyne & Packer, 2005). This indicates that educational programmes in natural environments could stress emotional engagement among visitors (e.g. through action resources such as reinforcing messages), especially since they have been found to maintain interest and motivate environmental actions by Ballantyne and Packer (2011). The latter study seems to be following the Four-Phase Model of Interest Development put forward by Hidi and Renninger (2006), but the authors did not make any reference to the model. Since, interest motivates behaviour for further engagement (Hidi & Renninger, 2016), studying interest generated as part of the biodiversity education programmes can motivate students to engage in biodiversity conservation activities. This is justified since the intended outcomes of environmental education programmes are shifting from knowledge, attitudes, and behaviours toward driving the community to take actions that deliver results (Ardoin et al., 2020).

A large and growing literature has evaluated environmental education programmes from developed countries. Few studies have focused on developing countries (Burnett et al., 2015). For example, Kuhar et al. (2010) documented knowledge retention after two years following participation in a forest reserve programme in Uganda while Ferreira (2002) detected little impact on knowledge and behaviour following a nature learning experience among South African students. Burnett et al. (2015) administered a questionnaire and a document of knowledge gain about the content of a conservation education programme in a natural park in South Africa. However, such studies are non-existent in Mauritius, a small island state, and given the investment in such programmes by local NGOs, documenting learning outcomes might be important to justify their funding sources.

Methods used to study biodiversity learning

The drawbacks of these long-term evaluation programmes discussed above are that they rely heavily on pre-post test based on participants self-reports. Falk et al. (2018) caution against any assumptions that changes are directly attributable to the visit since the individual is likely to have been exposed to other learning experiences. They emphasise that changes in the mental structures, that is learning, often take time to emerge and are highly reliant on pre-existing structures and subsequent re-enforcing events. Thus, research methods that capture existing (or pre-visit) mental structures might help address this challenge. As such, a heavy reliance on interviews and questionnaires as research tools might be inadequate.

Over the years, several scholars have attempted to address the methodological challenges of investigating prior knowledge and knowledge construction in informal settings of which nature reserves and nature parks form part. For example, Anderson et al. (2003) investigate conceptual changes resulting from a museum visit, by requesting students to draw concept maps before and after the visit, accompanied by interviews. This study enabled an investigation of ‘mental models’ and adopted the Human Constructivist approach to provide insights into the cognitive learning process. Leinhardt and Gregg (2002) used the concept web to investigate understanding following a museum visit. A promising tool is the Personal Meaning Map (PMM), a variant of concept maps, proposed by Falk (2003) as a useful tool to capture how visitors make meanings out of their visit. The basis of PMM is that it captures how a visitor conceptually organises ideas about a topic before and after an informal learning intervention and has had wide use in assessing a programme or visit impact (Van Winkle & Falk 2015). Most of these studies have coupled PMM with interview techniques. An advantage for researchers adopting PMM is the ability to capture prior knowledge and interest. Recently, Hartmeyer et al. (2017) capitalised on this aspect to demonstrate that PMM is a useful tool to capture factual and conceptual but not procedural knowledge in a classroom situation. Another interesting study by Faria et al. (2019) couples children’s PMM with drawings that helped the researcher understand the participants' main misconceptions. Concept maps, concept webs, PMMs and drawings form part of visual data, proving to be promising tools in researching affect in clinical psychology and social studies research (Blackbeard & Lindegger, 2015). However, the field of informal learning is still timid in embracing visual data collection tools, despite a few studies on children’s drawings and museum diorama to assess learning of biology (Tunnicliffe & Scheersoi, 2015). Therefore, PMM and visual data collection tools might help investigate students' affective and cognitive experiences during a trip to a nature reserve. In Chapters 5 and 6, I explore PMM and photographs as visual data collection tools.

2.7.4 Summary

In this section of the literature review, I have highlighted that biodiversity is a multi-dimensional concept requiring scientific, socio-economic and political considerations, making it difficult for students to grasp. There is a lack of agreement over what biodiversity education should consist of, thus I developed an analytical framework for investigating what students learn about biodiversity namely ecological literacy, biodiversity and society and nature and self lens. I also highlight that much research on environmental education has overlooked the role of such programmes in instilling interest among visitors. Thus there is an opportunity to connect research from interest and learning of biodiversity in informal settings, and the current study does that. To this end, an in-depth investigation of students' emotions is required. This might be possible through innovative data collection tools, especially visual data that enable deeper probing. Finally, there is a need to address the dearth of research on biodiversity learning in nature reserves among developing countries, including Mauritius.

2.8 Conclusion

This literature review has enlarged upon the construct 'interest' which is both an emotional state and a motivational variable that causes an individual to focus attention and desire to learn more about a content. SI is momentarily and may be caused by environmental stimuli such as surprising information that may lead to emotional arousal. I specified that interest is content specific as per the person-object theory of interest. I expanded upon the triggers of SI which have been mainly identified through experimental settings thereby calling for more research on SI in naturalistic settings through observational methods. I highlighted that triggers of SI might be occurring at the same time and that this is poorly understood. I also described learning in informal settings of experiential nature and proposed to study the experiences of the students by being guided by the Contextual Model of Learning. Learning will be investigated guided by Human Constructivism and affective learning frameworks while SI will be theoretically framed through the Four-Phase Model of Interest Development. I also drew attention to the potential connection between the FPMID and the CML. Finally, I discussed that biodiversity is a multi-dimensional concept that is challenging for learners to understand and propose an analytical framework to investigate what students learnt. I also discussed the scarcity of research on interest and the process of learning in informal environmental programmes despite the large body of research that documented programme impact. Finally, I proposed that both interest and learning may be investigated through innovative methods of data collection such as Personal Meaning Maps and Visual methods. In the next Chapter, I discuss the research design and methodology.

My study has therefore been conducted on an islet, Ile aux AigrettesNature reserve, Mauritius. I describe the visit in Chapter 4, highlighting students' experiences during encounters with the exhibits and interaction with the guide. In the next Chapter, I describe the methodology adopted for this study.

3 Research Design and Methodology

3.1 Introduction

In this Chapter, I discuss my research design and methodology. The study is about students' experience of a visit to Ile aux Aigrettes (IAA) nature reserve, Mauritius, focusing on their SI and learning of biodiversity. I adopted a case study design following interpretivist traditions to study three Scout groups comprising 13 students aged between 13 to 15 years. Data were collected before, during and after the visit and the research instruments were semi-structured interviews, Personal Meaning Maps (PMMs), auto-photographs, and accompanying photo-elicitation. In subsequent sections, I start by discussing the paradigms of research focusing on the interpretivist paradigm, which underpins this case study. I also provide details and justifications for the choice of my research instruments and participants detailing the data collection process. I highlight some challenges as well as ethical and trustworthiness guidelines that I followed.

3.2 Paradigms of Research

The way that one sees the world is largely a function of from where one views it. Thus, a research paradigm guides the researcher through the empirical research process, from setting the purpose of the research to selecting data collection methods, analysing data and reporting the findings (Treagust et al., 2014). Several theoretical paradigms have been discussed in the education research literature. Three predominate, namely the positivist (and post-positivist), the interpretivist/constructivist and the critical theory (Cohen et al., 2007).

The positivist and post-positivist paradigms in education research follow an empirical research tradition similar to pure sciences based on the premise that the social world can be studied in the same way as the natural world (Mackenzie & Knipe, 2006). Thus, theories are tested, and human experiences are described through observation, measurement and rational explanations. Studies that align with positivist and post-positivist paradigms are based on the ontological assumption that there is only one truth irrespective of individuals' subjective views. They have widely utilised pre- and post-tests to assess educational effectiveness of programmes that influenced policy and practice (Mackenzie & Knipe, 2006). Quantitative data is collected and analysed with attempts to claim generalizability within a population.

Contrary to the positivist paradigms, researchers in the interpretivist paradigm focus on the localized meaning of human experience (Yin, 2011). The interpretivists examine how individuals understand their experience and learning activities based on a relativist ontology and constructivist epistemologies. The focus is on situated meanings that people make out of their social and educational actions. The challenges for researchers in studying people's personal experiences lie in the difficulty of establishing the 'true or correct experience' since interpretation may be influenced by the researcher's own cultural, social and personal experiences and the readers' subjectivity. To address subjectivity, interpretivist researchers focus on providing 'thick descriptions' in their writings and document the process of data analysis in details. The qualitative data collected are usually in the form of interviews, observation and visual data.

A third dominant paradigm in educational research is the critical theory research paradigm that emphasises human interactions and is based on the assumption that power inequality shapes all ideas and social interactions (Yin, 2011). It considers values and ideas shaped by gender, ethnic, social, economic, cultural and political experiences, and the aim is to contribute to knowledge and transform societies.

My study is concerned with 'interest' (a construct portrayed as an emotion or a motivational variable) with respect to learning during a field trip. Research on interest in education has largely used a positivist approach through surveys and inferential statistics (e.g. Harackiewicz & Hulleman, 2010; Rotgans & Schmidt, 2014). These methods can miss unique features that hold the key to understanding a situation (Cohen et al., 2007). This is because the visit experience differs among individuals, and there are no established learning outcomes. Each individual will make a different meaning out of his/her visit experience. Therefore, the natural sciences approach that treats the natural world as part of an objective reality where there is only one truth and one meaning (Cohen et al., 2007) will not be applicable. An interpretivist framework for studying interest and learning is a more appropriate framework for my research to investigate how individual students interpret and make sense of their social world (Cohen et al., 2007).

The interpretivist view, while sharing the rigour of the natural sciences to describe and explain human behaviour, emphasises how people differ from inanimate natural phenomena and each other (Cohen et al., 2007). Therefore, I studied people's experiences through interpretivist philosophies, providing more detailed descriptions and an in-depth understanding of individuals' unique lived experiences instead of claiming generalisability through quantitative data collection methods (Szyjka, 2012). I aspire to understand the social phenomena under investigation through the participants' perspective within the context of the visit, and this demands a qualitative approach to inquiry in contrast with quantitative approaches. As the researcher, my positionality has been influenced by the positivism in natural science. Yet, I believe that learning and interest in informal settings are products of personal experiences, and each individual's experiences of interest and learning are unique.

Qualitative research involves studying people's lives in real-world conditions, presenting participants' views, and highlighting the participants' context, which makes it highly suitable for my research aims. Over the years, qualitative methods have gained popularity among researchers in an informal learning context (Phipps, 2010). The author found that 54 % of data analysis conducted from 1997 to 2007 was along qualitative lines. I adopted a case study research design for my investigation. Throughout this thesis, I document how data were analysed and attempt to provide 'thick descriptions' by presenting the photographs, Personal Meaning Maps and quoting selected interview transcripts from the students.

3.3 Case Study

Controlling participants' experiences in the context of a visit to a nature reserve would be impractical, disruptive and contrary to the common characteristics of the informal learning experiences such as fun, entertaining and free-choice (Falk & Dierking, 2013). Experimental approaches to study interest and learning during the trip to the nature reserve would be impractical. In light of the appeals from scholars such as Bell et al. (2009), I embraced naturalistic methods of data collection that are more reflective in providing detailed and fine-grained representation of learners' experiences in authentic settings. I, therefore, adopted a case study approach for my research. The central principle in the definition of a case study is that it explores a phenomenon in-depth and within its real-life context (Crowe et al., 2011). This aspect aligns the case study approach to the overall aim of studying the participants' lived experience of visiting IAA nature reserve concerning their SI and learning.

Three prominent scholars, Robert Yin, Robert Stake and Sharan Merriam, made landmark contributions to the case study methodology (Crowe et al., 2011). Yin's philosophical orientations appear to have positivistic epistemological orientations and distinguish between single-case studies and multiple case studies. Single case studies focus on the single occurrence of one particular unique phenomena, but its drawback lies in researchers' inability to claim generalisability. Multiple-case studies select several cases that act as a replication strategy (Zainal, 2007). Thus, Yin advocates for the prior setting up of theoretical propositions (Yazan, 2015) which may be tested and this is contrary to my aspirations of discovering students' experiences without any pre-conceived theories. Hence, in choosing the type of case study, I preferred methods according to Stake, who views constructivist epistemologies to guide case study designs. Among the three designs proposed by Stake, I chose the collective case study design, which involves studying multiple cases to generate a broader understanding of a particular issue (Crowe et al., 2011). The different students who visit the nature reserve in different groups were the unit of analysis to understand how the participants experienced the trip concerning SI and learning.

Both Stake and Merriam recommend that the case be viewed as an integrated system with well-defined boundaries, a method more suited to study programmes and people (Yazan, 2015). In my research, the system under study was the guided tour, and the boundaries were students' SI and learning during the tour. Regarding data collection, Stake says that there is no particular moment when data collection begins (Yazan, 2015), while Merriam provides well-defined guidelines regarding data collection. Merriam combines both Yin and Stake's work in proposing the design of case studies that I found useful. She proposes that purposeful sampling is conducted before data is gathered and provides guidelines from interviews, probing, and data analysis which I will discuss in sections below.

Despite their promises to study phenomena in-depth, case studies have several limitations which I had to overcome. For example, the large volume of data with the time restrictions to complete this research implied that I could only study a small group of 13 students. There are concerns over ethics, the validity and reliability of the findings as well as generalisability. I provide a detailed account of how I addressed these challenges in subsequent sections.

3.4 Research design

The following were key considerations in the research design: (i) investigating the content and what happened during the guided tour (ii) taking stock of the participants' prior knowledge of biodiversity and whether they had any personal interest in nature, (iii) investigating SI and (iv) investigating whether the trip had any influence on their interest and learning of biodiversity.

I first present a summary of the research design and process in Figure 3.1. In this section, I justify my choice of study sites and describe the participants in the study.

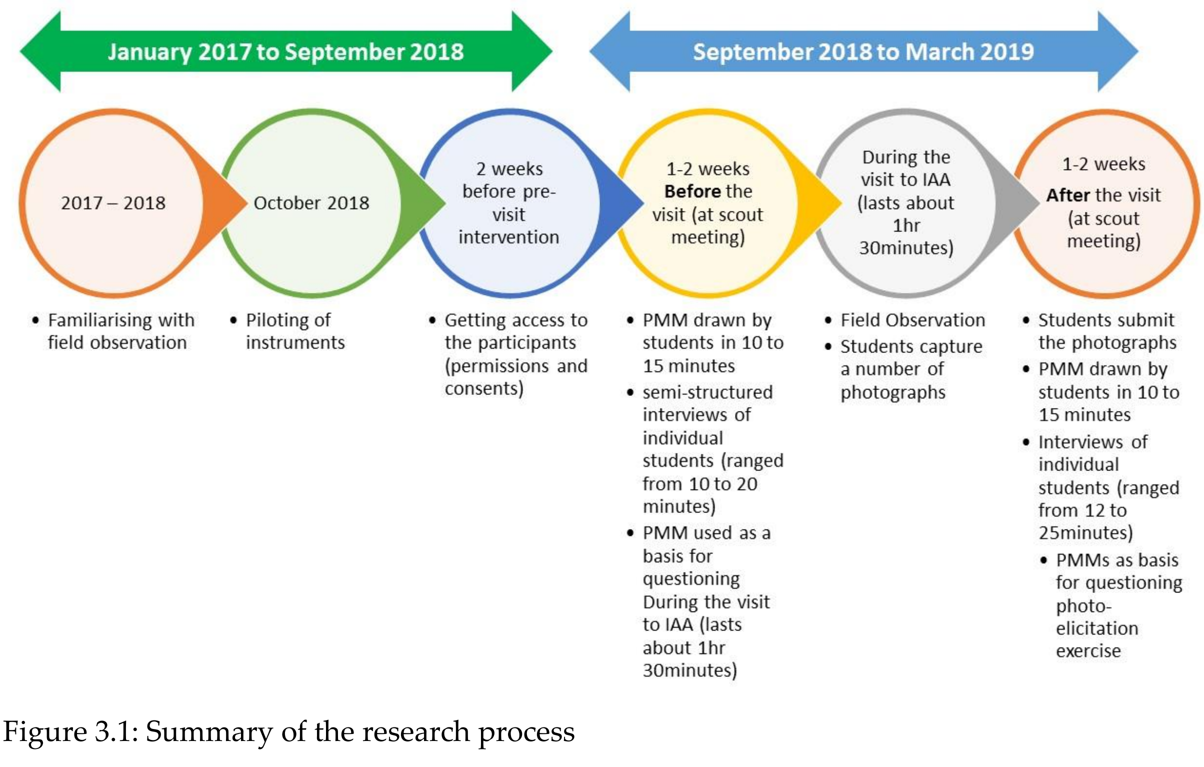


Figure 3.1: Summary of the research process

3.4.1 Choice of the study site

My choice of the study site was Ile aux Aigrettes (IAA) nature reserve, an off-shore islet situated about 800 metres off the southeastern coast of the island of Mauritius. The islet is currently managed by the Mauritian Wildlife Foundation (MWF), a non-governmental organisation (NGO) whose mission is to be exclusively concerned with the conservation and preservation of endangered plant and animal species. MWF has provided guided tours (eco-tours) for tourists since 1998. A special education programme tagged 'Learning with Nature' was set up with the support of the North of England Zoological Society, targeting students of primary and secondary schools. The students (usually from school groups) are taken along a pre-determined trail 'Le sentier du dodo' (meaning 'the dodo's trail') of about 1.5km, accompanied by a tour ranger. Information about the geography, history and geology of the island is provided. However, the focus of the tour is on biodiversity, species restoration, extinct species of Mauritius, and the factors that contributed to their extinction in Mauritius. Visitors may also have live encounters with endemic birds, reptiles and plants.

This guided tour of about 1 and a half hours duration sets the context for my study. It is the only programme that I could identify in Mauritius specifically targeting students and designed for visitors to have an 'authentic' experience of biodiversity and conservation. This aspect meets my interests in studying how students develop SI and learn about biodiversity in a natural setting. Guided tours are conducted in batches of 15 persons for one guide, including the Scout leader and myself, the researcher. To reach IAA, one must reach the jetty at 'Pte d'Esny' beach, where the MWF provides speed boats to reach IAA. The boat ride of about 5 to 8 minutes duration is within a calm blue lagoon, and all visitors are provided with life jackets.

Yin (2011) claims that the collaboration of the researcher with authorities is a crucial consideration for field studies. This motivated my choice of IAA because when I approached the Mauritian Wildlife Foundation, they readily agreed to collaborate with me and support my research. They have established policies to support research degree students. The agreement that I signed with the Mauritian Wildlife Foundation is in Appendix 1. The third reason for my choice is because IAA usually receives group visits through bookings and has a well-defined logistic structure to receive visitors. The other nature reserves in Mauritius are either not easily accessible or do not have special educational programmes.

The disadvantage of IAA is the distance for students residing in the north of Mauritius (where the majority of my participants reside). They first had to reach Pte D'Esny, which is about a 1-hour bus/car ride and then start the boat trip. This entails paying for bus fares and also entry fees of MUR 150 (about 4 USD) to IAA. To minimise the financial toll on parents and students, the MWF waived entrance fees for all the participants in my study. Furthermore, IAA provides guided tours. The trip to IAA is dominated by the guide who takes a leadership role, channelling students across pathways and acting as a mediator and communicator of messages (Randall & Rollins, 2009). The participants would have no flexibility in roaming around or talking freely, contrary to the notion of 'free choice in informal learning settings (Falk, 2005). However, I find that there is an opportunity to study how students experience the guided tour in an informal setting where 'free choice' is limited.

3.4.2 Choice of participants: Scouts

Another very important consideration was accessing participants aged 13 to 15 years who would be visiting the nature reserve. The age group was chosen as students are in their first five years of secondary school. None of the students had chosen their subject options for the subsequent Cambridge Higher School Certificate (HSC) examinations or career options.

My original plan was to choose schools that had made advanced bookings with IAA and approach them for my study. However, I was denied permission from the Ministry of Education in Mauritius without any written justification. This led me to consider studying students of the same age 13 to 15 years, who would visit the tour in a group and hence, I decided to turn to Scout groups.

Scout groups retained the advantage of having students aged 13 to 15 years and a degree of structure such as Scout leaders who agreed to facilitate the logistics of the study: for example organising meetings with students, facilitating the signature of consent and assent forms and organising the tour. Similar to the grade structure in schools, Scouts have students grouped into the following categories: Cubs (6-10 years), Scouts (11-18 years) and Rovers (above 18 years). I chose the category which fitted my desired age group. Furthermore, trips to forests and nature reserves form part of the Scout's yearly programmes and my research had minimum interference to their established programme of activities. The choice of Scout groups also added value to my study since Scout activities are under-researched despite having been reported to present numerous opportunities for science learning in an informal context (Jarman, 2005).

3.4.3 Sampling

As a novice independent researcher from Mauritius and registered in a South African University, I also had the challenge of getting myself accepted among potential participants and authorities, e.g. the Ministry of Education. I had to overcome the challenge of what Cohen et al. (2007) describe as 'access to participants denied by people who can control the researchers' access to those they want to target'. Thus, I had to choose a purposive sampling method to handpick the Scout group to be studied based on logistic and practical concerns. One of my friends is the leader of the Scout group named 'Les eclaireurs du nord', and she agreed to collaborate with me for the research. Through her Scout network, I could receive another group's participation in the 'Girl guides of Port-Louis', thereby representing a snowball sampling strategy.

'Eclaireurs du nord' is established in two villages in the north of the island, Pamplemousses and Grand Gaube, each having 30 and 25 students registered respectively. It is open for both boys and girls of all religious faiths, but most of the participants in my study were Mauritians of the catholic faith. The Scout meetings take place every week on the premises of the local church in both villages. The 'Girl Guides of Port Louis' is exclusively reserved for girls with a membership of 80 girls. The meeting place is the Hua Lien Club, a large multi-purpose complex set up by a group of people whose aim is to promote the Chinese culture in Mauritius. The majority of the Girl Guides are of Chinese descent though membership is open to young people of all cultural and religious backgrounds.

The groups aim to inculcate a set of skills among students that foster their physical, social, spiritual and mental development. During weekly meetings, the students receive training from the instructor such as survival techniques in the wild, first aid, caring for their health and the environment, helping others through team skills, mental reasoning and physical actions. Weekly activities enable students to have hands-on, and minds-on practice on the lesson taught. Besides, the groups have 4 to 6 outdoor outings per year, including overnight camping in natural places (beaches or forests). The Scout groups have a strict adherence to values and rules such as honour, loyalty, help to others, friendliness irrespective of differences, courtesy, respect for nature, respect to parents and higher authorities, and responsibility for one's actions.

3.4.4 The participants

The study is concerned with students and therefore I provide an overview of the school education system in Mauritius. The participants came from different secondary schools. In Mauritius there are three main types of school: (i) state secondary schools which are fully owned, managed and run by the state (ii) state-aided private schools which receive grants from the state but are managed and owned by private companies; these two types of schools are free for all students (iii) private fee-paying schools. My study participants attended all three types of schools. After primary education, the majority of students go to secondary schools and their entrance is based on their primary school results. Some schools only accommodate students with the best academic performances at the regional level (north, east, south and western part of the country). Education is compulsory in Mauritius until the age of 15 years. Some students drop out of school after Grade 9 (aged 15 years) to join vocational studies or work, while others continue until Grade 11, the last year of secondary schooling. Students sit for the Cambridge Higher School Certificate (HSC) to qualify for a university entrance. Usually, schools with the brightest students after primary schools perform better at the HSC level. Thus, the school that students attend reflects their academic standards, though it is not a rule. Since I did not have permission from schools to use their names, I describe the student participants according to their schools' performance at HSC, which might reflect their academic performance. Even if my study is not concerned with school learning, it reflects the students' academic standards which might help generate information about how much they have learnt. The details are in Appendix 2. In

Table 3.1 I provide details of the students, their Scout groups and the dates of data collection.

Table 3.1: Details of participants and dates of data collection

	Student Code	**Fictitious name**	**Age (years)**	**Grade**	**Years in Scouts**	**Name of Scout Group**	**Pre-Interview**	**Field Trip**	**Post-Interview**
1	GG002	Shreena (pilot) (female)	15	Grade 9	7	Eclaireurs du nord (2eme Compagnie)	22-Sep-18	6-Oct-18	13-Oct-18
2	GG008	Selvina (pilot) (female)	15	Grade 10	3	Eclaireurs du nord (2eme Compagnie)	22-Sep-18	6-Oct-18	13-Oct-18
3	P002	Joanna (female)	14	Grade 9	4	Eclaireurs du nord (1ere Compagnie)	2-Dec-18	7-Dec-18	15-Dec-18
4	P008	Owen (male)	14	Grade 9	2	Eclaireurs du nord (1ere Compagnie)	2-Dec-18	7-Dec-18	15-Dec-18
5	P010	Tom (male)	14	Grade 9	9	Eclaireurs du nord (1ere Compagnie)	2-Dec-18	7-Dec-18	8-Dec-18
6	P011	Anna (female)	14	Grade 9	2	Eclaireurs du nord (1ere Compagnie)	2-Dec-18	7-Dec-18	8-Dec-18
7	P012	Felix (male)	14	Grade 9	6	Eclaireurs du nord (1ere Compagnie)	2-Dec-18	7-Dec-18	8-Dec-18
8	P013	Pascal (male)	14	Grade 9	5	Eclaireurs du nord (1ere Compagnie)	2-Dec-18	7-Dec-18	15-Dec-18
9	P014	Ryan (male)	14	Grade 8	1	Eclaireurs du nord (1ere Compagnie)	2-Dec-18	7-Dec-18	8-Dec-18
10	P015	Steffy (female)	14	Grade 9	3	Eclaireurs du nord (1ere Compagnie)	2-Dec-18	7-Dec-18	8-Dec-18
11	HL 01	Alex (female)	15	Grade 10	5	Port Louis Girl Guides	16-Feb-19	17-Feb-19	2-Mar-19
12	HL03	Sonia (female)	14	Grade 9	2	Port Louis Girl Guides	16-Feb-19	17-Feb-19	2-Mar-19
13	HL04	Kelly (female)	15	Grade 10	5	Port Louis Girl Guides	16-Feb-19	17-Feb-19	2-Mar-19

The data collection process entailed that the student needed to be available for the research three times on three different days: pre-visit data collection, on the day of the trip and post-visit data collection. Compared to school attendance, attending Scout meetings is not viewed as compulsory by parents and students. This posed a challenge for me as the researcher since I experienced a high percentage of drop-outs of 53.6% because some students were not present during one of the days, for example, one student completed only the pre-visit interview. However, her parents did not permit her to go to IAA as her school results were unsatisfactory. The details about the number of participants at each stage of the data collection process are found in Table 3.2.

Table 3.2: Number of participants at each stage of the data collection process

Scout group	**Number of students**				
	Present for pre-visit interview	**Present during the field trips**	**Present during post-visit interviews**	**Submitted auto-photographs**	**Participated in photo-elicitation**
Eclaireurs du nord 2eme Compagnie (Grand Gaube) (PILOT)	8	3	2	2	2
Eclaireurs du nord 1ere Compagnie (Pamplemousses)	15	9	8	6	5
Girl Guides of Port Louis	5	4	3	3	2
Total number of students	28	16	13	11	9
Percentage of drop-outs from pre-visit interview to post-visit interview	53.6%				

Given the low number of students (13) who participated in the complete data collection process, I considered all of them, including the pilot, instead of selecting specific participants. Usually, six to 10 cases could be studied in multiple case studies and I had 13 cases of students who collectively formed the case study (Crowe et al., 2011).

3.5 Research Instruments

In developing the case study, I used multiple sources of data to allow for triangulation (Mathison, 1988). I used semi-structured interviews and Personal Meaning Maps (PMM) administered before and after the visit in a pre and post-design. Field observations were used during the guided tour and auto photographs were used as a basis for photo elicitation after the visit. Below, I discuss the data collection instruments, the pilot study and the research process.

3.5.1 Personal Meaning Maps

Through the use of Personal Meaning Maps (PMMs), I intended to grasp how students conceive the term 'biodiversity'. A PMM is a semantic organisation tool put forward specifically to study learning in informal learning settings by John Falk and colleagues (Falk, 2003). It has its origins from the work of (Novak, 2002) on concept maps which study how students structurally and graphically organise concepts, based on the premise that prior knowledge influences one's conceptual understanding in line with Ausubel's theory of meaningful learning. Compared with concept maps where there is always a correct map that the researcher uses as a basis to assess the extent of one's learning, there is no correct PMM. The PMM highlights the school of thought that in informal environments, learning is 'involuntary' and 'free choice and that each individual has unique prior knowledge on which new knowledge and meaning is constructed based on prior personal, social and environmental interactions (Falk, 2003). Therefore a PMM emphasises the highly individualised prior and new experiences in shaping knowledge gained in informal learning contexts.

PMMs embrace the basic principle of concept maps by using a central concept around which the student schematically draws links with sub-concepts. Still, there are several differences in PMMs, making them flexible but more suitable for exploration in an informal learning context. Falk (2003) describes two main drawbacks of concepts maps that may be overcome through PMMs: first, there is no 'correct' PMM so that the participant does not need considerable training to write a PMM (compared with concept maps). The untrained visitors whose agenda is to visit, learn and/or have fun in an informal context may complete the PMM in a relatively short time. Secondly, the use of scores and rubrics to assess concepts maps is too reductionist and positivist in nature. PMMs focus more on the 'degree of change' in knowledge based on prior knowledge which uniquely affects each individual's conceptual, attitudinal and emotional understanding, rather than on the nature of the change (Falk, 2003). In Figure 3.2 below, I provide an example of a PMM.

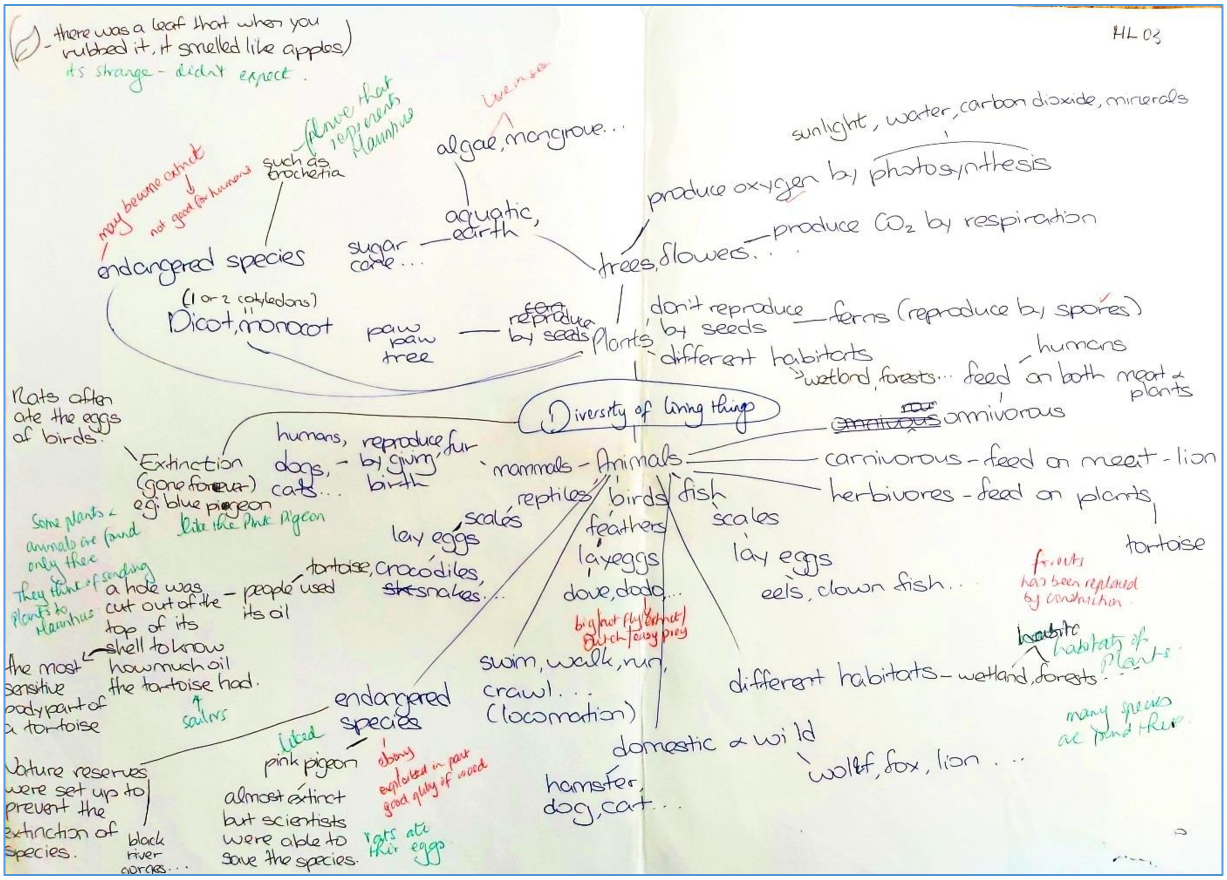


Figure 3.2: An example of a Personal Meaning Map drawn by a participant (Blue and Black ink: participant writings before and after the visit respectively, red and green ink, the researchers' notes before and after the visit)

3.5.2 Field observation

I decided upon a non-participant observation when I was present during the participants' visit to IAA and remained discreet with minimum interference during the tour. As I proceeded with my observation of the participants, I followed the guidelines to take field notes according to Cox-Petersen et al. (2003), recording each type of activity involving students (e.g. exhibits/ stopping points), the time spent, anecdotes, exclamations as part of the student and the guide's reactions, the number of students as well as social interactions. In Appendix 10.3, I provide an extract of my field observation notes to identify some key biodiversity-related concepts discussed during the tour.

3.5.3 Semi-structured interviews

During interviews, participants can discuss their interpretations of their social world, expressing their viewpoints (Cohen et al., 2007). I opted for semi-structured interviews, whereby I had a set of pre-defined questions to ensure systematic data collection. The specific choice of questions for each participant flowed conversationally. I then supplemented with additional questions to probe deeper to acquire greater details of what students remembered and what they found interesting. In this way, I could remain focused on the topic of the interview compared with unstructured interviews, and at the same time, remain open to the opportunities for new information brought in through subsequent probing questions. This in-depth investigation would not have been possible through the use of questionnaires. I audio-recorded each interview which I transcribed later for analysis. Each interview typically lasted between 10 to 20 minutes.

Appendix 10.7 gives details of the interview schedule, which consisted of 3 main sections: Section A consisted of questions to learn about the students (students' ideas of IAA, their engagement in the Scouts and their school and leisure activities). Section B consisted of questions aimed at their interest in biodiversity, and section C investigated their biodiversity knowledge.

Informed by literature, I investigated knowledge of biodiversity before and after the visit by asking questions about their understanding of the diversity of living things, endemic and extinct species, the importance of protecting all living things on earth to explore their understanding of the concept of biodiversity. Questions regarding the students' awareness on the culling of bats and the dodo's extinction aimed at investigating students understanding of biodiversity with respect to society while questions about students' leisure activities and their views about why species should be protected aimed at probing into the personal connection students had with nature. Appendix 17 gives a sample of an interview conducted with a student.

During the post-visit interviews, I had to investigate SI that might have occurred during the visit. I did not directly ask 'what interested you' due to the potential confusion that might arise since the word interest is commonly used in our daily language. Instead, I asked questions such as 'what did you like the most of your visit', 'describe 2 to 3 aspects of the visit that you are not likely to forget', 'what did you tell your friends and family about the visit', etc. Even if 'liking' or 'having fun' cannot be equated with interest, these questions helped me identify the aspects of the visit that caught students' attention. I was also able to identify aspects of the visit that gave students a pleasurable experience and permitted students to describe their emotional state, affect stimulation and experience of their visit. These questions helped further probing by asking them the question 'why'.

I also used the PMMs as a basis for questioning, asking for clarification on what students wrote both before and after the visit. After the visit, I asked questions about the auto-photographs that they chose to submit, a technique called photo-elicitation described hereunder.

3.5.4 Auto-photographs and Photo-elicitation

Auto-photography and photo-elicitation were chosen as a data collection method to gain insight into what captured students' SI. Auto-photography is when participants are asked to take photographs of their environment, and these photographs are used as actual data (Noland, 2006). The participant-generated photographs permit the researcher to decipher the meaning-making process from the participants' eyes. During photo-elicitation, these photographs are then presented back to the students who are asked what the photographs mean to them in an interview where both the researcher and the participant discuss them (Glaw et al., 2017). I adopted Glaw et al. (2017) guidelines for data collection and analysis of these two visual methods as described hereunder.

Firstly students were provided with a prompt to capture photographs. The prompt used with students was to capture and then select 10 photographs that best illustrated what 'caught their interest or attention' during their visit to the nature reserve. This prompt is directly related to my research question of identifying the triggers of interest during the guided tour as it may shed light on the physical aspects or exhibits, social interaction and personal thoughts and reflections of the participants.

All participants volunteered to use their mobile phones to take photographs so that I, as the researcher, did not have to supply them with a camera and teach them how to use it. This represented a degree of collaboration between the participants and myself. Out of the 13 participants, two did not have mobile phones and did not provide photographs.

After the visit, the 11 students who took photos were requested to choose and submit 10 photographs that best caught their attention during the visit. Among the 11 students, two students, Tom and Joana, provided 11 and 12 photos respectively insisting that these were very important for them. Furthermore, out of the 11 students, two students were not available for the photo-elicitation. They sent me the photographs by email after the post-visit exercise. Therefore the data included 113 auto-photographs from 11 students including 93 photographs from nine students who also participated in the photo-elicitation exercise (Table 3.2 above).

I labelled and assigned descriptors to each photograph as recommended by Glaw et al. (2017). For example, as shown in Figure 3.3, the photograph labelled P011-7 was submitted by the student identified using the code P011.

After the post-visit interviews, each student explained their choice of photos uploaded beforehand on my laptop. Students viewed and commented on one photograph at a time, explaining the reason why they selected those photos as suggested by Drew and Guillemin (2014). I also assured them that there were no right or wrong answers to the questions as I wanted to gather information about each individual's unique experience. This conversation was audio-recorded and transcribed. Figure 3.3 below shows an example of an auto-photograph and the conversation during the photo-elicitations. In Chapter 5, I describe in detail the process of analysis of the photographs.

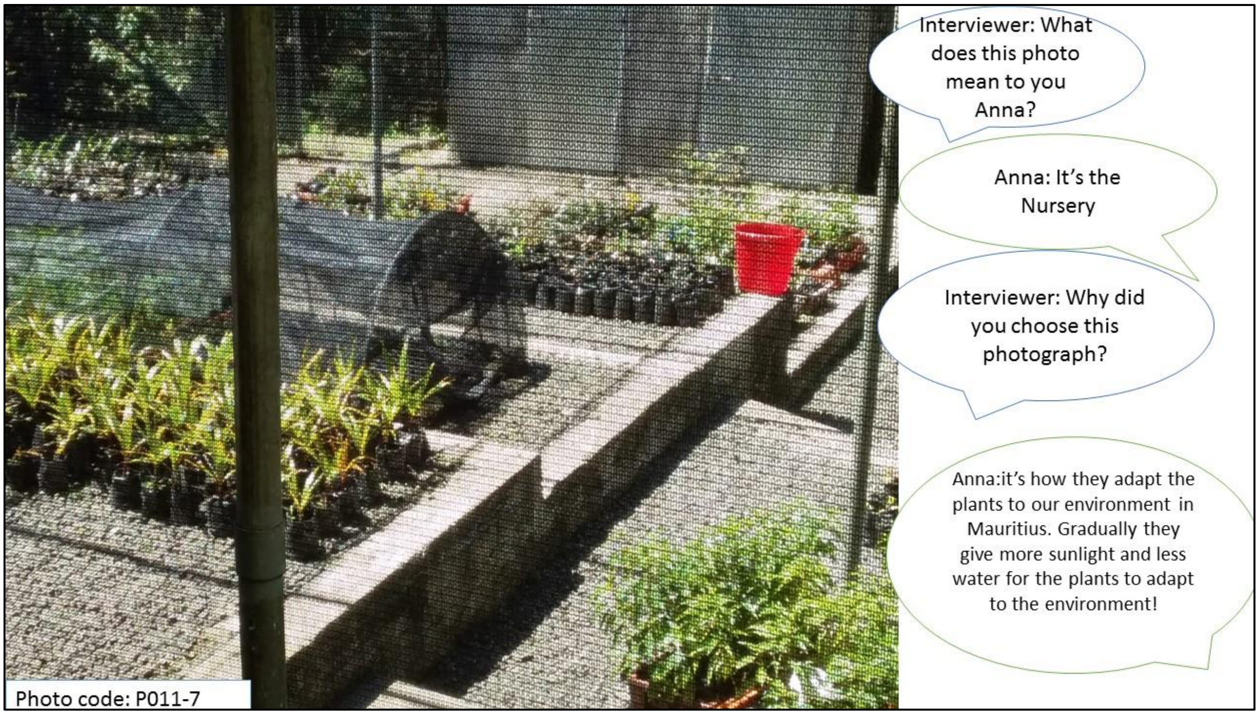


Figure 3.3: An auto-photograph labelled P-011- submitted by the student Anna (P-011) and a section of associated transcript during the photo-elicitation

In Appendix 17, I provide a full set of data collected from one student including interviews, auto-photographs, photo-elicitation and PMMs.

3.6 The process of data collection

The data collection process consisted of getting familiar with the site, piloting the instruments and collecting data.

3.6.1 Piloting

While writing my proposal in 2017, I visited the IAA nature reserve three times as a visitor to familiarise myself with the site and the guided tour, which helped me develop my research design. In August 2018, I participated in a guided tour attended by a school group. I took notes about exhibits, stopping points, some conversations and time frames. This helped me gain acquaintance with students' experiences of visiting IAA. My pilot study was conducted in October 2018 with the students of 'Eclaireurs du Nord: 2eme compagnie'. I conducted the field observations, collected photographs, did the photo-elicitation and PMMs and interviewed students. Both Falk (2003) and Lelliott (2009) stress the importance of the central phrase on the PMM. In my pilot study, I used 'diversity of life ', and I noticed that students tended to give details about human cultures, religions, and entertainment. Some completely missed the concept of living things. Therefore I modified the central phrase to the more specific 'diversity of living things'. Otherwise, I did not need to make further changes in the procedure and instruments, thus, I included the pilot group in my analysis.

3.6.2 Prior Arrangement

Given the specificities of my research context with Scout groups, I had to adapt the meeting place and schedule to suit the participants' context. Before my data collection, I obtained permission from the Scout leaders to meet students during their meetings. They agreed to facilitate the process of obtaining consents and assents, the interview and data collection processes. A copy of permission from a Scout group leader is in Appendix 10.4.

For two of the groups (Eclaireurs du Nord), their meeting place was the Catholique churchyard and the annexed playgrounds. For these groups, the PMMs and interviews were conducted in a sheltered place in the churchyard itself, where the Scout leaders arranged for tables and chairs. The third group, 'Girl Guides of Port Louis', met at the seat of Hua Lien Club, a large multi-purpose complex comprising a big hall and a large playground. The interviews with the girl guides were conducted in a small room inside the main hall. I ensured that the conversation between us remained private and was not being overheard by others.

On meeting each group, I introduced myself to the students and my research work and requested their help as participants. Their help would entail participating in an interview, drawing something like a concept map on paper and being present for the IAA trip. I told them that after the visit I would again interview them once they complete their diagrams. They would also be required to capture some photographs during the trip to IAA. All participants agreed to use their mobile phones for this activity. I explained that their participation was voluntary and that they may leave the research at any stage. I provided an information sheet about the research to them and their parents as per the requirements of the Human Research Ethics Committee (Non-Medical) of the University. Consent forms were given to them for their parents to sign (Appendix 5) as well as assent forms (Appendix 6) for the students to sign. A week later, I contacted the Scout leaders to see if permission was granted from students and parents and set a meeting date for both the IAA trip and the pre and post-visit interviews.

3.6.3 Before the visit

Lelliott (2009) provides useful guidelines for the successful administration of the PMM, which I adopted for my study. The guidelines highlight the following procedures: (i) A short training for the participants provided by the researcher (ii) students complete the PMM before the visit followed by semi-structured interviews using PMMs as a probe, (iii) students modify their PMMs after the visit and the post-visit interview follows.

I met the participants during one of the weekly Scout meetings, typically 1 to 2 weeks before the IAA trip to start with the data collection. I explained how to draw PMMs. Using the central phrase 'school' as an example I asked them to tell me everything they thought could be associated with 'school'. This could be factual information, opinions, ideas, etc. I drew the sub-concepts (friends, teachers, books, subjects, sports days) on a sheet of paper to show how concepts, ideas and thoughts could be linked. I reassured students that they could write in English, French or Creole and use small diagrams if they wanted.

After ensuring that each participant had understood how to draw a PMM I handed everyone a sheet of A3 size paper on which I wrote the central phrase 'Diversity of living things', which is a short and condensed description of biodiversity. They were given a blue pen to write their ideas around the central theme. Each participant was anonymized by having codes written on their PMM. Students typically completed their PMMs within an average of 10 to 15 minutes.

For each session, the students were given time off their Scout meetings to participate in the study. After they completed their PMMs I spent a few minutes perusing them before calling each student for the semi-structured interviews.

I then used the PMMs to clarify what students wrote and I made notes on the PMMs in red ink. Usually, students completed their PMMs in 10-15 minutes. A typical pre-visit interview would last for 10 to 20 minutes.

3.6.4 During the visit

The three Scout groups visited IAA on three different days and I accompanied each group For each Scout group the outing to IAA was part of the group's programme targeted at students aged 11 to 18 years, while my study targets adolescents aged 13 to 15 years. For ethical considerations and fairness all students aged 11 to 18 attended the Scouts outing to IAA. Nevertheless, I observed only those aged 13 to 15 years who were put together in the same group under one guide's supervision during the tour. On the day of the visit, the field observation started on the mainland when the guide met students on the jetty, continued during the boat ride of 5-8 minutes to reach IAA, the guided tour itself and until students were back to the mainland. A total of 13 students were observed. Students were invited to capture photographs from their phones. This exercise typically lasted about an hour and a half.

3.6.5 After the visit

As described in Table 3.1, after the visit, I met the students again during their Scout meeting and handed them their original individual PMMs, and a black pen. I invited them to review their original PMM making changes, additions or deletions if they wished regarding their thoughts on the phrase 'diversity of living things’. All students finished within 15 minutes. I uploaded their photographs onto my laptop and called them individually for a post-visit interview followed by using the PMMs as a probe. This time I made additions in green ink on the PMMs. I went through the photographs with the students asking them to describe the photographs as part of the photo-elicitation exercise. The post-visit interview, which was recorded and later transcribed, lasted from 12 to 20 minutes.

3.7 Data Analysis

All interview and photo-elicitation transcripts were analyzed using the Atlas TI software. Espousing the recommendations of Erlingsson and Brysiewicz (2017) a large amount of text from the transcripts was systematically organized by (i) firstly getting familiar with the transcripts and identifying segments of text which might be relevant to triggers of interest and biodiversity knowledge. Then, these segments or 'meaningful units' (Erlingsson & Brysiewicz, 2017), from the text were highlighted through the 'quotation' function of Atlas- TI using an inductive approach to analysis. (ii) secondly, each meaningful unit was assigned a 'code', which is a name that describes what that particular meaningful unit is about. During the inductive coding of the photo-elicitation the focus was on the 'why', the reason for participants' choice of specific photos among the rest. However, I also remained open to other pieces of information that students wanted to convey during the conversation. (iii) and thirdly, the codes were then sorted into common categories by grouping codes which deal with the same issue together. A total of 164 codes were allocated and an example of the coding process is shown in the interview extract below. Thus the codes were grouped into 17 categories which are described in Appendix 10.8.

Interview extract:

Interviewer: What did you tell her?

Felix: I told her that I saw a model of a **tortoise with a long head (***code: extinct tortoise; category: extinct animals)*, and I saw a **lizard** *(code: Telfair skink; category: endemic animal)* that have **never seen it before** *(code: first time; category: novelty),* and I saw a **big tortoise** *(code: big; category: size/numbers), (code: Tortoise, category: tortoise)* (Post int: Felix, line 14)

In Chapter 4, I describe how the field observation was considered to produce a narrative description of the field trip. In Chapter 5, I show how the autophotographs together with the interviews were analysed. In Chapters 6 and 7, I describe the analysis of the PMMs.

3.8 Trustworthiness

Quantitative researchers adopt standardised procedures and statistical analysis to make claims regarding the validity and reliability of their findings. On the contrary, the qualitative researcher being 'interpretivist' and hence part of the research process, has been described as 'never completely objective' (Farelly, 2013). I have tried to provide an appropriate representation of the issue under investigation giving due importance to the trustworthiness of the research process from the preparation, collection and analysis of the data and the reporting of the results (Elo et al., 2014). I embraced two critical concepts, validity and reliability, to ensure the quality of the research.

3.8.1 Validity

In establishing the validity of the current research I relied on a set of principles followed by qualitative researchers namely: credibility, dependability, confirmability, transferability and authenticity (Elo et al., 2014). In a similar line of thought, Yin (2011) proposes that transparency, methodic-ness and adherence to evidence be favoured. As a means of transparency, in Appendix 17, I provide a full set of data collected from one student including interviews, photo-elicitation, auto photographs and PMMs.I establish credibility by giving a thorough description of the study participants in this Chapter and subsequent Chapters while I analyse the data. I also used data triangulation, gathering data from multiple sources as recommended by Robert Stake for case study to improve the validity of the findings (Cohen et al., 2007).

Table 3.3 below provides a detailed explanation of each data collection instrument's administration and how they contributed to answer each research question.

Table 3.3 Administration of data collection instruments to answer the research questions.

Step	Data Collection Method	Time of administration	Purpose	Research Questions addressed
1	**PMMs** of students on what they know about biodiversity	Two weeks to 1 day before the field trip	Investigate Prior Knowledge of Biodiversity	Research Question 2
2	**Pre-visit semi-structured** Interview of students	Two weeks to 1 day before the field trip	Probe deeper on what they know and if anything interests them about biodiversity before their visit	Research Questions 1 and 2
3	**Field observation** while students are on a field trip	On the day of the field trip	Observe and take notes on what happens during the trip following a defined protocol	Research Questions 1 and 2
4	Students make changes in their original **PMM** on what they now know about Biodiversity after their visit	One day to 2 weeks later after the trip	Investigate whether students have gained new knowledge following the field trip	Research Question 2
5	**Post-visit semi-structured interview** on what students find interesting during the field trip. The **auto photographs** provided by students were used as a probe to ask questions on what students find interesting as part of **photo-elicitation**	One day to 2 weeks later after the trip- after students complete their PMM	Find out what are the situational factors of the field trip that students find most interesting and how they relate to what they have learnt	Research Question 1 and 2
6	**Post-visit semi-structured Interview** on what students have learnt during the field trip using the PMM as a probe	One day to 2 weeks later after the trip	Find out whether students have learnt about biodiversity during the field trip and what they learnt	Research Question 2
7	Analysis of data after data collection	Ongoing after each field trip and data collection session	Analyse what situational factors of the field trip students find most interesting and assess whether they are related to what they learn.	Research Question 3

Farelly (2013) claims that the participants are the only ones who can legitimately judge the credibility of the results and researchers may ask respondents to read interview transcripts to check whether they the researcher has recorded what they intended to say. However, the audio recordings were transcribed weeks after the data collection. It would have been time-consuming and challenging to access each participant again after the post-visit data collection. I addressed this issue by requesting a colleague to listen to the audio recording and cross-check my transcriptions. During the analysis process, I also requested a second person to code sections of my PMMs and interviews. This inter-rater transcriptions and coding technique also helped me introduce conformability and methodic-ness, ensuring congruence of the data's accuracy between two people.

I also remained authentic by adhering to the evidence obtained as preconised by scholars in presenting my findings. For example, I refer to interview quotes and present the PMMs and auto-photographs provided by the students in reporting my analysis in subsequent Chapters.

3.8.2 Replicability, reliability, and generalisability

Another concern is the quality of research and whether the same results will be obtained if the same phenomena are observed twice when the study is repeated. This is more difficult in qualitative research because of the uniqueness of each individual. Instead, qualitative researchers' notion of 'reliability' relates more to the researcher's integrity in ensuring that data is duly represented, analysed and recorded. As proposed by Farelly (2013), I report the procedures that led to the findings by showcasing my analytical procedures in subsequent Chapters. I relied on the practice of inter-rater reliability to assess the degree to which other researchers would classify my data similar to the way I categorised it. For example, a second colleague also coded a section of my PMMs and interviews as I described in Chapters 5, 6 and 7. The results of their coding were consistent with mine and this demonstrated that my results are reliable. I also detail the steps undertaken in my analysis so that a reader may walk through my thoughts and reflections to understand how I objectively made my claims based on data. In the Appendix section, I produce a few samples of the data collected and a detailed analysis section.

Given the unique nature of this qualitative case study which focuses on students' experience of visiting a nature reserve, it would be unreasonable to expect that the findings would be transferable to other nature reserves or settings. However, a detailed understanding of the issues in this particular case can form the basis for a better understanding of SI and learning about biodiversity in other similar settings. Therefore in reporting my results I provide an in-depth and thick description of the data.

Farelly (2013) suggests that getting the opinion of knowledgeable people in the area to confirm the results or point out possible inaccuracies is an interesting way of ensuring the research's quality. Thus, while enrolling on the PhD I made presentations on my analysis sections in two research schools organised by the Southern African Association of Research in Mathematics, Science and Technology Education (SAARMSTE). I received interesting feedback from peers and professors. I also presented my results in two conferences organised by SAARMSTE in January 2020 and 2021 and at the NARST conference in April 2021.

3.8.3 Reflexivity

Qualitative research also considers reflexivity about his/her own bias and assumptions in constructing meaning for data collected. I described my epistemological positions in Chapter 2 and how the research was approached. As recommended by Yin (2011), I kept a journal documenting my thoughts and personal interpretations throughout the data collection process and field observations. I also jotted down some of my thoughts about participants in the Atlas TI memo section, which I used to analyse my data**.**

3.9 Ethical Issues

While undertaking this research, I adhered to the ethical standards described in the literature by respecting people and procedures (Cohen et al., 2007). Firstly, I obtained clearance from the University's Human Ethics Research Committee (Non-Medical) of the University of Witwatersrand which ensured that the research procedures would cause no harm to the health and integrity of the research participants as follows:

As described in previous sections, I ensured the voluntary participation of participants and permission for their parents. Thus, there was an informed consent as per the Human Research Ethics Committee (HREC) (non-medical) of the university (Appendix 18). I received permission from the Mauritian Wildlife Foundation and the Scout group management. Data were not collected from anonymous participants since I could identify each participant. However, I ensured that all interview transcripts, photos and PMMs were anonymised by assigning codes to them so that I could retrace the codes associated with each student. In my writings, I use fictitious names of participants so that a reader would not identify the students. I ensured a high level of confidentiality during data collection and processing. All the interviews were recorded in a quiet place so that a third party did not overhear conversations. I kept the hard copies of the PMM safe and secured the data on my personal computer with passwords so that no one could access it.

Furthermore, all data will be destroyed three years after the submission of this thesis. As a researcher, I have responsibilities towards the participants and stakeholders who are the research outcomes beneficiaries. Thus, I plan to make presentations to the Scout groups and MWF. I intend to submit a copy of my thesis to the MWF and selected organisations in Mauritius involved in informal learning. The findings may be useful to their practice.

3.10 Cultural and Language issues

As a Mauritian researcher with Indian roots and Hindu religious faith, I felt completely at ease entering a churchyard and the premises of the Chinese club to interact with students of different cultural backgrounds. I did not have any difficulty getting accepted by the participants. Mauritius is a multi-cultural country and people are used to interacting, accepting and welcoming others of different cultural backgrounds. Furthermore, cultural considerations are not the focus of this study. The language was not a problem since the native language of the participants and myself is Mauritian Creole while French and English (the official language of the country and used as the language of instruction in schools) are widely used and understood as the language of communication. Consent forms were in English. For the interviews, I offered students the choice of speaking in one of the three languages, but all students conversed in French and Creole and occasionally used English words. All PMMs were written in English by the students, and some students who had difficulty expressing themselves through written English jotted a few phrases in French or Creole. I asked for clarifications during the interviews.

All interview transcripts were audio-recorded by using my mobile phone. The challenge was to transcribe the audio recordings using software due to the different languages employed by all participants. Thus, being well versed in all three languages, I listened to the audio recordings, transcribed and translated the interviews directly myself. To ensure reliability, I requested a colleague (who has similar language mastery as me) to do the same process using a sample of the interviews. We reached 100% agreement on my transcriptions to English.

3.11 Conclusion

During the research process, I made a few observations that might be of practical considerations for researchers studying learning in informal contexts:

Firstly, being denied access to school students by the Ministry of Education was a major challenge that I overcame by approaching Scout groups. I turned the rejection into an opportunity to study the learning experiences of adolescents in the roles that they play as a member of Scouts and their role as a school student. This forms part of life-wide learning representing the range of learning opportunities of an individual who navigates across a range of social settings and activities, and that nature of learning may be opportunistic but not less important (Bell et al., 2009)

Secondly, I noticed a high percentage of drop-outs (53.6%) among study participants in a completely informal context. This percentage might have been lower had it been a study involving schools. Thus, it is suggested that researchers consider the possibility of drop-outs while planning their study among youth groups.

The research methods and instruments were designed to capture both learning and SI in biodiversity. The fact that students had reviewed and selected photographs of the visit before they attended the post-visit interviews might have helped them 're-live' their experience again and might have influenced their discussions during the interviews. However, during the interviews, I highlighted that the focus was on what they felt and experienced during the visit. During the field observation, I remained a non-participant observer and did not intervene in the students' conversations among themselves or among the guide. My presence should not have affected the students' behaviours.

In this Chapter, I have described the research design and presented how the study was conducted. In Chapter 4, I set the context of the study through a narrative of how a student experiences the visit, and in Chapter 5, 6 and 7, I describe the data analysis and findings.

4 Chapter 4: Visiting Ile aux Aigrettes nature reserve: A narrative description

4.1 Introduction

This Chapter aims to provide a rich description of the guided tour that the three Scout groups undertook on Ile aux Aigrettes (IAA) nature reserve. I start by describing the site and the biodiversity conservation measures undertaken by Mauritian Wildlife Foundation, a Non-Governmental Organisation (NGO) responsible for managing IAA. This is followed by a narrative description of the guided tour through the eyes of the participants. The Chapter thus provides a glimpse of what happens during the visit, what students see and hear as part of their experience and how the guided tour is designed.

The Chapter is divided into the following sections:

(i) a description of IAA including the history of conservation work, the current work being undertaken by Mauritius Wildlife Foundation and its importance. To describe the site, I use data from the literature review and field observation notes.

(ii) a narrative description of students' experiences during a visit to the nature reserve as per the suggestions of Polkinghorne (1995). I use a chronology of events that take place to describe the content of the guided tour, the setting and the atmosphere. I also use photographs captured by students to support my description.

4.2 Site Description – Ile aux Aigrettes nature reserve

The study entails a visit of students to Ile aux Aigrettes (IAA) nature reserve, an islet of 26 hectares situated about 800m off the South East Coast of Mauritius (Mauritian Wildlife Foundation, 2012). Unlike mainland Mauritius which is of volcanic origin, IAA is made up of coralline limestone resulting from an eroded dune due to a drop in sea level about 10000 years ago. The islet gradually developed into a natural museum of endemic flora and fauna which ultimately became heavily degraded following the arrival of man on Mauritius during the 17th century. IAA is situated in the South Eastern side of Mauritius in the Bay of Mahebourg and was utilized as a military base during the second world war. Consequently, the local endemic trees including the Black Ebony (*Diospyros spp*) were heavily logged for their valuable wood. Accidental and deliberate introduction of plants and animals, some of which became invasive, coupled with tree felling contributed to the degradation of the ecosystem even after IAA was declared a nature reserve in 1965 (Mauritian Wildlife Foundation, 2012).

Since 1987, the Mauritian Wildlife Foundation, a local NGO, exclusively concerned with the conservation and preservation of the endangered flora and fauna of Mauritius, took over the management of IAA and set up an islet restoration programme comprising of weeding the islet of invasive plants followed by the planting of native plants. Once, the forest was re-established, endemic species of birds such as pink pigeons (*Columba mayeri*), Mauritius Fodies *(Foudia rubra)* and the Mauritius Olive White-eyes (*Zosterops chloronothos*), reptiles such as Telfair's Skink (*Leiolopisma telfairii)* and Guenther's Gecko (*Phelsuma guentheri*) once common on Mauritius was re-introduced from Round island, another islet in the north of Mauritius where these endemic reptiles still flourish in the wild. Interestingly, as part of the islet restoration programme, the Aldabra Giant Tortoise *(Aldabrachelys gigantea)* was introduced on IAA as an analogue species to perform the ecological role of two species of extinct endemic tortoises of Mauritius. These extinct species are the long-necked tortoise or saddled-back tortoise *(Cylindraspis triserrata*) and the Mauritius Domed Tortoise (*Cylindraspis inepta*). Currently, there are about 25 Giant Aldabra tortoises on the islet roaming freely in the wild, contributing to fruit and seed dispersal and fertilizing the endemic soil with their dung. Several scientific projects are ongoing on IAA including close monitoring of endemic fauna. Bronze models of extinct fauna such as the Giant Skink of Mauritius *(Leiolopisma mauritiana*), the long-necked tortoise of Mauritius *(Cylindraspis triserrata*), Commerson owl of Mauritius *(Mascarenotus sauzieri),* and the dodo (*Raphus cucullatus*) have been installed on IAA. Furthermore, a small museum/gift shop is operational on the islet where bronze models, animal skeletons, photographs/painting and specimens of plants and animals of the Mascarenes are displayed.

Eco-tours designed for the public visit started on IAA in 1998 as a means to promote ecotourism, provide a first-hand experience of conservation work and create local employment as part of sustainable development initiatives. The restored ecosystem on IAA provides a unique experience to visitors analogous to being a natural museum. The chosen eco-tour of my study is connected to the 'Learning with Nature' programme, initiated in 2009, targeting students aged 11 to 15 years. As students in groups of 15 are taken along a pre-determined trail, 'le sentier du dodo', of about 1.5km, accompanied by a tour ranger, information about the geography, history and geology of the island is provided, as shown in Figure 4.1 below. Encounters with endemic and rare species of plants and animals, tortoises and bronze models of extinct animals are part of the tour. Though the 'learning with nature' programme also included hands-on activities such planting in the nursery, the participants in my study did not have such opportunities, they only followed guided tours.

Figure 4.1: Trail on Ile aux Aigrettes undertaken by the participants with an approximate location of major stopping points

4.3 A description of the visit to IAA using a narrative approach

This section focuses on a descriptive account of the visit to Ile aux Aigrettes nature reserve to provide the context of the study which aims at describing how participants lived their experience of the guided tour. The use of narratives as a methodology may frame this human experience through storytelling comprising of actions, characters, settings, discourses and plot (Sandelowski, 1991). It is through stories or narratives that we can begin to understand human experience as lived, interpreted and expressed (Polkinghorne, 1995). Polkinghorne (1995) further emphasizes that human experiences are not independent events but rather they are a sequence of events framed by larger structures such as time and context. Polkinghorne (1995) further describes two ways of knowing the world through narrative inquiry: firstly an *analysis of narratives* whereby researchers search for themes that cut across stories moving from stories to common elements; secondly *narrative analysis* whereby a sequence of events are collected and synthesized into a story by a means of a plot or through emplotment, moving from elements to stories.

I choose *narrative analysis* since it is more suited to present the findings of my study focusing on a description of the content of the guided tour and how students reacted during their visit. The aim of this Chapter is not to interpret the data, but rather to describe a series of events happening during the visit and to 'walk' the reader to Ile aux Aigrettes nature reserve through the 'eyes' of my participants.

As suggested by Polkinghorne (1995), the narrative analysis is a synthesis of data from various sources, (field observation notes, semi-structured interviews, photo-elicitation and photographs provided by students) to produce a story that fits the data and concurrently brings in order and meaningfulness that is not visible in the data alone. It gives a retrospective synthesis of data from a bound study (Sandelowski, 1991) whereby my story has a beginning: the start of the visit, a middle: the visit itself and an end: the end of the visit or after the visit. The events were selected, given meaning, cohesion, direction and flow. The concept of narrative smoothing which involved brushing off rough edges and ignoring some parts of the data through a process of deletion, omission, addition, and transposition was adopted to produce a coherent story.

Of importance to highlight is that Polkinghorne (1995) recommends that the researcher describes how the story was shaped to ensure that the story was not 'cooked up '. Various authors put forward means to ensure the validity and reliability of the narrative produced. Polkinghorne (1995) adopted a seven criteria technique for narrative analysis which I illustrate with examples of how I used them to construct my story:

i. Description of the **cultural context** including values, social norms and contextual features that give meanings to events. For example in my study, students were part of Scout groups that espouse self-discipline as a value. Data were derived from semi-structured interviews and field observation.
ii. Embodies **nature** of the protagonist – Bodily dimensions and genetic properties e.g. e.g. tall and thin adolescent aged 14 years of the catholic faith. Data were derived from semi-structured interviews and observation.
iii. **Relationship** of the main character with other people and how the interaction occurred: e.g. Friends, Scout leaders, ranger – data derived from semi-structured interviews and field observation.
iv. **Personal choices and actions** of the central character, grasping his/her personal meanings, motivation and interests: e.g. what the protagonist like, dislike, enjoy, etc – data were derived from semi-structured interviews.
v. **Historical continuity** of the characters: e.g. past experiences and how they interact with present choices. – data were derived from semi-structured interviews.

vi. Generation of a **time-bound story** occurring in a context such that the central character appears as a unique individual in a specific context and situation. Data were derived from field observation notes.

vii. A **storyline or plot** that composes discrete data elements into a meaningful explanation of the protagonist action and responses. This involves sequential reconstruction of events that led to certain outcomes and the construction of the story into a whole using a beginning, a middle and an end. The researcher proceeds by asking questions about the reason for outcomes of events, how and why such events happened.

My storyline will be a chronological sequence of the visit from start to finish which occurs under the direction of the tour guide. Furthermore, Ollerenshaw and Creswell (2002) describe another narrative approach called the three-dimensional space, based on Clandinin and Connelly's (2000) work which I consider highly relevant to my study. This approach lies within the part of the interaction between the personal and social which occurs in the physical context such that interaction, continuity and situation form the core of the narrative. Even if these are already incorporated in the 7 criteria described above, they provide a simplified framework that fits the Contextual Model of Learning (Falk & Dierking, 2013) and is useful to organize my data to produce the narrative as shown in Table 4.1 below.

The techniques of narrative described above are relevant to the visit to the nature reserve as I could make a scene by scene construction of the contents of the guided tours. Espousing the techniques of Polkinghorne (1995) and Ollerenshraw and Creswell (2002), I constructed my story. I chose less of an addition but used more transposition of data elements from different students to construct the story of a participants' visit to a nature reserve. I drew data from field observation notes including the pilot study, semi-structured interviews and photo-elicitation and content of photographs. In the next section, I produce a narrative description of the visit to IAA using Sarah, a ficititous name, as a central character.

Table 4.1: Adaptation of three-dimensional space to my storytelling as an interaction between the personal, social and physical context which occurs over time.

	Interaction		**Continuity**			**Situation/Place**
	Pers onal	**Social**	**Past**	**Present**	**Future**	
Adapted from Clandinin and Connelly (2000)	Look inward to internal conditions, feelings, hopes	Look outward to other people, their intentions, assumptions and point of view	Look backwards to remembered experiences, feelings	Look at current experiences, feelings and occurrences	Future implied or possible experiences and plot lines	Context, time and space in the physical landscape
What I looked for in my data from field observation and interviews	Visit anticipation	How other students reacted. What they told others	First time visiting, Been in the forest before What students liked about the forest or their leisure time	How students felt when they touched things: Fear, interest, surprise	Will the person visit again, did they talk to people about the visit	The exhibit The time spent at each location Time spent walking What they see and hear

4.3.1 Before the visit

Who is Sarah?

Every day Sarah, aged 13, has a 30 minutes bus-ride to attend her state-aided secondary school. After passing her grade six exams three years ago, the Ministry of Education allocated her to a secondary school based on her place of residence and results. At school, Sarah, of Catholic, faith easily mingles and develops friendships with other girls of Hindu, Catholic and Muslim faith. Being among the shortest and thinnest girls in her class, Sarah is not very good at sports. However, she enjoys the school festivities during the annual sports and music day periods giving her a break from the boring Mathematics classes. She likes Art and French classes and though she does not have good grades in science, she enjoys the rare practical classes when the teacher sets up the microscope.

At school interacting with boys is impossible but she does have some male friends whom she meets during extra tuition and Scout meetings. Seven years ago, Sarah joined the '*Eclaireurs du nord de Pamplemousses*', a Scout group. The group espouses the values of Lord Baden Powell, the founder of the Scout movement but in this case, includes both male and female members. Her Scout leader organises alternate weekly meetings on Saturday afternoons at 15:00 and Sundays at 09:00. Here, she can have fun, learn about interesting things and good values like self-discipline during her free time. This schedule enables Sarah to attend her private lessons on Wednesdays after school and on Saturday mornings.

Sarah enjoys being part of the Scout team; a family affair since both her parents and brother are part of the movement. On the other hand, her friend and neighbour, Anna joined two years ago, having heard about the group's regular outings and mountain climbing activities. Every week, both girls proudly wear their khaki shorts and blue polo shirts with their achievement badges and walk for about 10 minutes from their houses to join their Scout friends at the locality's historical churchyard. They both hate the long knee-length unfashionable socks but they know that they protect their legs from being scratched and bitten by mosquitoes during outdoor activities. After the parades and briefing, each week, Sarah participates in different activities but her favourite is the 'passe-a-dix' game. Just like the other boys and girls, Sarah feels that 'passe a dix' is an excellent way of developing team spirit, communication and doing some physical exercise while having fun. Through this game an invention of their Scout leader, Sarah thinks she is developing communication skills and an ability to listen clearly and rapidly and to think strategically.

Sarah was delighted at the idea of visiting Ile aux Aigrettes nature reserve and eager for new discoveries and adventure. She still remembers the previous years' Scout camp during her school holidays in the Black River Gorges National Park where they had to bathe in the nearby river and pitch a tent using bamboo stem and leaves of the Ravenala plant. It would be similar to trekking in the woods but this time to a new place down in the South East of Mauritius. Discovering more about the country is part of the Scout's mission!

Interaction with a visitor (the researcher)

One Saturday afternoon, a woman named Bhamini attended the Scout meeting asking for help for her project with students of grades 7 to 9 that will help her become a 'Doctor'. She brought some forms to sign and those willing to help that Hindu looking lady will be interviewed, draw some sort of diagrams and go on the trip to Ile aux Aigrettes. The best is that they will be allowed to take photographs from their mobile phones during that trip. 'What an exceptional trip!' (Sarah thought, 'mobile phones are not usually allowed during Scout activities!')

Two weeks later, Bhamini came again with paper and pens. She taught the group how to draw a diagram called a Personal Meaning Map using the word 'school' as a central theme. She requested students to draw something similar putting down their thoughts and ideas on the theme 'Diversity of living things' either in English, French or Creole or a mix and if they wanted to, they may use their drawings. Sarah completed this exercise within 12 minutes jotting down stuff about animals, plants, their characteristics, reproduction, flowers etc. The group went back to their normal Scout activities and the lady called each student one by one for an interview. When Sarah's turn came she thought she brilliantly answered her questions about the forests and the sea in Mauritius. She described the dodo as a flightless fat bird killed by the Dutch for food until it went extinct. Sarah also talked about the pink pigeon, a rare bird she has heard about but could not answer the question about plants found only in Mauritius. After the interview, the group had their closing parade before attending the 17:00 weekly Saturday mass at the church.

Reaching Ile aux Aigrettes nature reserve

On the day of the outing, Sarah and Anna reached the churchyard 15 minutes before the start; a must for the two girls because lateness is against their Scout values. They met Mike their Scout leader on the way who raised his right hand to his forehead to salute them. Finally, at 07:30, Mike gathered all members for a parade and briefing before they hopped on the specifically hired van transporting them to Pte D'Esny to get to Ile aux Aigrettes. All of Sarah's friends contributed to the Rs100 (approximately 2.5 USD) for the transport and Sarah heard that entrance to IAA is free for them. Though enthusiastic, the Scouts did not talk much about the visit on the way. The topic of conversations ranged from their end of year school results to the forthcoming charity fundraising, regularly bursting with laughter.

Arriving at the embarkation point for IAA around 09.00, the Scouts were welcomed by a ranger named Rose as shown in Figure 4.2 below. Food consumption, except water, is prohibited on the islet. Rose talked about checking shoes for seeds but Sarah did not bother. Sarah's attention was on the green islet seated in the lagoon about 1km in front of her: Ile aux Aigrettes! (shown in Figure 4.3 below). She wanted to get there as soon as possible! The Scouts were split into 2 groups: those who participated in the interview were in one group together with two Scout leaders and Rose, the guide. Those who did not participate in the interview were taken by another guide.

Figure 4.2: Students in their Scout uniforms listening attentively to the ranger's instructions before starting the visit.

Figure 4.3: IAA seen from mainland Mauritius. Photo (P015-10) from student Stefy

The boat ride to IAA

The students put on their life jackets and they were soon ready for the five minute boat ride in the calm blue coloured lagoon of the Bay of Mahebourg. It was a clear warm sunny day of the summer month of December. Rose showed them the Grand Port Mountain range to their left with the prominent Lion Mountain which Sarah easily recognized, having climbed that mountain during one of the Scout outings. The sound of the motor muffled the voice of Rose but Sarah heard her say words like 'rare corals' and saw her pointing towards the clear, almost transparent water. She looked in the water which was about 1 to 2 metres deep and occasionally saw coral plates and algae. It was a wonderful sight, a rare landscape for Sarah who lives in the north of Mauritius.

The boat approached the islet. Sarah was mesmerized. It was like a forest in the middle of the lagoon. The trees anchored on that eroded rocky shore looked unfamiliar to her. She clicked some pictures of IAA from her phone. Once on the jetty, Sarah was ready to follow the guided tour led by Rose. The entrance of IAA is shown in Figure 4.4 below.

Figure 4.4: The entrance of IAA with the jetty. A photo (GG002-10) captured from the boat by Shreena

4.3.2 During the visit

Familiarizing with terms

Rose gathered the group in a semi-circle around her and talked for about 30 seconds non-stop.

Rose: "*Ile aux Aigrettes is an islet of around 26 ha and a half. The islet is of calcareous origin. So what is calcareous? (not waiting for an answer, she continued)… a mix of sand and sediment that accumulated and were compressed by the pressure of seawater. The islet was below the water and at one point in time. the sea level has gone down and the islet emerged out of the water like a mushroom….So what are we going to see on the islet? We will see a tropical coastal forest, a dry forest that is different from the ones that we see on the central plateau on the mainland where it is humid. The vegetation here is different. Before we go in, let me ensure that you are familiar with some terms that I will be using throughout. "Endemic" anyone knows what is endemic?*"

Sarah thought about 'endemic', she heard someone saying 'in danger of extinction'…

Rose: "*Endemic means it is unique to a region or a country, indigenous is when it is also found in another country, now what about exotic*?"

While Sarah was still trying to grasp the words and wondered why the group was so silent, Rose almost immediately answered: "*Exotic are the species which have been introduced in Mauritius such as rats or other plants. Also, biodiversity, do you know what biodiversity is? Biodiversity is an environment: made up of plants and animals. An ecosystem is when plants and animals work together to keep the biodiversity in good health*." Not bothering about how much students understood the terms, Rose continued:

> *"Well, you are on IAA, a nature reserve, meaning that the plants and animals here are protected. The Mauritian Wildlife Foundation started its work here in 1970 to remove exotic species and we are here to save species from extinction as we do not want the species to face the same plight as the dodo!"*
>
> Rose: "*Well what do you understand by species? (*she paused) *well, species is like 'race'! When you see a dog it's like a species and we have different species of plants and animals, different species of tortoises and the species that was endemic to Mauritius is now extinct. Let's go!"*

Tortoises and bats

The Scouts lined up and followed Rose along a narrow path amidst the vegetation. After about one minute they reached a big fenced cage (shown in Figure 4.5 below). Sarah saw a few baby tortoises with funny numbers written on their shells in white. Rose talked in a monologue again and the students listened attentively. Sarah heard her talking about Aldabra Tortoises brought on IAA to replace the extinct Mauritian Tortoises. The babies are kept here until they are five years old and then transferred to Round Island, a nature reserve where public access is prohibited.

As Rose continued talking about stuff like vegetarianism, herbivores and ecology, Sarah decided to take a few photos with her phone. So did her friends. They hardly had time, when Rose voice was being heard loud and clear again.

> Rose: "*See here. The bat of Mauritius called the 'Roussette'. It is enormous when it spreads its wings and it eats only fruits', do you think the bat is blind?"*
>
> *Tom: "it sees only at night???"*
>
> *Anna: "it listens to sounds!"*

Rose explained that this species of bats can see both during the day and at night and does not use echolocation. She explained that bats are the only endemic mammal in the country that is protected by law. It is a frugivorous mammal that gives birth to its young. At that point Sarah was confused, recalling the mess in her yard in the early mornings after bats have feasted on the unripe mangoes, she knew the government was killing them. Her thoughts were quickly interrupted when Rose explained that bat role is to disperse the seed of the fruit and transfer pollen to keep the forests in good health.

Figure 4.5: Mauritius fruit bat hanging in their cage and baby tortoises with numbers as identification

Some students took some photos again while others asked Rose some questions. Sarah did not bother as her attention was drawn towards a huge tortoise crawling lazily in the woods a few metres behind the cages. Anna seemed to have noticed it too and signalled to Rose. The guide invited the students to get closer to the tortoise with a gigantic carapace (more than 90cm circumference). Sarah heard one of the boys jokingly asking whether we could sit on its carapace at which Rose reprimanded: "*No way*!"

Rose squatted next to the tortoise and said: "*This is 'Big Daddy', the oldest male tortoise on IAA, weighing about 200kg and still young at 105 years old*". Sarah's mind was full of questions at that time: *young and 105 years old*??? Rose quickly explained that this species of tortoise can live up to 200 years and has been introduced from Aldabra, an island close to Seychelles. On IAA, the tortoises fulfil an important ecological role grazing leaves and dispersing seeds of fruits through its dung which also fertilizes the soil. Rose described that in the past the sailors used to kill tortoises for the oil under the carapace that could heal skin diseases. Photographs of tortoises are in Figure 4.6 below.

By that time Rose was gently stroking the shell of the big reptile and explained that "t*his top part is called the carapace, made up of keratin, the same substance as your nail and hair, it is very sensitive to the touch due to nerve endings attached to it and its ribs are fused with the carapace; this is why one should never sit on it or rub rocks on it's the shell*". Just then to the awe of students, Big Daddy stood upright and took 2-3 steps backwards! Several students flexed their arms to take a picture of the animal in silence as if respecting the tortoise and trying not to disturb it. Tom wanted to touch the shell but Rose cautioned him to remain gentle since the tortoise may bite him if it becomes aggressive. Rose also explained something about the tortoise drinking water and how to distinguish between males and females but Sarah did not pay attention, she wanted to gently stroke the carapace. The guide then brought the group to a more open space where there was a rectangular pond-like structure containing a mixture of greyish soil and sand. This was an artificial tortoise nest where tortoises lay eggs that scientists collect to prevent them from being eaten by the shrew, a pest on the islet. Sarah's mind was diverted and could not grasp when Rose said something about the sex of baby tortoises and temperature.

Figure 4.6: Male tortoise and female tortoise encountered at different places during the tour

The kiosk – Conservation work

Five minutes later the group were under a man-made kiosk with thatched leaves and were seated on the wooden benches. Rose described the posters in front of them: the first poster was an aerial photograph of IAA introducing the Mauritian Wildlife Foundation as an NGO which strives for the conservation of species. Rose said: "conservation includes protection, preservation, restoration and management". Sarah could not really understand the differences among these words.

Rose continued: "*there are 3 species of birds that we have saved from the brink of extinction: pink pigeon– we have 30 pink pigeons here on IAA, we used to have only 9 in Mauritius, 'Oiseau a lunettes' and 'Cardinal de Maurice'- the Mauritius fody*". Sarah curiously observed the picture of an olive green bird with white circles around the eyes as if it was wearing glasses and the Mauritius fody with a red head and belly. She thought the fody looked like the ones she regularly sees everywhere in Mauritius but she was quickly disillusioned when she heard Rose explaining that the Mauritius fody is not to be confused with the Madagascan fody. In the Mauritius fody, endemic to Mauritius, the female is olive green in colour and the male develops a red belly during mating seasons to seduce the females. Rose explained more but Sarah was again lost in her thoughts, desiring to see these rare birds here on IAA. She glanced at her attentive friends who smiled when they heard the female seduction thing.

Without stopping, Rose moved to the next poster showing a big lizard called a 'skink'. 'Strange' Sarah thought! Rose said it has disappeared from mainland Mauritius due to deforestation and predation but it luckily survived on Round island and was re-introduced on IAA. Sarah's eyes brightened with excitement when Rose informed them that they might be able to see this reptile with electronic chips under the skin. Rose then mentioned something about a rare plant. Sarah could only grasp the name of the 'Ebony' tree which she remembers from her school learning, were heavily logged by the Dutch for its valuable wood. Rose while starting to walk, advised the students to listen, to observe well and ask questions.

Extinct Skink and Owl – causes of extinction

The students followed Rose one after the other in silence along the curvy narrow path (about 75cm wide) amidst the trees. Sarah heard Rose explaining something to Anna but she could not distinguish what the conversation was about. Soon they reached a clearing surrounded by tall trees.

All of a sudden Sarah heard an exclamation: *hey look, look at that*!!! Sarah's friends hesitantly gathered in a circle around something. She squeezed herself between 2 tall boys and there it was! Sitting on a rock, to her awe, was a big lizard, fatter than her arms and taller than her ruler! Sarah quickly realized that it was fake as other small green and blue coloured geckos were crawling on it.

Just then Rose started: "*This is a model of the Giant Skink. It has disappeared from Mauritius mostly due to predation by rats which probably ate its babies and its eggs or due to natural causes. In fact, the rats are very problematic because they climb trees, eat eggs and the young and it's catastrophic. Even if we did not see the Giant Skink, with the help of bones and through science and technology we could reproduce this bronze*." The bronze model of the Giant Skink is in Figure 4.7 below.

Figure 4.7: Bronze Model of the Extinct Giant Skink –Photo P013-6

No one listened to Rose at that time, they were again busy taking photos of that big strange lizard model which looked so real. Some were examining its eyes and touching its tail. Rose took a few steps further along the track and the students followed. There were tall trees with the forest getting denser. Rose stopped and there in the far corner was an owl seated on a log as shown in Figure 4.8 below. The group approached in silence.

Rose started: "*So this is the owl, endemic to Mauritius now extinct!* It is called the '*Hibou de Maurice' or 'Commerson Owl'. It was carnivorous predating on lizards, small rodents and butterflies. Do you know that Mauritius used to have its endemic owl*?"

Sarah: "*No*!"

Rose: "*Me too I did not know before I came to work here*!"

Pascal (looking at the bronze model of the owl): "*Hey one side the eye is small and the other side it's big*?"

Sarah: "*it's winking at you*!" The students burst into laughter.

Tom: "*Who made these Bronze Models*?"

Rose: "*A museum from the United Kingdom with whom we have a partnership*. *So what caused its extinction?"*

Tom: "*The Dutch?"*

Rose: "*Actually predation, Lack of food… yes… well deforestation, loss of habitats and food!"*

Figure 4.8: Bronze Model of the extinct owl of Mauritius surrounded by the Banyan Tree – Photo - GG002-2

Endemic Trees and the Ebony Tree

Rose drew attention to a tree: "*look at this tree with roots having a hair-like appearance… It has several names, tell me the Mauritian name*"

She expected an answer but everybody was looking around and trying to think

Anna said: "*La Fouche!*"

Rose: "*Yes La Fouche, 'Multipliant' but we call it a 'Banyan'. What is interesting about this tree is the roots. Look at the roots.. it starts from the top. We tend to think of roots coming up from the ground".*

The students looked up towards the branches and followed the roots with their eyes, towards the ground, some roots touch the ground and grow into a new tree, while others remained hanging. Sarah thought she had seen the tree before but before she could ask a question, Rose was walking towards a different tree a few metres away. She talked non-stop again providing a piece of detailed information.

Rose: "*Behind you is an Ebony Tree… Long ago the Ebony tree was very much in demand due to its natural black coloured wood called the Bois D'ebene. (Ebony Wood). It is a heavy, dense hard wood, and if you cut a piece and put it in water it may sink. It is valuable and very expensive and grows very slowly about 1mm in diameter (like a hair width) per year. When we say ebony wood it's not the whole tree it's only the inner part, the heart. Here in Mauritius, we have 12 species of Ebony tree. The one here is 'Diospyros egretarum' because it grows only on IAA and we have other species like the Diospyros tesselaria etc. Now look up, it's a female tree, look at the colour of the trunk and the mosses that grow on it".*

At that point, Rose raised her hand and reached out for a branch to show to students. Everybody looked up at the branches, some got close, they looked only at the tree that Rose was showing to them (Sarah took pictures).

Rose: "*This tree is called 'dioecious' in English. Dioecious means Duo, 'Deux' (Two). There are separate male and female plants like the papaya, the kiwi fruit, the Pandanus which we commonly call, Vacoas.,. Now come closer...look at the bigger trunk, this is a male tree with many black spots on the trunk as you can see, you will not find these black spots on the females*"

Sarah heard some affirmative exclamations from her friends but she got lost in her thoughts thinking about the kiwi fruits and that di-iicoous thing Rose was talking about. Rose mentioned words like pollen, pollination and sepal: these complicated things her biology teacher draws on the board. Her attention was sparkled when Rose spoke: "*Geckos and lizards participate in pollination*!" Strange! Sarah thought that only bees did that! Rose also explained that the fruit of ebony is eaten by tortoises and pass them out far from the tree in their dung.

All of a sudden Rose said pointing to seedlings on the ground: "*You will see, I will crush these seedlings, what you see*?"

As she spoke Rose stamped her feet on the beautiful seedlings, crushed them and then removed her foot.

Sarah was astounded: "*It moved! It springs back*"!!!

Rose: "*Even after I crushed it, it springs back because the stems of the seedlings are very elastic. This vegetation has learnt to adapt to its environment. Imagine what would happen to these seedlings if a tortoise walked on them several times in a day!! Also, note the red veins which is a warning sign of danger to deter tortoises from eating them. Let's go to the nursery*!"

The nursery

Five minutes later the group was inside the nursery among seedlings and young plants as shown in Figure 4.9. Sarah had never been to a similar place before. Rose talked about biologists who collect seeds of rare plants and let them germinate. The seedlings are progressively supplied with less water and more sun to enable them to survive in the wild. Sarah listened less but was more intrigued by the strange-looking seeds placed on different trays and again the peculiar names in creole 'Bois de Cadoque', 'Bois Pipe', 'Bois de rat'. Sarah saw a man working in another area, looking after potted plants of all types. She could not see much because the place was covered with a darkened net.

Figure 4.9: Photos of the nursery showing potted plants being hardened (P011-7) and potted endemic plants with their seeds and seedlings (HL01-5).

Rose went back to her explanation: "*Heterophylly is a phenomenon that the vegetation over here has developed over time to adapt to an environment with a lot of tortoises. Hetero- means different… a plant can have different shaped leaves on the same tree. When leaves are young they usually have smaller leaves with a red vein as this deters tortoises from eating them giving a signal that it is sour and poisonous. I will show you as we move"*

The group followed Rose back into the woods again walking and chatting among themselves. Anna was walking behind Rose asking more questions. Rose halted again: "*Come come observe these trees. This is an endemic tree called 'Bois de boeuf'. Notice the smaller young leaves with a reddish vein, as the tree grows to about 1.2m, see how the leaves become larger and the red veins have disappeared. At this height, tortoises cannot reach the leaves, so there is no need for red veins. This is an example of heterophylly".*

Sarah saw Tom's arms in front of her face, extending his phone to take a better picture of that tree. She did not tell him anything, thinking about the tortoises.

Rose then showed them another tree with a set of small white flowers: "*This tree here is called 'Bois de Rat'*". Pascal was laughing at that name: Rats' wood! Rose invited them to smell the flowers without plucking them. Sarah was enjoying the scent but was quickly disgusted as Rose explained that if the flowers are plucked and kept overnight, their smell turns pungent like a dead rat! Figure 4.10 shows a student smelling flowers.

Figure 4.10: Student smelling the flowers of an endemic orchid Photo P015-4

The pink pigeon

Five minutes later they reached their next stopping point, Rose cautioned them to remain silent not to disturb the birds. All of a sudden Sarah saw a beautiful Pink and Brown Pigeon walking gracefully on the forest floor. Sarah quickly aimed her camera almost whispering to signal her friends: *over there, over there!* At that time someone whispered: pink pigeon! pink pigeon! Figure 4.11 is a photograph of the pink pigeon.

Figure 4.11: Photograph of a pink pigeon on a branch (Photo-GG08-2)

Sarah was excited! She had only seen the bird in pictures and on TV and she felt a strange kind of satisfaction to find it in real life! She saw Pascal approaching, discrete and furtive, he bent under the vegetation and stepped over a branch to get a better picture… and all this in silence. Everyone wanted a nice photo of the bird which was walking away from them until it disappeared among the dense vegetation. Rose explained that the markings are used by scientists to locate birds' nest and monitor them. They are also feeder-fed. Sarah did not care much about all these long explanations. She felt satisfied and looked around for more pink pigeons. She also became more conscious about the chirping of the birds among the rustling leaves. She heard Mike, their group leader exclaiming*: "I've been in Scouts for 15 years now and it's the first time I see this bird!"* Sarah thought how thankful she was to be a Scout, to be able to see these rare things and almost fell pity for her school friends who could not enjoy these offerings of nature in Mauritius.

The extinct dodo and long-necked tortoise

Later, Rose brought them to a small clearing with two bronze sculptures: Sarah recognized the dodo but it's the first time she saw a life-size sculpture of a dodo almost the height of her knees, standing on the forest floor. There was a strange tortoise with a long neck which was the height of Sarah's hips! (shown in Figure 4.12).

Rose asked the students to hurry and not waiting for everyone to come, she began to explain:

Figure 4.12: Saddled-back or long neck extinct tortoise sculpture (GG08-1)

Rose: "*This sculpture represents one of the 2 species of endemic tortoises that we had in Mauritius but are now extinct. We called it the Long-necked tortoise or the saddle-back tortoise as it's carapace has the shape of a saddle. The very long neck is an adaptation to heterophylly. The tortoises could not feed on the small leaves and evolved to reach out for leaves higher up in the tree. Why did it go extinct?*"

Sarah was still trying to answer when Rose continued talking, not waiting for students to respond!

Rose: "*It is written in old books that Mauritius was covered with tortoises. There were so many that people killed them for food especially for the seamen. Sailors used their fat as a medicine to cure a disease called 'scurvy'. Scurvy is a disease that seamen suffered from due to lack of fresh fruits and vegetables and hence vitamin deficiency! These reasons as well as predation by invasive species contributed to the disappearance of the tortoises*".

Just like her friends, Sarah listened in silence, feeling that she was learning a lot. Tom and Mike sat on the wooden bench observing the sculpture of the dodo shown in Figure 4.13.

Rose: *"So this is a sculpture of the dodo, it was big, and stood 75-90cm tall above the ground. A frugivorous bird, using its big beak that could break hard seeds and pull branches…but it was a big bird that did not fly but could run fast with big feet. See the shape of the wings, very small...so why did the bird not develop wings?"*

Sarah: "*it was big?*"

Rose: "*yes it was big but why?*"

Rose: "*the main reason is that it did not have any predators before the arrival of man. I want to draw your attention: the Dutch killed only some dodos to eat but its extinction is also due to deforestation, habitat loss and the introduction of rodents and pests that eat its eggs. It used to lay one egg per clutch per year*."

Sarah thought it was a nice explanation, More than just grasping the information she was carried away by Rose's enthusiasm varying her voice tone, showing empathy and gesturing with her hands and face.

Figure 4.13: The sculpture of the extinct dodo (P010-7)

More plants and trees

Rose looked at her watch and summoned the group to hurry. Sarah feeling a bit tired by that time, was drinking more water and the group walked slower. Rose showed them a burnt ebony tree, devoid of leaves and branches Sarah felt happy to see inside, dark black inside and an outer pale brown wood. She listened to Rose talking again about how the ebony was so valuable in the past: the 'black gold' prized for its inner hard black wood to make furniture and piano keys.

As they continued walking Rose drew their attention to more trees, some exhibiting heterophylly. Then Sarah saw familiar palm-like trees. She missed the explanations at that time, feeling tired but took a photo of that Palm that looked like a bottle! Now Sarah noticed the different shapes of the leaves and the trunk. Sarah saw her friends taking a picture of a small knee-length plant that had been fenced off. It was beautiful with small reddish, green leaves of about 1 cm long and thorns. The different plants encountered are in Figure 4.14.

Sarah found Rose pointing to another plant with large leaves beautifully arranged in spirals. Rose called it 'Bleu Latanier' or 'Vacoas' whose leaves have a blueish reflection when it rains. The leaves are used to make baskets and thatched roofs. Sarah quickly recalled how her grandmother related her childhood spent in poverty in huts made up of thatched roofs! She thought maybe grandma used that plant!

Figure 4.14: Photos of different endemic plants submitted by participants

Cannon

By that time the Scouts could feel the heat, they had already been walking and listening for about an hour. Sarah was astounded when they came across a cannon 7 to 8 metres long laying on the ground as shown in Figure 4.15. Why a cannon on IAA??? Rose spoke about IAA being used as a military base during World War II. Sarah did not follow the explanation, she preferred to look around and rest.

Figure 4.15: Photograph from Selvina showing the Cannon (GG008-4)

Telfair Skink

All of a sudden the students heard a brisk rustling sound of dried leaves less than 1 metre from them. Sarah was startled and grabbed Anna's arms: "*Hey, look at the lizard there*!"

Rose asked them to remain still and pointed to something moving on the ground.

Rose: "*See this is the Telfair Skink!!! The one we saw in the pictures*."

Sarah: "*hey yes see it is now there, it's there, brown!"*

Pascal:"*it's not brown it's grey!"*

Anna (now showing to the other friends who have approached): *"There!! Hey, am afraid!"*

Mike looked at the students extending their phones to take photos: "*hey take the picture then you WhatsApp me!"*

The students joked and teased one another, curious at the sight of this Telfair Skink and making fun of Anna who was afraid of this 40cm long lizard! Rose let them enjoy the experience and then explained that the Telfair Skink is found only on IAA and Round Island.

Pascal: "Am thinking it is camouflaged, it's intelligent!"

Rose: "Yes it also eats snails, disperses seeds and transfers pollen, this is the Telfair skink and it has a chip beneath its skin. It is like a GPS. 10 scientists are living on IAA, some study the skink. They walk around IAA, catch it, scan it to get a unique number and follow its health, movements and reproduction."

Some students were still watching the skink moving around and not paying attention until the reptile disappeared amidst the vegetation. Photos of the Telfair skink are in Figure 4.16.

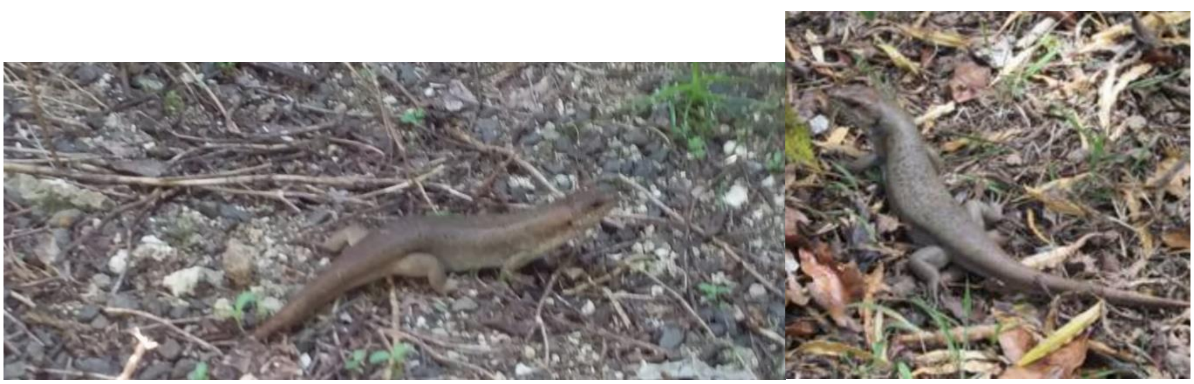


Figure 4.16: Telfair Skink was seen at two places in the wild (Photo P013-2 and P011-6)

Museum and end of the visit

It was almost the end of the visit, about an hour and a quarter since they left mainland Mauritius. Rose brought them to a small wooden room which she called a museum. Sarah saw artistic wall paintings of the Dutch period, one of which was in her textbooks but her attention was drawn more towards the models of birds and lizards. The group spread out taking photos and not really listening to Rose's explanation.

Sarah was attracted to a large bronze parakeet of similar size to the ones she saw at Casela but Rose said it's an extinct broad-billed parrot once found in Mauritius. Rose showed them a cross-section of real Ebony wood and now Sarah touched that bark clearly distinguishing an inner black core and outer paler brown structures. Anna excitedly approached Sarah, holding a small tortoise "*here, here, this is where the nerves are attached*". Sarah noticed Pascal capturing a photo of another extinct bird, looking like a hen. It was called the Red Rail of Mauritius. There was also a model of the extinct Mauritius blue pigeon. Some exhibits found in the museum are in Figure 4.17.

Figure 4.17: Extinct Blue parrot of Mauritius (P012-4) and cross-section of ebony bark (GG008-6)

Rose finally thanked them for their attention and the group clapped before roaming around the attached gift shop. Sarah found the books and soft toys too expensive but she desperately wanted a souvenir of IAA. So she settled for a Fridge magnet costing Rs150 (approximately 4USD) to bring home.

Rose summoned the group towards the jetty to wait for the boat. The drive home lasted about one hour. Pascal was still teasing Anna about the Telfair Skink in the van but Sarah was too tired for jokes. She dozed off in the van.

4.3.3 After the visit

At home, Sarah enthusiastically related to her mum about the unexpected encounter with the skink, the plants with red veins and the tortoises with long necks. She also showed some photos from her phone. During the week, Sarah enjoyed the school holidays, watching comics on TV and listening to music on YouTube. She also plays badminton on the streets in the afternoon with her brother and some friends.

One week later during the Scout meeting, Sarah completed the spider drawings this time making some additions: 'leaves with red veins', 'dodo', 'endemic' and 'skink'. She wanted to write more but could not bring words to paper and left it like that. During the following weeks, she heard on the radio that bats are destroying the fruit yields and will be killed by the government but she had no opinion about that. Her memories of the visit to IAA soon faded but she still remembers that it was a wonderful adventurous experience. One day while watching the news on TV, Sarah saw videos of IAA and recognized the bronze model of the Giant Skink. She heard something like the Mauritius Commercial Bank was giving money to the Mauritian Wildlife Foundation. She did not care much about what these rich people were doing but recalls the wonderful time she spent in that beautiful place where plants and animals are protected.

4.4 Discussion

In the narrative, I describe the visit experience of a group of Scouts to Ile aux Aigrettes nature reserve through Sarah's eyes. Just like a visit to museums and science centres as described by Falk and Dierking (2013), the social, physical and personal context plays a crucial role in the concurrently influencing experience. It is challenging to decipher which of the three contexts is most successful at influencing experience. The data for the description of the guided tour as part of the physical context was drawn mainly from field observation notes and audio-recording. This enabled me to portray some of the conversations between the students and the guide describing the tour as authentic and 'lived'. Furthermore, Sarah's experience was a superimposition of what different students experienced during the visit as identified during the interviews and photo-elicitation exercise. This enabled me to picture the personal context of the students and their pre-visit interest and activities. This narrative also portrays the social context of the Scouts' group that heavily influences the behaviour of the participants while visiting an informal learning setting. The three main factors can be identified in the narrative: (i) Scout values, (ii) nature of the guided visit and its richness (iii) surprise and wonder (iv) the experience of different students and (v) biodiversity and ecology concepts.

4.4.1 Scouts

The scene for this narrative is set by portraying Sarah as a Scout. The values such as respect for others and self-discipline espoused by these young people are highlighted since it forms part of the social and personal context of the participants when they go on an outing with the Scout group. Despite the occasional jokes and teasing, the participants as a sign of respect refrained from interrupting Rose, the guide. Even if they might have been curious about what they saw and heard, the participants did not venture to touch things when they had already been asked not to, respecting the rules set by Rose. They also did not persist in questioning during Rose's explanations. The presence of Mike, the Scout leader as a sign of authority, did not really influence their behaviour as he seems to have a friendly but firm approach with the students. Thus, the entry values and beliefs of students influence their behaviour while visiting an informal learning place (Bell et al., 2009; Falk & Dierking, 2013). Therefore, even if students might have been interested in engaging with particular exhibits (e.g. touching), they would remain obedient to the guide when she requested them to proceed to the next stopping point, such that the time spent by students at exhibits would not be illustrative of their interest.

In the methodology Chapter, I report a high drop-out in the participants (above 50%). Scout group outings are independent of schools and often perceived as a rewarding leisure activity. The fact that one of Sarah's friends was not permitted to go on the trip as a punishment for unsatisfactory school results exemplifie this. Furthermore, Scout outings are seemingly unrelated to school but do contribute to the holistic development of the students. In this narrative, the fact that Sarah relates memories of school demonstrated that science learning cuts across contexts, thereby strengthening the contribution of out-of-school contexts to enhance learning especially of science (Braund & Reiss, 2006).

4.4.2 Nature of the guided tour

The visit was heavily driven by the guide such that the visitors had almost no free choice for self-exploration or to choose how much time to spend at an exhibit. Time spent at an exhibit (Sandifer, 2003) therefore is not an accurate indicator of interest and learning in this guided tour. Here the exhibits are living plants and animals as well as different stopping points such as bronze sculptures encountered with no labels. Visitors rely heavily on the guide to learn more thereby strengthening the importance of trained guides to impart correct information and meaningful experiences to visitors.

As per the Contextual Model of Learning (Falk & Dierking, 2013), the guide forms part of the socio-cultural context that influences an informal learning experience. IAA provides guided tours whereby the visit is dominated by the guide who takes a leadership role, channelling students across pathways and acting as a mediator and communicator of messages (Randall & Rollins, 2009). This is illustrated by the detailed description of exhibits provided by the guide. The guided tour is rich in information as illustrated when Rose explained the extinction of tortoises bringing in elements of the history of sailors, diseases, predation, etc. I describe this aspect in the narrative by providing some details of the guide's talk.

During field observation, I noted several times that the guides spoke non-stop for 30 seconds delivering a lot of information. Rangers completed the tour in a maximum of an hour and a half making sure they reached the end of the visit to catch the boat on time. Students seemed to listen attentively to Rose at all times looking at her when she explained. Several times, the guide questioned students and she provided the answer herself without waiting for their responses such that students' attention was quickly diverted with another piece of information. For example, Sarah could not understand the difference when Rose said that conservation is about management, protection, preservation of species. She also often lost attention during the visit. However, while walking along the path, the guide did converse with students and answered some questions individually. Thus, the guide's role is crucial in this tour and this highlights the importance of social interactions in fostering learning among students.

4.4.3 Surprise, strangeness and wonder

Sarah stood in wonder in front of the pink pigeon she was seeing for the first time. Like Sarah, most of the students were seeing the 'exhibits' for the first time in their life. Seeing the pink pigeon, in reality, stimulated a reaction from the disciplined Scouts who could not keep on listening to Rose. They would prefer to track the bird and take nice photographs. Furthermore, the visit entailed unanticipated encounters with animals, for example, Sarah saw a tortoise 'Big daddy' roaming near the bat cage and she was surprised by the well-camouflaged Telfair Skink. In contrast, Anna was startled by the presence of the reptile and these elements contribute to the lived experience of the visit.

4.4.4 Different experiences

Even though the narrative focuses on Sarah, the other characters like Tom, Pascal and Anna were living their experiences differently. For example, while Sarah was observing the parakeet in the museum, Pascal was taking pictures of the hen and Anna was talking to the guide, asking several questions. Even if the delivery of the guided tour was the same for everyone, the way they experienced it differed based on their likings and choices. While Rose was stepping on the seedling of the ebony, others were busy taking photos of the owl and the Banyan tree. This aspect will be further discussed in subsequent Chapters.

4.4.5 Biodiversity and ecology concepts

The tour is rich in information about biodiversity, ecology and conservation concepts as well as the history of Mauritius. Firstly, there is familiarization with terms such as 'exotic, endemic and ecosystem' which provides the foundation for building on new concepts during the tour. Some main concepts identified are:

i. Feeding habits in animals: frugivorous bats, herbivorous tortoises and omnivores.

ii. Reproduction in animals and mating behaviours: Bats are mammals giving birth to their young. The tortoises, the Telfair skink and birds lay eggs. The eggs of tortoises are incubated and the sex of the baby is determined by the temperature of the soil. The Mauritius fody has special mating behaviours, such as the male develops red plumage to attract females during the mating seasons, a piece of information that impressed students. Furthermore, the dodo used to lay one egg per clutch per year.

iii. Sex differentiation in plants and animals: The ebony is dioecious just like the pawpaw and kiwi. The different shapes of the tortoise's carapace is used to differentiate the male and female. Other information includes the male and female Mauritius fody .

iv. Ecological roles of animals – The bats, geckos and skink are important for pollination and dispersal of seeds. The tortoises disseminate fruits and seeds through their dung which also fertilizes the soil. They graze on weeds and low plants and in doing so trim the vegetation. The leaves of the palm are habitats of geckos.

v. Biology and anatomy of tortoises: There are explanations about the tortoise reproduction, the nerve endings attached to the carapace making it sensitive to touch, the tortoise can live without food for a long time. The long lifespan of the tortoises and their weight is also detailed.

vi. Diversity of plants and trees – The different endemic trees are presented to students and some display particularities which help to identify them such as the 'Bois de rats' with pungent plucked flowers or 'Bois de chandelle' used to make torches in the past. The roots of the banyan tree grow into new plants from top to bottom, unlike other plants.

vii. Extinction – The concept of extinction is emphasized at several points. The extinction of endemic tortoises, the extinct species found in the museums as well as the owl, the dodo, the Giant skink and the saddle-back tortoise. Moreover, causes of extinction are well explained: firstly due to invasive species such as rats predating on eggs of birds and reptiles, secondly habitat destruction due to deforestation and to a lesser extent the extermination by human activities such as capturing tortoises for food and oil.

viii. History – The content of the guided tour includes information on the history of Mauritius: colonization, the Dutch period and extinction waves, as well as the use of IAA as a defence military base during IAA. There are also details about the historical use of plants and animals for the benefit of mankind such as leaves to make thatched roofs, Bois de chandelle to make torches and tortoises' oil to treat skin diseases. A well-detailed example is the overexploitation of the ebony wood to make piano keys and ship masts.

ix. Conservation practices by Mauritian Wildlife Foundation (MWF): MWF saved the pink pigeon from the brink of extinction especially described through posters in the kiosk. There are more activities on IAA in addition to the guided visits. Scientists stay there to study the Telfair skink, the Mauritius fody and pink pigeon. Tagging is shown through the numbers in tortoises' carapace, the chip under the skink of the Telfair skink and rings in birds legs. There is the propagation of endemic plants in the nursery, collection of seeds and hardening of seedlings before transplanting out of IAA.

x. Evolution and adaptation to the environment: The guide talks about how plants have developed heterophylly and red veins as an adaptation against tortoises and in turn the tortoise developed long necks. However, I believe that the missing information is that this process took thousands of years to evolve and develop into new species. Similarly, the seedlings with elastic stems to withstand the weight of the tortoises is explained but it should be emphasized that the process took years and years to avoid misconceptions about the timescale of evolution and adaptation to the environmental pressures.

xi. Other concepts: Concepts such as predation, grazers and camouflage are used regularly; however, there is little reference to other concepts like the food web and balance in the ecosystem.

xii. The culling of endemic Mauritian bats – the government authorization of mass culling of the endemic Mauritian bats claimed by planters to destroy their fruit harvest is not explained enough during the tour. Scientists and environmental activist are against the culling of a protected species as it puts the population at risk. This is a missed opportunity to trigger socio-scientific debates around the conservation of biodiversity.

The fact that these different concepts related to biodiversity were described during the tour illustrates how Scouting activities present opportunities for students to learn science as described by Jarman (2005). The concepts identified will be used in subsequent Chapters to discuss what students learnt about biodiversity.

4.5 Conclusion

In this Chapter, I provided the context of the visit of the Scout groups to Ile aux Aigrettes nature reserve highlighting how a student experienced the visit. I also described the interplay between the personal, social and physical context of the visit and how forming part of a Scout group influenced behaviours of students during the tour due to personal and group values. I also identified the content of the guided tour in terms of the main biodiversity and ecology concepts that were elaborated by the guide. This later enabled a comparison of what was being offered by IAA and what students took out of it. In this Chapter, I also highlighted how students' attention was captivated by several exhibits e.g. the tortoise and the pink pigeon. They also captured photographs of selected exhibits. In the next Chapter, I describe how these exhibits and the content of the guide's explanation triggered SI.

5 Chapter 5: Identifying the Triggers of Situational Interest

5.1 Introduction

One of the objectives of this case study research is to represent and report the participants' experiences of Situational Interest (SI) during their visit to the nature reserve as authentically and as close to their lived experiences as possible. To this end, four main data collection instruments were used namely: field observation, semi-structured interviews, collection of photographs from participants and photo-elicitation. I start this Chapter by providing an overview of the affordances of photographs and present the analytical framework that guided their analysis. I then describe the process of analysing photographs, photo-elicitation and semi-structured interviews with the view to answer research question 1: What are the features (situational factors) of a visit to a nature reserve that stimulate interest among students? I then identify the sources or triggers of SI among students during the visit to the Ile aux Aigrettes Nature Reserve.

5.2 Photographs and photo-elicitation

Photographs form part of visual images which deepen the richness of data collected due to their ability to capture more details of the world of participants compared to verbal and written methods and hence they help to achieve data enhancement (Glaw et al., 2017). Visual methods including photographs enable participants to express their tacit knowledge and emotions and are particularly effective when participants are hesitant or have difficulty expressing themselves verbally or in writing (Pain, 2012). Photographs as actual data are therefore appropriate to investigate SI. Photographs have thus enabled me to overcome the field observation and interview challenges of deciphering what goes on in the minds of adolescents in a 'walk and talk' (Braund & Reiss, 2006) type of educational intervention of my study, largely directed by the tour guide as highlighted in the previous Chapter. Students captured their photographs during the visit (auto-photography) and during photo-elicitation after the visit, the students were asked to explain these participant-generated photographs. Photo-elicitation thus provided a means of stimulated recall that allowed the investigation of cognitive and affective processes by inviting participants to recall their thinking and feelings during the tour to the nature reserve (Fox-Turnbull, 2011). For example, a few adolescents in my study reported being stressed as they had to concentrate during the post-visit data collection phase whereby they had to first draw a PMM, then answer semi-structured interviews followed by the photo-elicitation exercise. Having the photo-elicitation process after the PMM and interview enabled the participants to relax, detach and allowed a shifting of the focus from the participants as the subject of study towards the photographs as the subject of study (Noland, 2006).

In this Chapter, I analyse the data using the 'Interpretive engagement' framework from Drew and Guillemin (2014), which focuses on the process of meaning-making from participants through visual images. The concept of meaning-making is a useful approach to understand visitor experiences in museum environments (Silverman, 1995); it highlights the visitor's active role in creating the meaning of his/her experiences as a product of the personal, social and physical context. The same concept is related to the Contextual Model of Learning (Falk & Dierking, 2013), which is the overarching framework for this research. Thus, the interpretive engagement framework is suitable to guide the analysis process and enabled the integrated analysis of the auto-photographs, semi-structured interviews and photo-elicitation.

Analytical framework - the 'Interpretive engagement framework'

I report the data analysis and the results in three stages according to the interpretive engagement framework (Drew & Guillemin, 2014). As per the framework, in each stage, I gave due consideration to the five key elements namely the researcher, the participant, the audience for which the image was produced, the image and the context of its production. The three stages as described by Drew and Guillemin (2014) are as follows:

Stage 1*: participant-engagement*. This stage was an analysis of the photographs from the participants' perspectives, that is, how they interpreted the photographs and what meaning they attributed to the images. The reflections from the participants obtained during photo-elicitation were considered. This part of the analysis which was highly participant-driven was concerned with what the participants wanted me, the researcher, to see, hear and consider regarding the image produced.

Stage 2: *researcher-driven engagement.* This stage involved a deeper examination of the auto-photographs from the researcher's perspective considering participants' explanations, processes and context of image production. This stage enabled me as the researcher to integrate data gathered from other instruments such as semi-interviews and field observation in the analysis to add to the context and details that informed data interpretation.

Stage 3: *re-contextualizing* whereby the data from Stage 2 was re-used for a deeper analysis and discussion considering the overarching theoretical frameworks used for the research.

The interpretive engagement framework is thus highly suitable for analysing the data collected from four sources (semi-structured interview, auto-photographs, field observation and photo-elicitation) to find how students made meaning out of their visit to the IAA emphasizing interest. In the next sections, I describe how the analysis was conducted and present the results for each stage.

5.3 Stage 1 of the interpretive engagement framework: meaning-making through participant engagement

5.3.1 Analysing auto-photographs

In this stage, I analysed the auto-photographs from the participants' perspective implying that the students' description of the photographs was crucial. I, therefore, considered only the nine students who participated in the photo-elicitation with a total of 93 photographs. Based on the words that students used to describe 'what' the photos represented, their auto-photographs were coded and grouped under the main categories. An example of the coding and grouping into categories is shown in Figure 5.1 below.

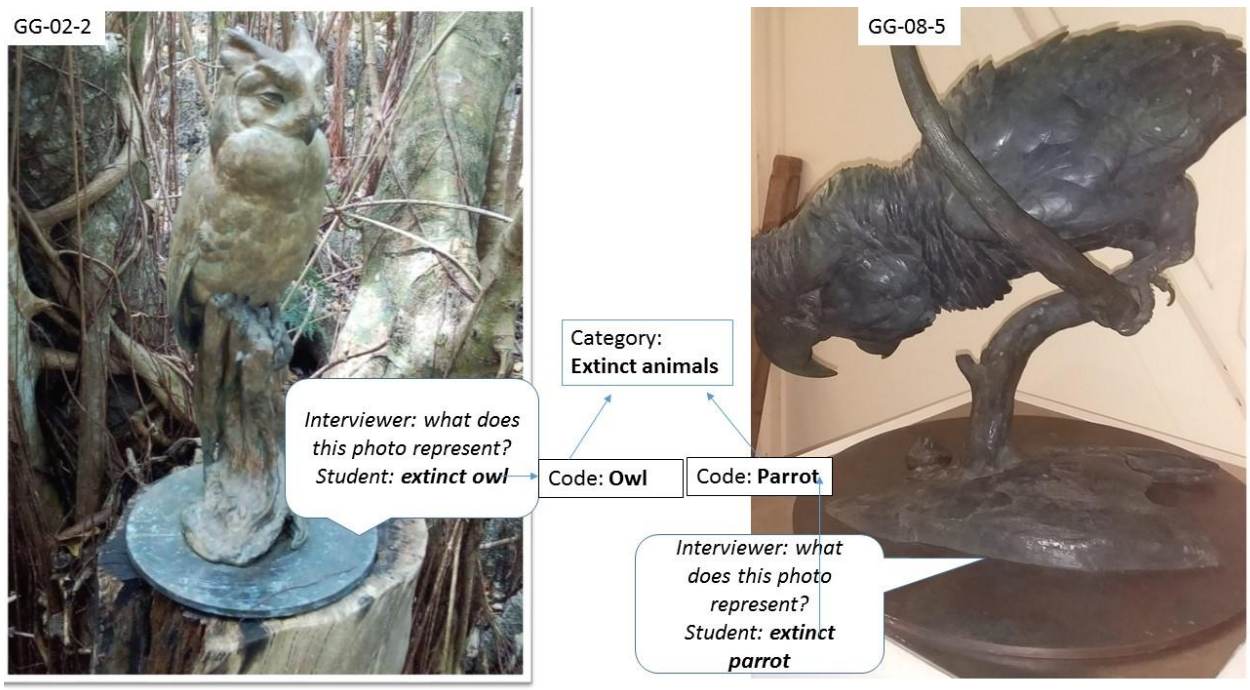


Figure 5.1: Example of coding of photographs as a result of photo-elicitation and grouping of codes into categories

The photos were grouped into 11 categories namely 'tortoises' (17 photos), 'extinct animals' (17 photos), 'beauty' (14 photos), 'trees' (13 photos), 'bats and skinks' (10 photos), 'endemic birds' (6 photos), 'nursery' (6 photos), the 'formation of IAA' (4 photos), 'smell' (3 photos), 'friends' (1 photo) and the 'cannon' (1 photo). Instead of being grouped under 'extinct animals', the extinct long-necked tortoise was included under 'tortoises' because when referring to the long-necked tortoise, students described it as a tortoise with little reference to its extinction. The category 'beauty' englobed all exhibits and aspects of the visit that students described as being 'beautiful' instead of stating the names of exhibits.

5.3.2 Results from the analysis of the auto-photographs

Diversity of photographs submitted by the group of participants

Figure 5.2 below shows the diversity of phtographs submitted by students.

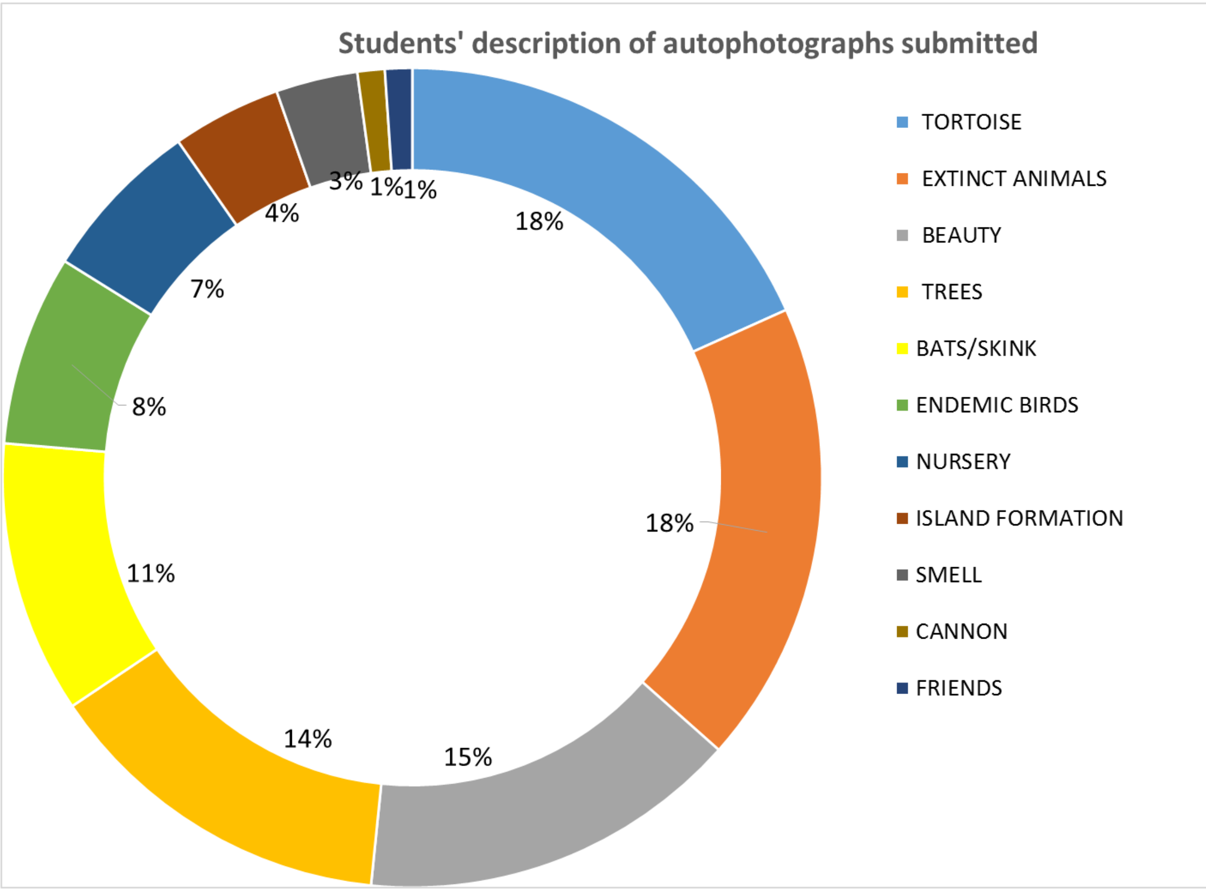


Figure 5.2: Classification of 93 photographs into main categories based on participants' interpretation

As shown in Figure 5.2, the fact that 11 categories were obtained indicate that students' attention was caught by various stopping points presented to them during the tour. The 'tortoise' and 'extinct animals' categories were the most popular, each representing 18% of photographs submitted. The 'beauty' aspect represented 15% of the photographs that students described as 'beautiful' without naming the plants, animals or landscapes that were in the photographs. This indicates that students were captivated by the aesthetic experience offered by IAA. Furthermore, students described plants as 'trees' (14% of the photographs) as well as bats and skink (11%). The least popular photos were those that represented the cannon (1%), friends (1%), smell (3%) and those related to island formation (4%), indicating that these aspects of the tour captivated the attention of fewer students.

The next step was to find out how each student chose their photographs to determine which category was most popular across the participants as shown in Figure 5.3 below. It also helped to determine whether a particular student had any preference for certain aspects of the visit and exhibits based on the categories of photos chosen.

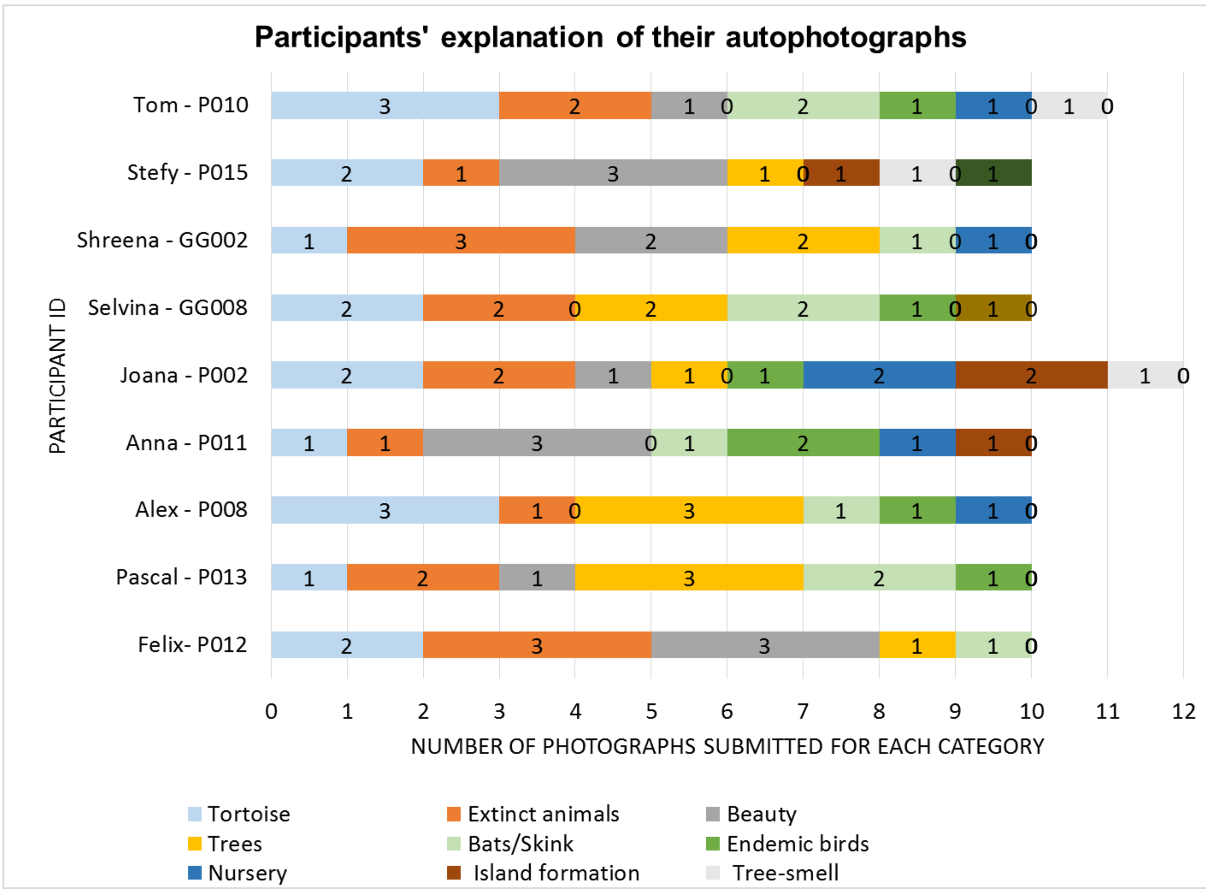


Figure 5.3: Individual students' choice of photographs falling under different categories

Among the nine students, everyone provided at least one photograph of the tortoises and an extinct animal as shown in Figure 5.3, revealing that 'tortoise' and 'extinct animals' captured the attention of all the students. Seven students provided photographs representing beautiful aspects of the visit. Six participants submitted photos of endemic birds including the pink pigeon and the Mauritius fody , the only two endemic birds sighted during the guided tour indicating the popularity of the endemic birds among participants. Five students provided photos that are linked to the nursery such as potted plants or plants. This, therefore, positions the popularity of categories chosen in the following order 'Tortoise' and 'Extinct Animals' as the most popular followed by 'beauty ' aspect, 'endemic birds' and 'nursery'.

Furthermore, Figure 5.3 provides an insight into the range of categories that caught the attention of each participant as follows:

- Joana was captivated by **eight** categories ranging from the tortoise, extinct animals, trees, extinct animals, beautiful things, endemic bird, nursery, island formation and the act of smelling plant parts.
- The attention of Tom, Stefy and Anna was geared towards **seven** categories
- Selvina, Alex and Pascal were attracted to **six** main categories.

This information illustrates that these students' attention was caught by a diversity of categories or aspects of the visit rather than being skewed towards one or two exhibits only. However, a few students were more inclined to focus on specific aspects of the visit based on their personal preferences. This is further supported by the fact that students submitted 1 to 3 photos falling under specific categories. For example, Felix's interest was mainly in the tortoise, extinct animals, beauty, trees and bats/skink. He did not provide any photographs of the nursery. As stated during his pre-visit interview, Tom is used to watching documentaries about wildlife and he produced 7 photos representing animals (3 tortoises, 2 extinct animals, and 2 Bats/skink), illustrating that his prior interest might have influenced where he focused his attention during the trip. This information demonstrates that students may have personal pre-disposition for a particular type of content even if some content (e.g. tortoises and extinct animals) was equally popular among everyone.

5.3.3 Analysis of the photo-elicitation

The next step in the analysis was a deeper examination of the most popular categories of photographs (tortoise, extinct animals, beauty, trees, nursery, bats, skink and endemic birds) together with photo-elicitation transcripts. Each meaningful segment of the conversation during the photo-elicitation exercise was inductively coded as described in section 3.7 of the methodology Chapter. The software Atlas TI permitted me to identify the simultaneous occurrence (co-occurrence) of codes in the photo-elicitation that were related to particular exhibit categories. I thus gained insight into why these 'exhibits' were chosen by students. Using the case of the tortoise, I report about the analysis process in detail and a similar analysis was conducted for the other categories. Since the other themes (friends, history and smell) are less frequent, I choose not to report about them at this stage.

Table 5.1 below describes how the conversation around each photograph was analysed. The bolded parts of the photo-elicitation extracts were coded as shown in the Table. The inductively derived codes which co-occur with the category 'tortoise' were 'size', 'numbers', 'conservation effort', 'first time', 'new knowledge/discovery', 'sex differentiation', 'ecological role' and 'lifespan' emerged as shown in Table 5.1.

Table 5.1: Codes that co-occurred with the category 'Tortoise' during photo-elicitation

Codes grouped in category 'tortoises'	**Selected extracts from the photo-elicitation**	**Co-occurring codes with the code 'tortoises'**
Baby Tortoises	(i) Pascal: These are small tortoises and every 5 years they displaced from the cage **(ii)** Alex: these are the baby tortoises that I found cute. Interviewer: What else did you notice? Alex: they **put codes in the carapace**... I mean it's to identify them, but I think it damages the carapace, I find this a bit …dull **(iii)** Tom**:** A **small** tortoise, I think they are newly born, they are taking care of it. They give it a name or **rather a number to recognize them**.	Size, Numbers Conservation practices Conservation practices Size, number Conservation practices
Carapace of the tortoise	**(i)** Alex: I found this cool because I have **never seen** how it is inside, I **have never seen** when there is no tortoise in this. It was well-formed and I could see the patterns inside **(ii)** Stefy**:** the carapace, we must not sit on it, not rub rocks on it, because they get hurt, it's not because it is hard that we can sit on it. The lady told us that this is fragile for the tortoise"	First time New Knowledge/discovery
Male tortoise	**(i)** Anna**:** I think it's the **biggest** male tortoise. It's the dominant male (ii) Joana: **Male** Tortoise Interviewer: Why is it interesting? Joana: Like I told you before they **eat fruits and spread the seed around. Yes and it helps the plants** etc	Size, Sex differentiation Ecological role
Female Tortoise	**(i)** Interviewer: this one also is a tortoise? Joana: the one we saw before was **a male** it was called big daddy, this **one is a female** that was resting	Sex differentiation
Tortoise	**(i)** Selvina**:** this is Big Daddy. It comes from Seychelles, it is still young even if it's the **oldest** and it can live up to **200 years,** tortoises are used on IAA to **keep the environment clean and protect nature**" (ii) Shreena: Tortoise! Big Daddy, is the oldest on IAA, if I am not mistaken he is **100 year**s or something, I forgot. I **never thought** a tortoise can live till this age but. It's found that a tortoise has got a long life and can live long" **(iv)** Interviewer**:** why did you put this as your favourite photo? Stefy: I found it **beautiful** **(v) Felix**: this one also the **first time** I saw that **size**. This one also the feet is **big** and the carapace was bumpy	Lifespan Number Ecological role Lifespan, Numbers New discovery Beauty First time, Size

5.3.4 Results from the analysis of photo-elicitation

In Table 5.2 below I provide a summary of the codes that co-occurred with each category of exhibits and further explanation about students' description around each category of codes.

Table 5.2: Co-occurrence of codes with each category of exhibits

Category under which photographs were grouped	**Number of photos submitted in this category**	**Number of students who submitted in this category**	**How students described the photographs**	**Codes that co-occurred with this category**
TORTOISE	17	9	'male tortoise', 'female tortoise', 'tortoise', 'baby tortoise', 'carapace'	'size/numbers','new knowledge/discovery', 'beauty', 'sex differentiation', 'ecological role', 'lifespan'
EXTINCT ANIMALS	17	9	'dodo','extinct giant skink','extinct hen','extinct parakeet', 'owl', 'extinct bat'	'big', 'empathy', 'extinction', 'habitats', 'new knowledge/ discovery', 'size/numbers'
BEAUTY	14	7	'extinct animals are beautiful', 'the tree is beautiful'	'beauty', 'red veins', 'extinct animals'
TREES	13	7	'trees'	'beauty', 'smell','red veins', 'new knowledge'
BATS/SKINK	10	7	'bat, 'skink', 'lizard'	'big', 'empathy', 'extinction', 'habitats', 'new knowledge/ discovery', 'size/numbers', 'surprise', 'camouflage'
ENDEMIC BIRDS	7	6	'pink pigeon', 'Fody'	'first time', 'new knowledge', 'seeing in reality ' 'beautiful'
NURSERY	6	5	'potted plants in the nursery', 'nursery'	'beauty', 'smell', 'red veins', 'new knowledge'
ISLAND FORMATION	4	3	'rocks','coral rocks'	'new discovery'
SMELL	3	3	'I am smelling'	'body experience'
CANNON	1	1	'cannon'	'new knowledge'
FRIENDS	1	1	'my friend and I'	'enjoy'
Total number of photographs	93			

Tortoise

As illustrated from the extracts of photo-elicitation as shown in Table 5.1 above, some students demonstrated the ability to recall specific information related to biodiversity for example about the lifespan, ecological role of tortoises, sex differentiation among tortoises and importance of the carapace. Such information appears to be impressive and new to students. Thus, 'size/numbers', 'beauty ', 'new knowledge/discovery' seem to trigger interest for tortoises among participants.

Extinct animals

A total of 17 photographs representing models of extinct animals was collected from all nine students. All bronze models anchored amidst the vegetation as well as the bronze model of the blue pigeon, the extinct bat and the parakeet found in the museum were represented. The popularity of the photos was as follows: giant skink (5), owl (4) and dodo (3), parakeet (2) and bats (1) and blue pigeon (1 each). The analysis process for extinct animals is in Appendix 9.

All the students described that the animals in the photographs were extinct. Some of them even linked extinction with habitat destruction and invasive species such as rats introduced through human colonization. The codes related to size/numbers and novelty aspects resurfaced especially while discussing the extinct parakeet of Mauritius which was comparatively bigger than the parakeets that students may have seen. Furthermore, empathy was noted among participants who found it unfortunate that these animals went extinct. The co-occurring codes were: big, empathy, extinction, habitats, new knowledge/ discovery, size/numbers.

Trees and nursery

As exemplified by the interview extracts below, students produced photographs which they described as 'trees' and largely associated with 'red veins', illustrating a recall of the phenomenon of heterophylly described during the tour.

Alex: "This is a plant with red veins. The red veins for predators not to eat them"

Interviewer: "Who were the predators?"

Alex: "Tortoise" (Post int: Alex, line 76)

The 'red veins' was clearly linked with the tortoises demonstrating that those students understood how plants developed a defensive mechanism to protect against their predators-the tortoises. Furthermore, the student, Selvina erased her misconception that the ebony was extinct from Mauritius and she associated the plant with its past exploitation by colonisers as shown in the extract below.

Interviewer: "What is it?"

Selvina: "Ebony Tree. Outside it is white and inside it is black. I thought it was already extinct but it is still found on IAA. The Dutch used it to make a piano, piano keys and their own furniture."

Interviewer: "Is it found only on IAA?"

*Selvina: "On Round Island also at Black River" (*Post int: Selvina, line 122)

Nursery photographs represented the hardening process of nursery plants before putting them into the soil by progressively providing more sunlight and water, which students explained in their own words. Again students showed an understanding or awareness of conservation practices thereby indicating signs of knowledge acquisition. I further discuss what students learnt in Chapter 6.

Tom, Stefy and Joana provided photographs associated with the smell of leaves and scented flowers and they found that interesting, illustrating how the act of smelling things became a memorable experience for them. 'Beauty' was another commonly occurring code since students reported finding the trees such as the Banyan and the Pandanus beautiful with long hanging roots and their prop roots above the soil respectively. Thus investigating why photographs under the category tree and nursery were selected, the most common emerging codes were 'beauty', 'smell' and 'red veins', 'new knowledge' which are linked to impressive information that students learnt about the exhibits.

Bats/Skink and Endemic birds

Photos submitted in this category represented pink pigeons, the Mauritius fody , the Telfair Skink and the Mauritius fruit bats. The most frequently co-occurring codes for these were 'first time', 'new knowledge', 'seeing in reality ' and 'beautiful' especially the pink pigeon. The code 'surprise' and 'camouflage' were recorded at the sight of the Telfair Skink. Students also reported the colour change in the plumage of the male Mauritius fody during mating season. Students said they were impressed by this information as they never thought that birds could change their plumage colours or that "*bats could see both at night and during the day*". Thus, the reason for the choice of these photographs was 'they learned something new' especially regarding the sex differentiation in Mauritius fody , their mating season and camouflage. Furthermore, the fact that students were encountering these animals in the wild for the first time, gave them a heightened emotional state of satisfaction to see the animals in real life compared to abstract textbook illustrations. Therefore novelty was associated with the emotional arousal of experiencing biodiversity in its authentic context.

Beauty

As per phase one of the 'interpretive engagement framework', the photos were coded according to the words of students. 'Beauty' was recurrently used to describe exhibits, trees and landscapes. Out of the nine participants, seven provided a photo that represented 'beauty' according to them. The most common photos of 'beauty' were of the landscape, a photo composition of the blue sea and the green vegetation sometimes with a boat. Furthermore, Felix described the beauty of the extinct endemic birds, the extinct red rail and the blue pigeon while

Anna provided photos of some trees along the main path which according to her represented the beauty of nature. Thus, students' SI seemed to be triggered by the 'beauty' aspect.

From the analysis of the photo-elicitation from the perspective of the students, the following emerging codes were regrouped into the main themes according to similarities as shown in Table 5.3.

Table 5.3: Grouping of categories into themes

	Codes/categories	**Main theme**	**The reasoning for grouping of codes/categories into the theme**
1	Size, Number	Size/Number	Regrouping size/numbers together
2	First time, reality, new discovery, new knowledge	Novelty	Related to new encounters
3	Predation, ecological role, lifespan, sex differentiation, conservation practices	Impressive information	The information impressed participants and is linked to the new knowledge gained.
4	Beauty	Beauty	When students speak about beautiful things
5	Empathy, surprise	Strong emotions	Relates to emotional arousal

5.4 Stage 2: Meaning-making through the researcher's perspective - Analysing auto-photographs and interview transcripts

Drew and Guillemin (2014) propose a series of potential questions that a researcher may address while analysing how the image/photograph conveys meaning. These are: what is being shown, the components of the image, the arrangement of the photos, the vantage point, where is the viewers' eye drawn in the image, different components of the image, colours, etc. Though my research is about understanding the 'lived' experience of the students, it is not concerned with identity formation, culture and psychology research. Therefore concepts like vantage point and use of colours were not relevant. I was also not concerned with the arrangement of the photos since students just selected any 10 photographs in no particular order such that there was no ranking of the most preferred photos among the 10. At this stage of analysis, photo-elicitation was not required. I considered all 113 photographs provided by the 11 students.Thus, as the researcher, I decided to examine the photographs and ask myself the following pertinent questions (i) what is shown and not shown in the images (ii) what does the photographer want the viewer to focus on (iii) are there photos that are commonly taken by all students (iv) what relationships do students make with the image?

5.4.1 What do the photographs show?

A total of 113 photographs collected from 11 students were examined from the researcher's perspective. Photo-elicitation was not considered at this stage since the analysis consisted of how I interprete the photographs from the researcher's perspective. Apart from the photographs that represented landscapes, all other photos (92%) showed that the photographer wanted to capture one specific aspect or object for example a photo of an extinct animal, or a bird or a tree or pots in the nursery such that a central image was presented to the viewer. This was confirmed during the photo-elicitation exercise during which students talked only about the central image. Therefore, guided by the question 'what is the image showing', all 113 photos were coded according to the central object in the photograph. In Appendix 10, I present the details of how auto-photographs were coded and regrouped into categories. I also explain the logic of my coding relying on my field observation notes especially the stopping points and the guide's elocution.

From the categorisation of photos from my perspective as a researcher, it was found that 'extinct animals', 'conservation effort' were highly popular with 24 photographs in each category. Once again the category 'tortoise' was highest in number (16) even if the extinct saddle-back tortoise (long-necked tortoise) was not included in the category 'tortoise'. As the researcher, I find that the saddle-back tortoise is an extinct animal and is better grouped under 'extinction'. 'Endemic plants' and 'endemic animals' had 21 photos in each category. Informed by my readings of literature, my perspective as the researcher revealed the additional category 'seductive details' (comprising of 8 photographs), described as aspects of the guided tour not directly related to the content of the visit but that contributed to the overall experience of the students (Schraw and Lehman, 2001). Furthermore, my examination of the photographs, as the researcher, did not reveal the category 'beauty' as described by students in the above section. Only one student submitted a selfie with her friend and nobody submitted a photograph with the guide. This logic of analysis enabled a comparison between the offerings of IAA and how students make meaning out of the content. The results were similar to those obtained while analysing from the participants' perspective in terms of the most and least popular photographs as shown in Appendix 10:

(i) 'conservation practices' which includes nursery and tortoises (21%). Aldabra tortoises were included in this category since they act as analogue species on IAA, fulfilling the role of the extinct tortoise of Mauritius.

(ii) extinct animals include bronze models of animals encountered along the trail and in the museum (21%). The category includes the extinct saddle-back tortoise of Mauritius which students described as 'long-necked' tortoise

(iii) endemic birds/animals which include bats, skinks, pink pigeons and Mauritius fody -(19%)

(iv) endemic plants which are not in the nursery, meaning they were found along the trail- (19%)

(v) Seductive details (Schraw & Lehman, 2001) which are photographs not directly related to the stopping points and exhibits of the guided tour such as landscapes, mountains, a picture of IAA from the mainland, etc

(vi) Friends – representing photos of students (1%)

(viii) Cannon – photographs of the cannon on IAA (1%)

5.4.2 Photographs commonly captured by all students?

An investigation of how each student chose photos was the next step in the analysis to determine if certain categories of photos were common among all students as shown in Figure 5.4.

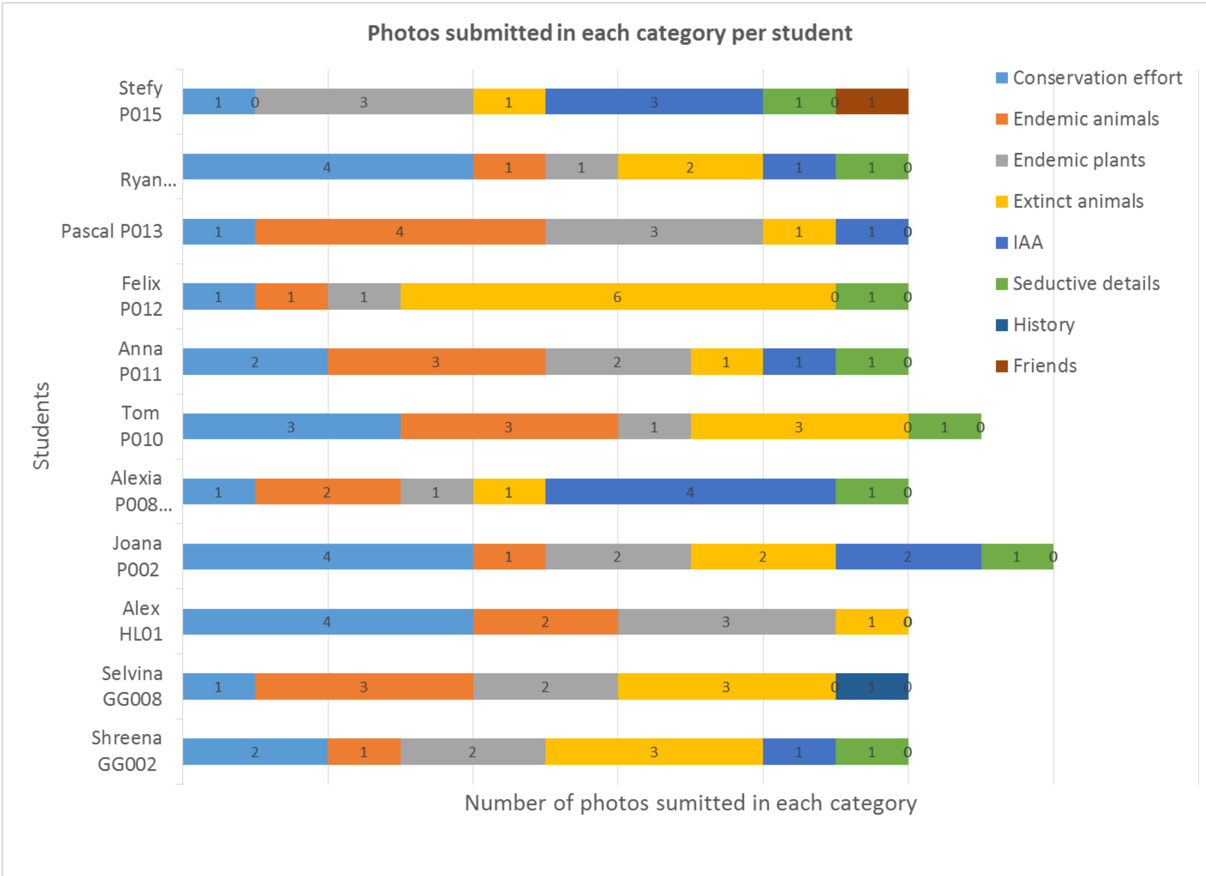


Figure 5.4: How individual students submitted photographs categorized from the researcher's perspective

All students submitted a photo of a tortoise and at least one photo representing 'conservation effort', 'endemic plants' and extinct animals. All students except Stefy provided a photo of an endemic animal. Seven out of 11 students who submitted photos were captivated by 'seductive details' that are aspects of the visit that caught their attention but not directly related to the content of the visit. These results support the findings of the analysis from the participants' perspective in terms of the categories of exhibits that were most successful at captivating the attention of students.

The photos were grouped into eight categories in all and each participant submitted photos present into four, five or six categories. Some students were more likely to be attracted to specific aspects of the tour for example Ryan was more inclined towards conservation effort (tortoises), Pascal towards 'endemic animals' and Owen towards IAA and its formation, with each student choosing four photos in the respective categories. The information indicates that students' personal preferences influenced their choice of photos related to the content of the guided tour. This illustrates how the personal context of a visitor affects the visit experience (Falk & Dierking, 2013).

5.4.3 Analysis of semi-structured interviews to investigate interest

As part of stage 2 of the interpretive engagement framework, the interviews can be integrated into the analysis (Drew & Guillemin, 2014). This is opportune for me to report on the analysis of the semi-structured interviews conducted before the photo-elicitation exercise. The data consisted of post-interview transcripts of 13 participants considering the five questions that were meant to investigate interest as described in the methodology Chapter and in Appendix 7. The questions focused on 'what students liked about the visit, how they would describe it to other people and what they remembered about the visit. A full description of the results of this analysis is provided in Appendix 11.

Based on the five interview questions meant to investigate interest, the emerging themes which appear to be sources of SI were:

Strong emotions – The guided tour instilled strong emotion among students who used words like 'incredible', 'pleasurable', 'agreeably surprised' and 'interesting' to describe their visit.

Impressive Information– students recalled several terms or concepts related to ecology and biodiversity that they claimed to have been influential in their visit experience: for example, the sex differentiation among the Mauritius fody and its mating behaviour, the Telfair skink is well camouflaged, the tortoise dung contributes to fertilise the soil, the red veins of plants is to deter predators. Biodiversity terms grouped aspects like IAA is the habitat to rare plants and animals which are protected. Since this information seemed to have impressed students they were themed under 'impressive information'.

Novelty- Students described their visit experience as ' a new discovery ' or they liked the visit because they 'learned new things ', or saw some animals/plants for the first time. The novelty aspect of the experience contributed to their SI since they all visited the place for the first time.

Size/numbers – Students seemed to be impressed by large sizes especially of the tortoise but also of extinct endemic birds such as the parakeet.

Body experiences – Students enjoyed, recalled or seemed in a heightened emotional state when they smelled flowers/leaves and stepped on rocks and roots.

Social aspects – Some students mentioned that they liked how the guide explained or rubbed the tortoise neck.

Seductive details – this is when students mentioned about enjoying the boat ride or when they enjoyed the beautiful landscapes.

The content of the guided tour/exhibits – It might seem logical that students were interested in the content of the guided tour. However, the semi-structured interviews conducted independently of the analysis of the photographs submitted revealed that out of all the stopping points that were presented to students by the guide, the participants' attention was geared towards the following aspects: tortoise, endemic animals, endemic plants, extinct species, the whole of IAA, its formation, and its specificity as a nature reserve attraction. Seemingly these specific exhibits should possess certain attributes such that students' attention was geared towards them. Therefore I considered the attributes of the exhibits that caught the attention of students as a means to identify the triggers of SI.

5.4.4 Analysing semi-structured interviews and photo-elicitation transcripts: the attributes of the most popular exhibits

Analysing the photographs both from the participant's perspective and from the researchers' perspective show that certain exhibits were most popular among students. The exhibits are tortoises, extinct animals, endemic birds/animals, endemic plants and nursery. As a triangulation process, I analysed the photo-elicitation and all post-visit interview transcripts in parallel to decode why students found these exhibits most attractive. The co-occurrence function in Atlas TI was used to identify the factors of SI that are associated with each of these exhibits. In Appendix 10.12, I present the co-occurring codes for the exhibits analysed.

Tortoises

During the semi-structured interviews, all 13 students showed a clear interest in the tortoises. Some students were impressed with the information received about tortoises recalling significant details. For example, Owen talked about the dates inscribed on the carapace of the tortoises while Alex remembered: *"… the giant tortoise, there were a male and a female when I touched, it was… the surface was different, for the female it was more smooth"*. The fact that Alex touched the carapace, reveals that her hands-on experience permitted her to remember. Felix seemingly impressed by the size of the tortoise told his parents that he encountered a *"Big tortoise which was a male"*. Other students could recall and retell richer information illustrating how they remembered the exact words of the guide, as shown in the extract below.

> *Interviewer: "Ok, Did you enjoy your visit, did you have fun?"*
>
> *Selvina: "yes"*
>
> *Interviewer: "explain to me"*
>
> *Selvina: "There were many things I did not know about IAA for example tortoise comes from Seychelles. The Mauritius Tortoise is extinct for a long time... And for the tortoises to lay eggs they made an artificial pond, and that IAA was formed from corals"* (Post int: Selvina, line 11)

Selvina learned something new about the extinct endemic tortoise of Mauritius which she distinguished from the introduced Aldabra Tortoises from Seychelles. She remembered the artificial pond such that the knowledge and the information she obtained about tortoises contributed to her experience of enjoying her visit. Another student, Shreena recalled the relationship between the tortoises and the plants having red veins which deter tortoises from grazing on them. These participants captured and submitted photographs of tortoises.

In stage 1 of the analysis (section 5.4), it was found that students were attracted to tortoises because of their large sizes and because they acquired new knowledge or made new discoveries revealing that the novelty aspect caught interest. This novelty aspect is linked to the impressive and new information students received during the tour. This is supported by the fact that they could recall and describe ecology-related concepts such as carapace, dissemination, the ecological role of tortoises, sex differentiation, lifespan and predation. Students' SI, directed towards the tortoises, seems to have been triggered by the size/numbers, novelty and impressiveness of the information gained about the tortoise which is intricately linked to the ecological concepts or learning new things.

Extinct animals

It was found that encountering life-size models of the extinct animals contributed to a positive visit experience, for example, Kelly describes how her interest was captivated when she learnt about the previous existence of the blue pigeon:

> *Interviewer: "Can you describe your visit in one word or few short words?"*
> *Kelly: "The visit is interesting, we learnt new things. Before I didn't know that the Blue Pigeon existed, It used to exist because now it is no longer here, it's a pity! Otherwise, it went well".* (Post int: Kelly, line 4)

During the interviews and photo-elicitation, students could provide more details about the dodo which went extinct due to the activities of the Dutch on the island and invasive species. While talking about the saddle-back tortoise, students made reference to the growth of the neck to reach out to leaves higher up in trees. Some also spoke about the 'owl' which Selvina thought "*existed only in comics*!" She claimed to be sad not to see able to see it again. Thus, students displayed empathy towards extinction, were impressed by the large size of extinct animals and enjoyed the new learning about the existence of these species. It is to be highlighted that the theme 'novelty' was associated with all extinct animals except the dodo which is iconic to Mauritius indicating that students were already familiar with the dodo.

Endemic bird/animals

The other themes that encompassed a large number of photographs were 'endemic birds/animals' including the representation of the pink pigeon, the Mauritius fody , the Telfair skink and the Mauritius Fruit bat in the cage. Stefy was the only student who did not provide a photograph of an endemic animal.

The reason for students' choice of photographs of endemic animals and birds as discussed in stage 1 of the analysis was because these animals were novel for students. Some participants reached a heightened emotional state to see the animals *de visu* since their knowledge of the animals was restricted to what they saw in books and on TV. The sudden and unexpected encounter with the Telfair skink in the wild produced surprise among students. Felix, who submitted a photograph of the Telfair skink, was particularly captivated and wanted to do some research on the internet about the animals indicating a sign of SI that motivated the desire to learn more. Another student marvelled at the beautiful colours of the two birds as illustrated below:

Pascal: "I will never forget the Cardinal and the pink pigeon which is a 3-coloured bird, brown, white and pink"

Interviewer: "ok, what made you get interested in the pink pigeon?"

Pascal: "it was beautiful" (Post int: Pascal, line 32)

Thus, the themes that emerged from the coding of semi-structured interviews together with photo-elicitation were: novelty, strong emotions of wonder and surprise, beauty, learning about ecology and biodiversity-related terms, and to a lesser extent body experience.

Endemic plants

All photographs of endemic plants were close-ups focusing on one specific plant except for a photo representing the landscapes. Therefore, participants' attention was concentrated on one plant while taking the picture. As shown in Appendix 10, the photographs represented 11 different endemic plants or their fruits indicating a relatively wide range of plants that students noticed and found interesting. Five students produced a photograph of the fenced 'Bois de catafaille' plant about 50 cm tall with small red-veined leaves about 1cm in length and thorns. Two main elements emerged from the photo-elicitation for the choice of 'Bois de catafaille': the fact that it had small leaves and that the leaves had red veins even if students did not mention the word 'heterophylly'. Nevertheless, they could clearly describe that smaller plants had red veins to deter the tortoises from eating them and that the red veins disappear in leaves found higher up on the tree indicating a connection with new knowledge gained and the triggering of interest. Learning about the phenomenon of heterophylly was new and impressive for students.

During the semi-structured interviews students related how seeing and learning about the endemic plants contributed to making their visit enjoyable as described by Anna below. The information was mainly impressive and new to them or they could link with what is familiar:

Interviewer: "Did you have fun or enjoyed yourself during your visit?"

Anna: "yes. … I learnt more about Mauritius and its endemic plants. I understood the functioning of plants for example the way the 'Pied la fourche' (Ficus spp) when its roots grow from top to downwards another tree grows. I liked the Ebony Tree, the outside is brownish and the heart inside is black. I understood how to differentiate a male from a female!"(Post int: Anna, line 13)

Shreena provided a photo of the ebony trunk and claimed to have liked the information associated with the history of ebony exploitation, familiar to her. She further referred to endemic plants during the semi-structured interview when asked to describe her visit:

Interviewer: "Ok Can you tell me something or an anecdote that occurred during your visit that you think you will never forget in your whole life?"

Shreena (smiling): "Many things! When the guide told us about the Blue Latanier .I looked at it and I told her the Latanier is not blue in colour. She explained that when it rains, the leaves get a blue reflection and when it is small it is completely blue. There are many plants when they are small the leaves are of one type of shape with a small red vein. When it grows taller, the shapes changes and it loses its red vein, I never thought this exists!"
Interviewer: "Anything else?"
Shreena: "like Bois de Rats also, she said the flowers smell very very good, and can perfume the whole island but if I pluck the leaves, keep in our hand, it smells bad like dead rats!!" (Post int: Shreena, line 42)

This student was particularly impressed by the information, vividly describing the trees and the experiences that she had while seeing these trees or hearing the guide tell a short story about each plant. Just like Shreena, other students were also amazed by the smell of the leaves and flowers, for example, Stefy provided a picture where she is smelling an orchid. The act of smelling consisted of a body experience that contributed to SI. The codes that co-occurred with endemic plants were a novelty, body experience, ecology terms linked to impressive information and biodiversity and beauty.

Nursery

Nursery photos consisted of potted seedlings arranged next to the seeds on the table as well as potted plants undergoing a hardening process under black nets. The guide explained heterophylly and plant propagation. Interestingly during the semi-structured interview, only one student Kelly (who did not submit photos) talked about the nursery among aspects of the trip that she liked the most since she was able to see how the '*big trees outside were when they were younger* '. She even talked to her parents about the nursery. The other students talked about the nursery only during the photo-elicitation because of the new knowledge/information that they gained, for example, Anna and Joana talked about hardening; "*Anna: it's how they adapt the plants to our environment. Gradually they give more sunlight and less water for the plants to adapt to the environment*". Alex found the nursery interesting because she learnt something new: "*I did not know that all these exists there are many types of plants*". The most frequently occurring codes were a novelty and learning about conservation.

A summary of the main codes that were identified as potential triggers of interest based on interviews and photo-elicitation is provided in Figure 5.5 below. The links illustrate how each group of exhibits triggered SI. Thus, novelty, beauty, size and numbers strong emotions as well as impressive information related to the exhibits could be important triggers of SI. The Figure also shows that the triggers of interest do not operate in isolation but appear to be linked. A particular exhibit or aspect of the tour for example extinct animals may trigger SI for different reasons, for example, novelty, size and strong emotions. The linkage among these situational factors is further investigated in subsequent sections.

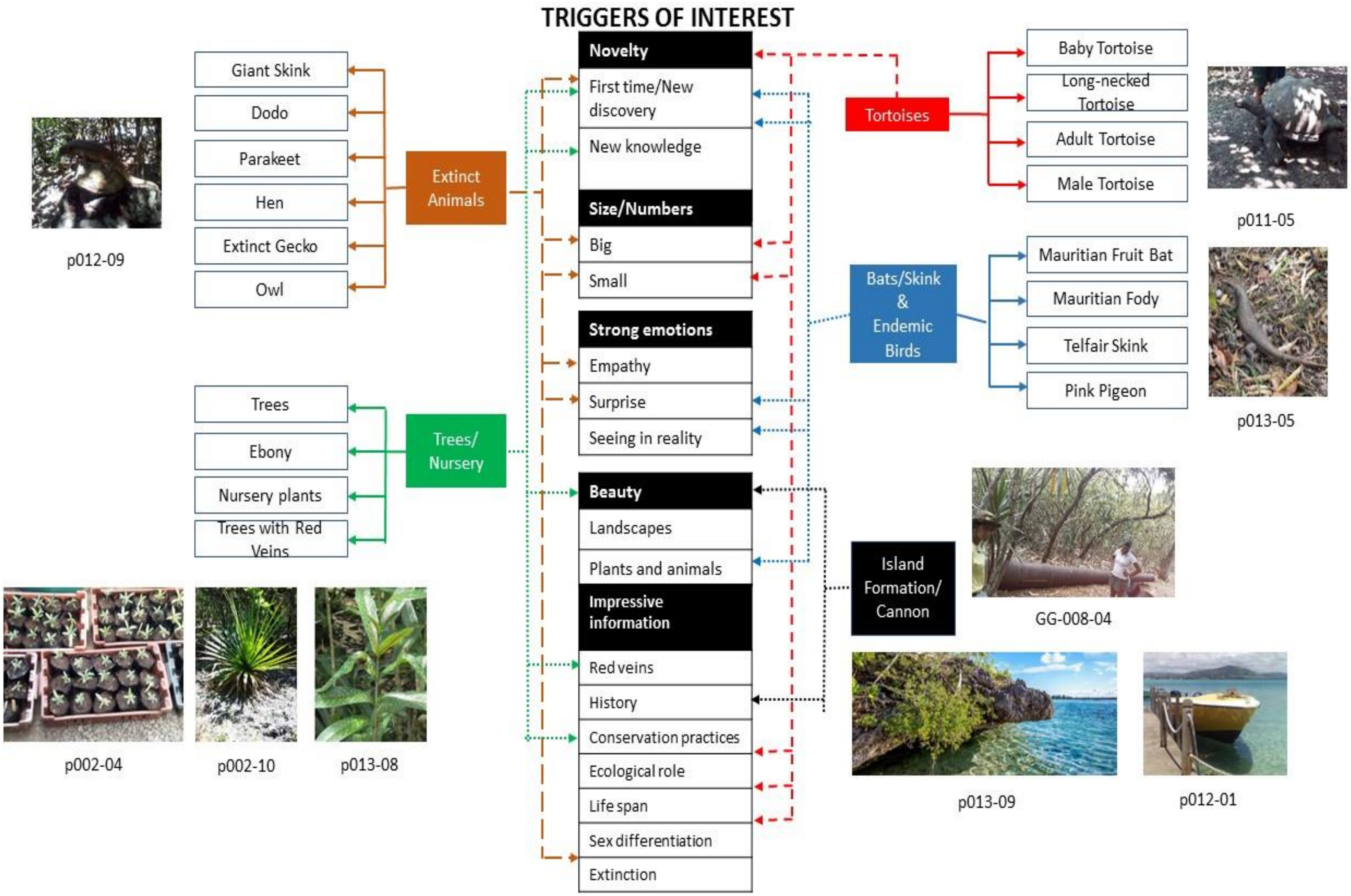


Figure 5.5: Derivation of triggers of interest from photo-elicitation and interviews about the most popular exhibits

5.5 Stage 3 of the interpretative engagement framework: re-contextualising data to identify the triggers of situational interest

So far I analysed the data using stage 1 (from the participants' perspective) and stage 2 (from the researchers' perspective) of the interpretive engagement framework. It was found that certain aspects of the guided tour or exhibits were more successful at capturing the attention of participants. Each 'exhibit' possessed inherent qualities that captured attention, triggered interest or contributed to enhancing the visitors' experience for a variety of reasons. The emerging themes from the analysis of auto-photographs, interviews and photo-elicitation could be important triggers of SI. These are novelty, impressive information, strong emotions, beauty and size/numbers, all being intricately linked and this is investigated further. In Figure 5.6 below, I present a schema of the analysis process and the derivative findings which I take on board for the next step of the analysis using the interpretive engagement framework: stage 3: re-contextualisation of the data.

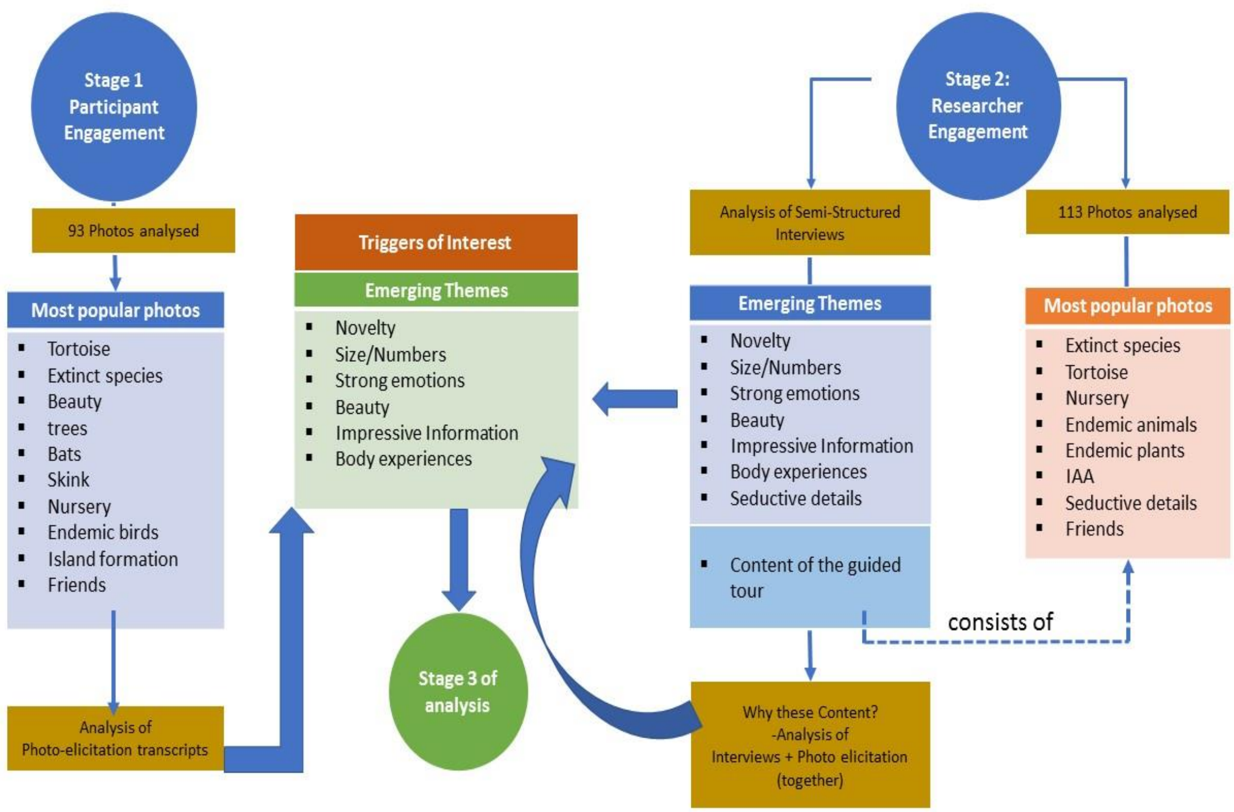


Figure 5.6: The process of data analysis using stage 1 and stage 2 of the interpretive engagement framework and emerging themes as potential triggers of interest based on the coding of interviews, photo-elicitation and photographs.

The third stage of the interpretive engagement framework relates to meaning-making through re-contextualisation using the same data as in Stage 2 and the data is interpreted in light of the theoretical framework governing the research (Drew & Guillemin, 2014). Hence, I use the Contextual Model of Learning (CML) as well as the Four-Phase Model of Interest Development (FPMID) to situate the data.

5.5.1 The interrelationship between the triggers of interest.

In the next step in the analysis, I attempted to find how the triggers of interest related to one another. To achieve this, I consider the data from the photo-elicitation and the post-visit semi-structured interviews.

Table 5.4 summarises the main themes that emerged from the coding process in stage 1 and 2 and how each theme is associated with the photographs of exhibits such as tortoises, extinct animals, endemic animals and endemic plants.

Table 5.4: Summary of main themes that emerged from the interviews and their co-occurrences with the most popular photographs

Exhibits	**Tortoises**	**Extinct animals**	**Endemic plants**	**Endemic animals**
Most frequently co-occurring themes associated with the exhibits	**Novelty** Size/numbers Biodiversity terms Emotions Endemic plants (red veins) Beauty conservation	**Novelty** Size/numbers Emotions(empathy) Beauty Extinction Ecology terms	**Novelty** Biodiversity terms rare Beauty Body experience	**Novelty** Biodiversity terms Emotions

From

Table 5.4 it can be seen that the most frequent theme that cuts across the interviews for all the exhibits is novelty. Furthermore, an exhibit was associated with several factors that trigger SI such that these situational factors do not occur alone but appear linked to each other. Using the network function in Atlas TI, I developed a schematic representation of the relationship between the codes and themes that emerged from the interviews, photo-elicitation and auto-photographs. A diagrammatic representation of the relationship among the triggers of interest is shown in Figure 5.7. A more detailed diagram with the codes which have been generated in Atlas TI is found in Appendix 10.13.

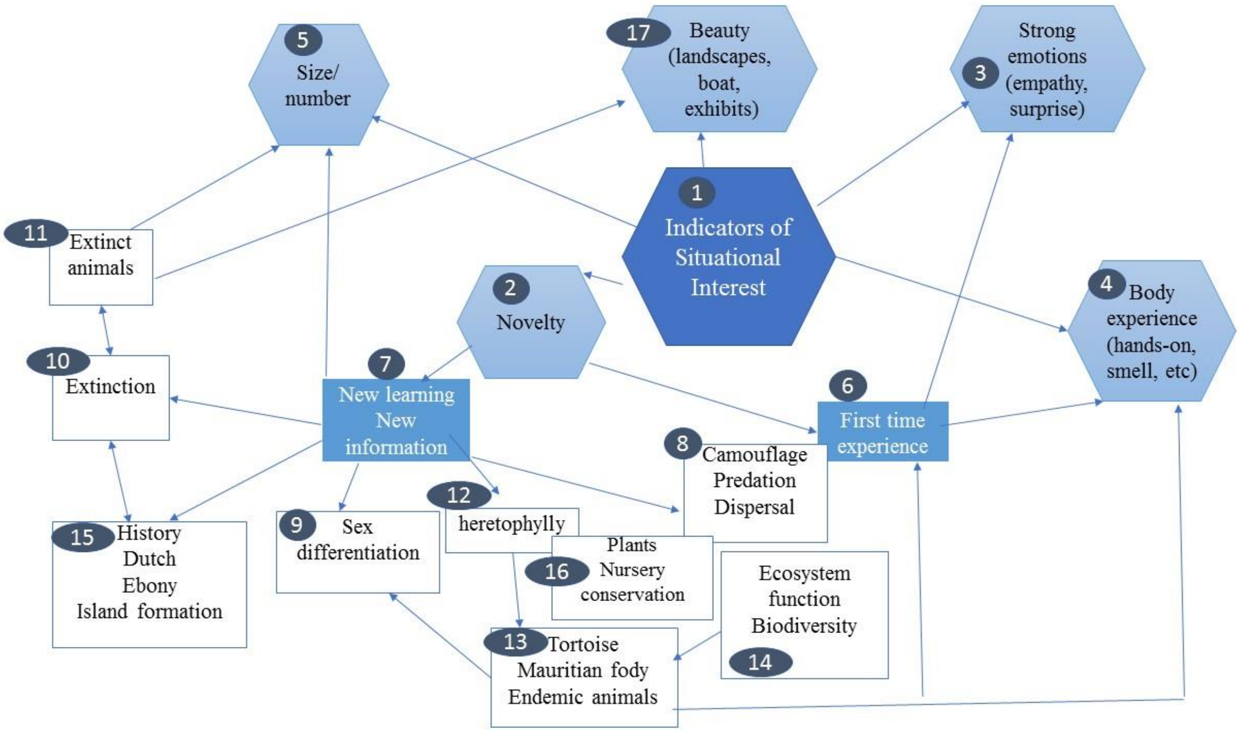


Figure 5.7: Schematic representation of the relationship between the triggers of situational interest

The schematic representation of the relationship between triggers of interest as per Figure 5.7 is explained below:

1. Central to the network are the triggers of situational interest that occurred during the visit and were termed as 'Indicators of Situational Interest'. Five indicators of SI were directly linked: novelty (2), strong emotions (3), body experience (4), size/numbers (5), beauty (17) and ecology/biodiversity terms (8 to 16).

2. Novelty is an interest indicator and has two main components: firstly, a knowledge-based component which is linked to information obtained during the guided tour and has been coded as 'new knowledge' and 'new discovery' (7). Secondly, an experience-based component which is linked to the feeling of visiting IAA for the first time or encountering exhibits as a new experience (6).

3. Strong emotions were experienced by participants when encountering the exhibits on the tour such as surprise, empathy, the feeling of interest and feeling it was incredible, for example seeing the pink pigeon in real life. The students had always heard about it but never seen *de visu*.

4. Body experience – all experiences that engaged the students' senses during the visit such as smelling leaves or flowers, walking on roots and touching tortoises' carapace or rocks.

5. Size/numbers – this was a frequently occurring theme whereby students described being impressed by the large sizes or remembered numbers such as the age of the tortoise (105years) or that they are translocated after five years. Students were also impressed by the large size of the extinct animals on display (11) which was new to them.

6. New experience of the visit is an aspect of Novelty. All students went to IAA for the first time, for some, the boat ride experience was a first. Students also spoke about seeing certain plants, animals and extinct species for the first time and this contributed to instil a special feeling and hence capture their interest.

7. New learning and discovery was part of the 'novelty' and was intricately linked to the content of the guided tour. These include endemic animals and plants, extinct species, history of IAA and the nursery. These codes co-occurred with the following ecology and biodiversity terms which seem impressive to the participants. They were regrouped under a main theme 'impressive information' detailed at 8 to 16.

8. Terms such as camouflage which were associated with the 'Telfair skink', dissemination of fruits and dispersal of seeds by the birds and the tortoise, habitats of plants and animals, and conservation practices in the nursery (16) where plants undergo a process of hardening before translocation. During interviews, students talked about sex differentiation (9) in tortoises and the Mauritius fody , an endemic bird which, during the mating season the male changes colour from a dull brown to reddish-orange coloured plumage on the head and breast. This kind of information was new and impressive to students.

10. Extinction – The students' interests were captured by extinct animals which they recognized as being 'extinct' and that a few students linked to their extinction caused by invasive species such as rats and shrews.

11. The extinct species (11) stood out due to their unique large sizes encountered by participants for the first time, something that surprised and impressed them. Extinct species were linked to strong emotions as students demonstrated empathy to extinction (not shown in the diagram).

12. Heterophylly was coded for when students mentioned being intrigued by the plants that had 'red veins' during the seedling stage as a deterrent to their predators (8), the tortoises (13). Students did not expect that veins of plants changed colours as they grew or that tortoises could have a long neck to reach out to leaves higher up on plants.

13. The most popular photographs were of the tortoises and students recalled detailed information about these animals during the interviews both as something that impressed them and something that they learned about a lot. They talked about the 'carapace' being sensitive and large and used to distinguish males from females as well as the association of tortoises with heterophylly.

14. A few students recognized the importance of tortoises, animals in general, bats and plants for proper ecosystem function and this was linked to learning about biodiversity.

15. Photographs representing historical aspects of IAA are few, however, students made the connection during interviews especially regarding the overexploitation of 'ebony' during the Dutch period and the formation of IAA as originating from corals rather than of volcanic origin.

17. Beauty - analysing photographs from students' perspective revealed that the reason for their choice of photographs was because the exhibit (plants, animals) were beautiful. Moreover, they were also intrigued by the beautiful landscapes representing the sea and the lush green vegetation which form part of the seductive details of the trip. Thus, students got an aesthetic experience of the visit which contributed to triggering their interest.

From the schematic representation of the triggers of interest and how the codes co-occurred (Figures 5.5 and 5.6), I refined the themes for the triggers of interest as novelty, body experience, first time experience, strong emotions, size/numbers, impressive information (encompassing ecology and biodiversity concepts) and aesthetic experience which reflects the two main components of interest discussed in the literature: the cognitive component and the affective component (Hidi & Renninger, 2006) which are intricately linked. Thus, I produced Figure 5.8 as a model illustrating the dynamics of the interaction among the triggers of interest.

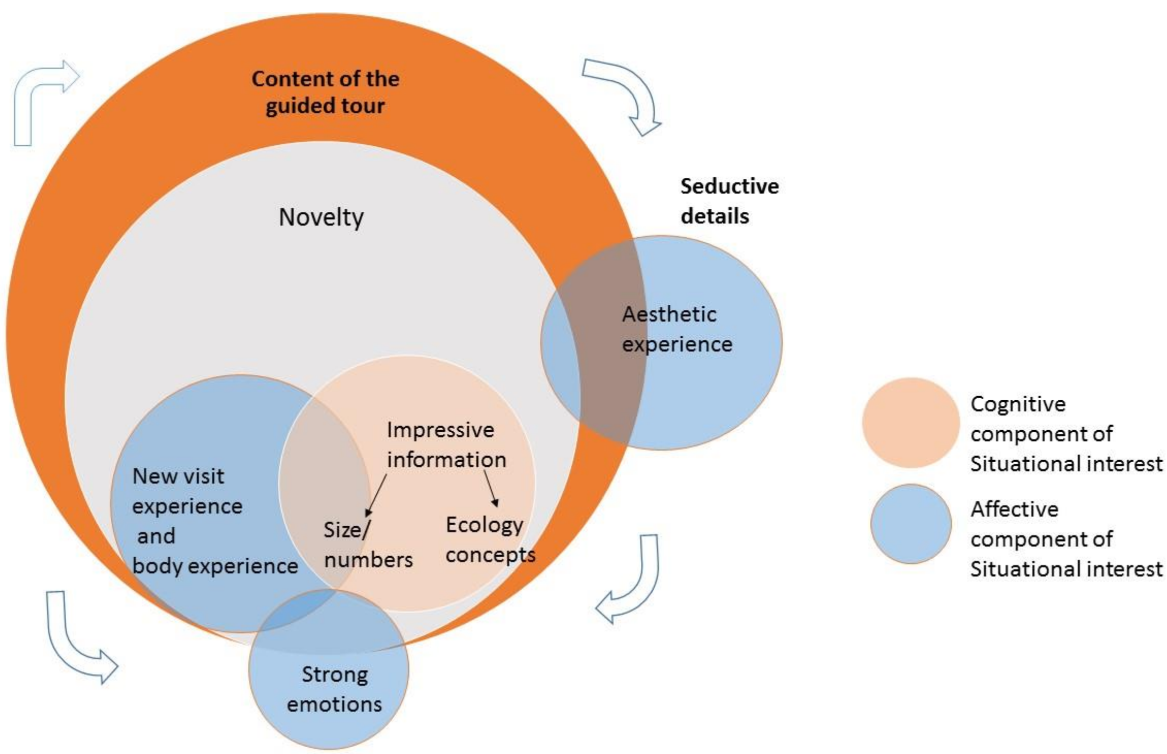


Figure 5.8: Model for the interaction of different triggers of interest: novelty, new visit experience, body experience, impressive information, size/numbers, an aesthetic experience which has a blend of affective and cognitive components of situational interest.

Figure 5.8 can be described as follows: All students visited IAA for the first time. Novelty as a trigger of interest acts as an umbrella housing all the other triggers since body experience, the experience of visiting a new place, being impressed by size/numbers as well as impressive information were all new to students. Body experience and the first time experience occurred because of encounters with exhibits but not necessarily due to the knowledge or information gained. For example, when describing the act of smelling flowers and leaves, students did not give further details about the plants. However, at some point, body experience was associated with the size/numbers as students were astounded by the large sizes of the tortoises and extinct animals and small sizes of leaves. Impressive information englobed all the ecology and biodiversity concepts that students talked about both because they could describe the meaning of these concepts but also because they enjoyed learning something new and impressive. Thus, impressive information forms part of the cognitive component of interest.

Students experienced strong emotions partially because they were surprised or met the unexpected but also for other reasons such as feeling empathy for extinct species encountered for the first time or finding the visit as an experience of discovery. The aesthetic experience being part of the affective component of interest was elicited by two main factors: firstly the exhibits which were part of the visit and secondly by seductive details not directly related to the content of the guided tour such as beautiful landscapes and the sea.

The factors that trigger SI were novelty, new visit experience, body experience, impressive information, size/numbers, aesthetic experience. Thus, when students visit the nature reserve for the first time, there is an interplay of several factors which act together to elicit SI and it seems that the novelty aspect is influential in this process. In the next section of this Chapter, I discuss the findings in light of the theoretical frameworks used in this research.

5.6 Discussion of findings

5.6.1 Has interest been triggered?

The objective of this Chapter was to identify the triggers of Situational Interest (SI) during the visit to the nature reserve. In so doing, the objects of interest were also identified in terms of the exhibits that influenced the visit experience of students the most. This was achieved mainly through the collection of auto-photographs captured by participants for this research; therefore the anticipated audience was the researcher. The choice of 10 photos that best illustrated their visit experience and that caught their interest is an indication that these photos represent the objects of interest of students. However, these 10 photographs among many others, may have been produced for a broader audience for example to show to other people or for the students' future reference for example Selvina, Shreena and Tom showed their photographs to their parents and siblings while Kelly talked about IAA to her friends at school. The fact that students were willing to share their experience with significant others confirms that SI was triggered during the visit. Re-visiting the photographs is a sign of re-engagement with the content of the visit and thus, Maintained Situational Interest (Hidi & Renninger, 2006). Therefore, requesting students to capture photographs during school visits to an informal learning setting for future reference might help students progress from the Triggered Situational Interest (TSI) to Maintained Situational Interest (MSI) and extend the learning experience beyond the visit.

5.6.2 The objects of interest

The Four-Phase Model of Interest Development (FPMID) posits that SI is predominantly influenced by situation-specific environmental stimuli (Hidi & Renninger, 2006). These stimuli trigger interest for a 'content' such that one's interest is always directed towards something such as an object or activity. This content specificity describes the relationship the person makes with the 'object of interest' which could be things, topics, subject matter or ideas (Krapp & Prenzel, 2011). Even if initially the study aimed at identifying triggers of interest for 'biodiversity' during the visit to the nature reserve as a whole, the use of auto-photography and photo-elicitation has enabled the identification of specific exhibits that best triggered interest among students. I, therefore, highlight the suitability of this visual method for research in informal learning settings. Furthermore, each of these exhibits become a different 'object of interest' which individually ignited interest due to their differing inherent qualities. The nature reserve is providing multiple objects of interest and multiple opportunities for triggering interest. For example, extinct species impress due to their large sizes and instilled empathy while endemic birds stood out due to their beauty and impressive information. Thus incorporating a variety of experiences and triggers of SI implies catering to the needs of different visitors with different personal preferences. This could be exploited by practitioners who offer guided tours.

The second triggering of SI directed towards a different exhibit but still within the context of the visit might represent an opportunity for the onset of the Maintained Situational Phase such that the switch from phase one (Triggered SI) towards phase 2 (Maintained SI). This might have occurred during the guided visit itself. Further discussion is in Chapter 8.

5.6.3 The physical, social and personal context

The Contextual Model of Learning (Falk & Dierking,2013) discusses the importance of the physical, social and personal context of an individual in shaping his/her museum experience (Falk & Dierking, 2013). The physical context of a museum visit comprises of 'architecture', orientation in physical space, design and objects/artefacts, ambience, orientation in physical space, design and exposure to exhibits and programmes amongst others. In the case of the current guided tour, the nature reserve itself, with its fauna and fauna and the bronze models of extinct species, is analogous to the architecture. The trail represents a sequential presentation of the exhibits and the orientation in the physical space while the encounters with various exhibits represent the exposure to the exhibits. From the photographs, it is evident that the physical context of the visit had a crucial role in influencing visitor experience. Each stopping point during the guided tour was represented among the photographs except inside the kiosk when the guide explained about conservation work through panels which seemingly did not succeed in captivating student's attention enough. This indicates the potential of the other exhibits in generating interest among students but 'just describing information' found on panels in the kiosk with students sitting on a bench in a classroom-like situation, was not captivating to students. Students neither produced photographs nor talked about the kiosk during the interviews.

Less evident but not less important in this research is the social context which describes how the participants' social interaction with others (friends, members of the group or docent) shapes the museum experience. Apart from one photograph of a student with her friend, illustrations or discussions about friends or other members of the Scout group were rare, indicating that the student's interest was not really sparked by friends. The fact that there were few opportunities for students to interact, talk and engage in group activities could explain this. Given the potential of peer to peer social involvement in triggering interest (Dohn, 2013), it might be a missed opportunity for Mauritian Wildlife Foundation to deliver more meaningful learning and interest stimulating experiences to participants.

Moreover, the guide was absent in the photographs presented but several students described having 'liked' the visit as "*the guide explains well and was interesting*". Apart from few labels in the museums, there are no explanatory labels on the exhibits in the wild, thereby emphasising how the guide's explanations were crucial in providing the correct impressive information to students that ignited their interest. This finding further justifies the need for well-trained rangers/ guides who are both knowledgeable about biodiversity content but who are also able to create suspense and surprise as a means to capture interest and prevent boredom.

The personal context of each participant comprising of prior knowledge, prior interest and visit motivation influences their experience. For this research the motivation for visiting was the same, it was part of a Scout group outing which students usually enjoyed. They looked forward to the visit anticipating adventure and discovery just like other outings but they had a blurry idea of what awaited them on IAA. Though some exhibits like the tortoise captured the attention of everyone, some students were more likely to be captivated by aspects such as 'learning something new' or the beauty of exhibits based on their personal preferences.

5.6.4 The triggers of interest

The findings reveal the following intricately linked triggers of interest: novelty, body experience, first time experience, strong emotions, size/numbers, impressive information (encompassing ecology and biodiversity concepts) and aesthetic experience. Apart from size/numbers, these triggers have been identified in literature but in other contexts such as in controlled experimental setting where participants read purposely written text to control interest variables aiming to study one trigger at a time (e.g. Ainley et al., 2002). In out-of-school settings, Dohn (2013) identified interest triggers such as surprise, novelty, hands-on, social involvement and knowledge acquisition while Huann-shyang et al. (2013) additional identified aesthetic experiences. Renninger and Bachrach (2015) propose that an understanding of both the nature of the activity and the characteristics of the learner is mandated to shed light on the dynamic operation of triggers of interest, which have been described in this Chapter. They further discuss the possibility of co-occurrence of triggers of interest using the hypothetical example of novelty such that a '*learner may engage in a new activity, learn new information or be startled by the novelty of the environment'*. A key finding in this study is evidence that novelty might be a determinant trigger of interest in students visiting a nature reserve for the first time. The novelty aspect of the visit has two components: a knowledge or cognitive component which is linked to the impressive information that students are exposed to and an affective component, comprising of the new experiences, being startled by the new environment and body experiences.

Novelty and affect (new experience and body experience)

The affective component of novelty also includes the 'body experiences' comprising of the hands-on, smelling and touching etc. which stimulates the senses of the visitor producing a pleasurable experience. Of particular note is that participants could not touch exhibits of their own free will as in science centres. Nevertheless, they found it interesting to participate in simple activities like smelling flowers and touching tortoise carapace (under the guide's supervision) or even seeing beautiful things, thereby engaging the whole body and senses. Hence, the term 'bodily experiences' would be more appropriate to term this a trigger of SI instead of 'hands-on' commonly used in informal learning settings and found to be a trigger of interest by Dohn (2010) and Huann-shyang et al. (2013). For example, students found it interesting to be walking in specific places, touching fossilized coral, examining the transverse section of the rare ebony tree to differentiate between the inner dark heartwood and the outer sapwood. Moreover, the wonder and unique feelings of seeing abstract concepts in real life were also categorised under the trigger 'bodily experiences' for example Pascal referring to the pink pigeon said: "*I have always seen it in pictures, and it's a different sensation to see it in real life, in front of me, and I got a picture where it is looking at me*". This produced a heightened emotional state with joy and satisfaction that characterize the affective reaction to the environmental stimuli. Pascal's experience is an example of personal significance that results in a positive experiential state as he engaged in his object of interest.

Novelty and knowledge acquisition (impressive information and size/numbers)

Students' interest was triggered when they learnt something new or previously unknown. New learning was a prominent aspect of novelty which is intricately linked to the content of the guided tour and the exhibits encountered. The information provided by the guide was highly impressive for the students such as information about sizes and numbers. For example, Felix was impressed when he learnt that the male and female in the ebony were on separate plants, others were impressed by the 'red veins' and conservation practices for example the hardening of the seedlings in the nursery. The nature of the information itself fascinated the students and seems to be closely linked to new knowledge gained/novelty. Some participants demonstrated signs of a challenge to their existing knowledge, they had to re-visit their previous conceptions as illustrated by one student Shreena. She initially thought that bats could see only at night but then learnt that the bats present at the nature reserve could see both during the day and night, resulting in a small degree of cognitive activation that triggers SI (Quinlan, 2019).

The nature of information could be compared to the complexity of information (Hidi, 1990) or vivid text reported by Schraw and Lehman (2001) described as rich imagery, provocative and engaging themes. The student Joana vividly recalls and can easily explain that the red veins of young leaves deter predators and having seen it *de visu*, impressed her. Thus, impressive information which students found valuable (Schraw & Lehman, 2001) was a trigger of interest.

Both the recalling of ecology/biodiversity concepts and size/numbers which were impressive to students illustrate one common aspect: students were consciously aware that they were learning something new, enjoying the act of learning new things since they were all visiting for the first time. This impressive information triggered their interest. The findings partially concur with the knowledge-deficit hypothesis of Rotgans and Schmidth (2014) which states that SI is triggered when one is consciously aware of a gap between his/her existing knowledge and what seemingly needs to be known. During this phase, the SI causes knowledge gain which ultimately results in individual interest that may produce more SI (Rotgans & Schmidth, 2017). In my opinion, the model they put forward adds depth, instead of a challenge, to the Four Phase Model of Interest Development that describes a sequential development of SI to Individual interest over time. In my study, impressive information triggers SI which in turn produces knowledge gain but does not state whether Individual interest is a by-product of this knowledge gain or a subsequent phase of SI as put forward by Rotgans and Schmidth (2017). Nevertheless, the findings suggest that the progress from Triggered Situational Interest (TSI) to Maintained Situational Interest (MSI) may have knowledge gain as an intersecting factor. The whole of the guided tour with different stopping points was rich in new information to students. Students were continuously exposed to new elements of information, producing an enduring knowledge deficit. However, there were repeated encounters with the 'tortoise' a popular exhibit, for example, the first encounter occurred in the cage with baby tortoises, the second encounter was the 'tortoises' nests' and there were third and sometimes fourth encounters when adult tortoises were seen walking freely in the nature reserve, implying repeated engagement and scaffolding of information about the tortoises. This repeated engagement, in my opinion, opens the door for the progression from the TSI to MSI on a fast-forward time scale during the guided tour itself. Thus, there is a possibility that knowledge gain may cause Maintained SI to occur during the visit itself due to repeated encounters with content, instead of the Maintained SI causing knowledge gain. Further investigation on this aspect is mandated and I extend this discussion in Chapter 8.

Strong Emotions

'Strong emotions' hasbeen found to be a trigger of interest partly intersecting with the content of the guided tour, novelty and knowledge acquisition. Emotions such as surprise, meeting the unexpected have been observed concurring with the findings of Dohn (2010, 2013) and Huann-shyang et al. (2013). Less pleasant emotions have been noted in terms of empathy for extinction in this study. Renninger (2007) writes that interest in an informal setting is conceptualized both as a heightened affect for science (or the content) and pre-disposition to engage again. However, the role of cognition has been identified more frequently compared to affect in the present study. These were identified through in-depth interviews, field observation and photo-elicitation technique. The 'walk and talk' nature of the guided tour and lack of group activities implied that the affective processes that come into play during the tour could not be easily identified during field observation. Moreover, in the current study, I classified strong emotions as a trigger of interest elicited by both the content of the guided tour and the seductive details not related to the content. For example, the special feeling of discovering a new place, the road trip to a new place far from home, the boat trip and the landscapes all contribute to the emotional state of being a visitor to a nature reserve. These form part of the emotions grouped as collative variables in the literature (Renninger & Bachrach, 2015).

Aesthetic experience

Similar to strong emotions, partly connected to the nature of the guided tour and partly connected to the seductive details, aesthetic experience was an important trigger of interest. From being the pleasant experience of seeing the beautiful landscapes not related to the visit to finding the exhibits (Mauritius fody, plants, extinct animals) beautiful, aesthetic experience was an important trigger of interest especially when operating in conjunction with other triggers such as novelty and knowledge acquisition.

5.7 Summary of Findings and Conclusion

The following main findings emerged through analysing the photographs, semi-structured interviews and photo-elicitation:

- Out of the numerous exhibits at the nature reserves, some were more successful at triggering interest among students for example extinct species, tortoises, endemic birds and animals, endemic plants and nursery featured among the photographs submitted by students. The historical aspects of the tour were less popular. Some of these exhibits such as tortoises and extinct animals were popular among all students, analogous to central exhibits that are key attractions in science centres and museums. Other exhibits were popular only among certain students based on their personal preferences. Seductive details such as beautiful landscapes contributed to enhancing the visitor experience.
- Analysing semi-structured interviews destined to identify aspects of the visit that students liked, remembered or talked to others as a means to capture SI revealed that students' interest was triggered by the novelty aspects of the visit. They were impressed by beauty as well as information on size and numbers. All students visited the place for the first time and it was a

time of discovery and learning for them. They were also impressed by the nature of the information obtained during the guided tour especially those related to ecology, biodiversity and conservation practices. They could explain in their own words concepts, terms or aspects such as heterophylly, predation, extinction, life-span, sex differentiation, etc. Certain exhibits or events that occurred during the trip elicited strong emotional arousal among some participants such as surprise, empathy and seeing birds or plants in reality. They were also deeply attracted to the content of the guided tour that exhibits items such as tortoises, endemic plants, endemic animals and extinct species. Less frequent but still present were the body experiences of participants during the tour through the few opportunities they had to smell leaves/flowers, touch 'tortoises' carapace' and walk on things. Certain experiences like being caught by surprise were categorised as body experience.

- A deeper analysis of the semi-structured interviews concurrently with photo-elicitation revealed that the most successful exhibits were able to elicit meaningful visit experiences due to their novelty, beauty, impressive size/numbers and capacity to produce affect. A few students remembered certain biodiversity/ecological concepts clearly and could explain the concepts in their own simple words even if they do not know the technical biological terms. For example lifespan, red veins, sex differentiation, mating, co-evolution. Moreover, certain exhibits trigger interest for different reasons, for example, the extinct species produces empathy and surprise and impress due to their large sizes while the tortoises captured interest due to the large amount of new information that students obtained such as translocation, lifespan, sex differentiation and its relationship with the plants with red veins.

In this Chapter, I identified the triggers of interest during the visit to the nature reserve and attempted to show how they interact with one another thereby answering my research question 'What are the triggers of interest during a visit to a nature reserve '. I have also been able to identify the exhibits at the nature reserve, which are more successful at triggering SI: tortoises, models of extinct animals, endemic animals, endemic plants and the nursery. The triggers of SI are novelty, body experience, first time experience, strong emotions, size/numbers, impressive information (encompassing ecology and biodiversity concepts) and aesthetic experience. These triggers do not operate in isolation but in conjunction with one another. The novelty was found to be a key trigger of interest impacting knowledge acquisition, the experience of the visit as well as affect. Furthermore, impressive information was crucial in eliciting SI due to their impressive and novelty aspect. Impressive information is related to biodiversity, in the next Chapter I analyse what students learnt about biodiversity as they visited IAA.

6 Chapter 6: Learning about Biodiversity

6.1 Introduction

In Chapter 4, I described the typical experience of a student while elaborating on the stopping points during the visit to the nature reserve and some key biodiversity concepts presented to students. In Chapter 5, the triggers of situational interest (SI) were identified. In this Chapter, I analyse learning about biodiversity during the field trip to answer research question 2: what do students learn about biodiversity? To this end, I analysed the Personal Meaning Maps (PMM) from 13 students, to identify the shift in biodiversity knowledge. I further conducted a qualitative analysis of the semi-structured interviews and PMMs to investigate what students learnt about biodiversity in light of the analytical framework developed from literature which I describe hereunder.

6.2 A framework for analyzing what students learnt about biodiversity

As discussed in the literature review Chapter, the term biodiversity has been reported to be full of complexities. It involves diversity at species, ecosystem, and genetic levels connected to cultural, social, and economic issues (Saito, 2013). Furthermore, I also proposed that students' learning about biodiversity could be approached from three lenses namely: an 'ecological literacy' lens, a 'biodiversity and society' lens and 'nature and self' lens. The 'ecological literacy' lens is concerned with understanding the concept, its importance, endemic and extinct species and conservation measures. The 'biodiversity and society' lens is about students' understanding of societal and historical aspects that put biodiversity at risk. 'Nature and self' lens is concerned with students personal involvement in nature and the moral stance they adopt on the protection of life. These lenses acted as an analytical framework that guided my data analysis. I provide a summary of the three lenses and aspects of learning that were investigated in Table 6.1 below.

Table 6.1: Aspects of learning investigated as per the three lenses identified

Lenses of biodiversity learning	Aspects of learning that were investigated
Ecological literacy	i. What do students understand about the concept of biodiversity? ii. What do students understand about the importance of biodiversity? iii. What do students know about endemic and extinct species? iv. How far are students aware of conservation practices undertaken to preserve biodiversity?
Biodiversity and society	i. What is the awareness of students regarding the negative impact of human activities on ecosystems? ii. What is the awareness of students regarding the current debates surrounding the endemic bats in Mauritius? iii. What is the awareness of students regarding the factors that contributed to the extinction of the dodo?
Nature and self	i. How far do learners appreciate the intrinsic value of biodiversity demonstrated through appreciation, enjoyment in learning and experiencing biodiversity? ii. What moral stance do students take regarding the position of humans concerning biodiversity?

6.3 How students conceptualize 'biodiversity' – an analysis of the PMMs

As a first step in the analysis, I examined students' conceptualization of 'biodiversity' based on the 13 Personal Meaning Maps (PMM) collected before and after the visit. A key aspect of a PMM is that it eliminates the pre-conception on what learners should know, therefore enabling me to investigate the meaning students make about biodiversity both before and after the visit.

As discussed in Chapter 2, the term biodiversity is vast. There might be many possible answers from learners, making it challenging to assess what the group learns collectively. As a first step in the analysis, I performed an inductive content analysis of biodiversity-related concepts written on the PMM without considering the interviews. Novak and Canas (2008) describe concepts as a '*perceived regularity in events or objects…designated by a label*'. Thus, a concept would be a word or a phrase representing a scientific idea, illustrated by words having shared meaning. Written words were regarded as a concept only if they represent a scientific idea, such as 'reproduction', 'asexual reproduction', and 'sexual reproduction'. Examples of plants and animals such as sugarcane, lion, were disregarded as a 'concept' but considered examples of concepts.

The PMMs of each of the 13 students were loaded on Atlas TI software. I inductively coded each idea or concept related to biodiversity written on the PMM without considering how they structure individual linkages among concepts. The logic guiding my coding was: What are the main biodiversity concepts that students write in their PMM? At this stage, the notes I made on the PMMs were not considered since the interviews with students were recorded and analysed separately. Each concept that students wrote on their PMM was assigned a code, as shown in Figure 6.1 below. To ensure my findings' reliability, a colleague volunteered to code a sample of two PMMs, and we had 98% agreement.

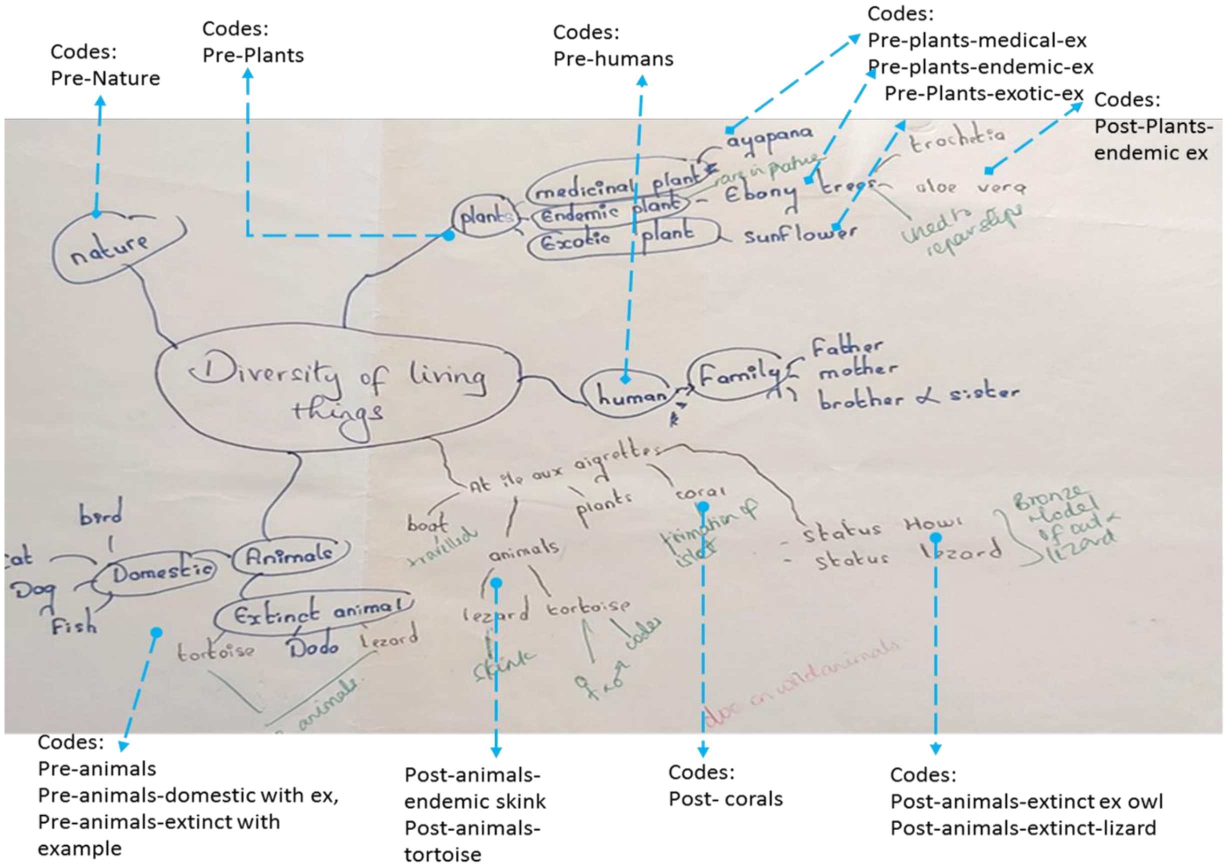


Figure 6.1: Example of inductive coding from a PMM

Coding description

While coding the PMMs, I remained aware of my discussion with each student during which they explained their PMM. The codes starting with ‘Pre’ and ‘Post’ indicated students' writing before (in blue ink) and after (in black ink) the visit respectively. The notes I made as a researcher were in red before the visit and in green after the visit. The following rules were adopted to ensure rigour in my proceedings:

- I differentiated between main concepts, sub-concepts and examples of concepts to distinguish between conceptual additions or examples of concepts. As shown in Figure 6.1

above, the main concept is plants from which the sub-concepts ‘endemic’, ‘exotic’ and ‘medicinal plants’ branch out. ‘Ebony’ is an example of the concept of ‘endemic plants’.

- If students added two or more examples of the sub-concepts, I coded it as ‘examples of concepts’, making notes to identify any relevance to the guided tour. For example, if students added ‘skink’ and ‘pink pigeon’ to ‘endemic species’, it was coded as ‘examples of endemic species’. This shows a better understanding of endemic species supported by relevant examples.
- When students wrote about ‘humans’ detailing ‘families’, ‘brother’, etc., it was counted as one code, ‘humans’ to illustrate the association of humans as part of biodiversity.
- Some students wrote about their emotions during the guided tour, for example: ‘I want to go again, it was interesting’. I coded such references as visit experience to illustrate that students acknowledge that their visit to IAA was related to biodiversity.

After coding the 13 PMMs of all students, the 90 different codes were grouped into categories. An example is shown in Table 6.2.

Table 6.2: Grouping of codes into main categories using an inductive approach

Description of extract from PMM	**Codes**	**Categories: Sub-concepts/ examples of concepts**	**Themes: Main concepts linked to the diversity of living things**	**Coding logic**
Extinction linked to animals	Pre-animals-extinction	Extinction	Animals	Extinct animals are part of the group of animals
Plants are branched into medicinal	Pre-plants-medicinal	Use of Plants as medicines	Plants	The student is aware of the importance of plants as medicines
Endemic is linked directly to the central phrase (diversity of living things’ with ebony as an example	Pre-Endemic	endemic with example	Endemic	The student can give examples of endemic species (ebony). Biodiversity consists of endemic species

6.3.1 Results from qualitative analysis of PMMs

Before the visit, students conceptualized ‘diversity of living things’ in terms of ‘different types’ of animals (13), plants (11), humans (8) and nature.

Diversity of Plants

A summary of students’ understanding of plant diversity before and after the visit is provided in Table 6.3 below.

Table 6.3: Main concepts associated with plants before and after the visit (the numbers in brackets represent the frequency of occurrence in the 13 PMMs)

Main concepts in PMM linked to plants	**Concepts written in Pre-visit PMMs**	**Additional Concepts written in post-visit PMMs**
Different plants	Plants differ by colour and sizes (2) and growth (1)	Some plants have leaves with red veins (3) Plants have leaves with smell (2)
Endemic plants	Plants comprise endemic plants (3) including (1) example (ebony)	Additional examples of endemic plants such as ebony, Trochetia, Aloe vera (3)
Exotic Plants	Plants comprise exotic plants (2) including (1) example	
Medicinal Plants	Plants comprise medicinal plants (9) including examples (4) useful to humans	
Mode of reproduction	Plants differ in their mode of reproduction(sexual, asexual, spores) – (1)	
Usefulness of plants	Plants provide oxygen to humans (3) Biodiversity provides water to humans (1)	Plants provide oxygen and medicines to humans (2)
Endangered plants		There are endangered plants (2), and ebony is an example (1)

As can be seen in Table 6.3 the analysis of the pre-visit PMM, revealed that for the students, 'different types of plants' implied medicinal plants (9 students), endemic plants (4 students) and exotic plants (3 students). Fewer students wrote about variety in plants in terms of monocots/dicots (1 student) or variety in size or growth. Furthermore, eight students made links between plants and how they benefit humans. As shown in the examples in Table 6.3, students showed that they knew that plants provide humans with oxygen, water, medicines and food. These concepts in students' PMMs indicate that plants were conceptualised as providers of ecosystem services to humanity.

After the visit, conceptual additions related to the IAA visit were noted for example the concept of an endangered plant (2 students) and examples of endemic or endangered plants (11 students) such as ebony and Trochetia. Three students included 'plants with red veins' indicating a reference to the endemic plants encountered on IAA which display the phenomenon of heterophylly. Two students referred to the 'plants that smell like an apple' which shows their recall of the event when the guide invited them to smell the leaves of 'Bois de Renette' an endemic plant with leaves smelling like the green apple. Thus, students recognised an additional type of plants, 'endemic' plants, that they tend to associate with endangered plants. Therefore, it appears that the visit enabled students to learn about examples of 'endemic' or 'endangered plants'. According to the Contextual Model of Learning, these represent the plant exhibits encountered on IAA and exhibits form part of the physical context of the visit that favours learning (Falk & Dierking, 2013).

Diversity of animals

As shown in Table 6.4 below, animals were largely differentiated as domestic animals (9 students) and wild animals (5 students) before the visit. Only three students included the concept of extinct animals. Four students also described animal diversity in terms of their feeding habits (herbivores and carnivores).

Table 6.4: Students' conceptualisation of diversity among animals before and after the visit

Main concepts in PMM linked to animals	Concepts written in pre-visit PMMs	Additional concepts written in post-visit PMMs
Groups of animals	-Animals comprise **domestic** animals (9) with examples of cats, and dogs -Animals comprise **wild** animals (3) with examples (2) -Animals comprise **extinct** animals (3) including an example of the dodo	-Animals comprise **extinct** animals (1) **-Additional examples** of extinct animals: owl (2), Blue pigeon (2), lizard/skink(1), long-neck tortoise (1) -Animals comprise **rare** animals (2), and examples are pink pigeon (2), a skink (1), Mauritius fody (1), bats (1)
Feeding habits	-Animals have different feeding habits- herbivore, carnivore and omnivore (4) with examples of each (1)	
Additional examples of animals		-**Additional examples** of animals not linked to groups of animals –tortoise (6), pink pigeon (4), lizard/skink (3), Mauritius fody (4) includes details of its body colour (3)
Ecological role		- Tortoise dung is a fertilizer (1)

Following the visit, the highest number of additions was the concept of 'extinct' animals or examples such as giant skink, saddle-back tortoise, extinct owl, blue pigeon (9 students). Examples of endemic or 'rare animals' encountered during the visit were the most frequent additions in post-visit PMMs. These include the pink pigeon, the skink and the Mauritius fody. Furthermore, six students included tortoise in their post-visit PMM. Therefore, the visit enabled students to remember the exhibits about extinct and endemic animals (especially their names).

Ecosystem diversity and the place of human beings

Only four students provided examples of different ecosystems and the diversity of plants and animals in terms of classification (mammals, reptiles, birds, insects), feeding habits (herbivore, carnivore) and mode of reproduction (lays eggs, give birth, or monocots and dicots for plants). This indicates that before the visit, the idea of ecosystem diversity was not deeply ingrained in the minds of the students for them to include it in their PMM. Based on the post-visit PMM, these students did not include ecosystem diversity in their post-visit PMM either, indicating that their conceptualisation of the 'biodiversity' as different types of plants and animals remained unchanged. There was no inclusion of diversity at the genetic level at all among the group. Thus, students could not show a comprehensive understanding of biodiversity at species, ecosystem and genetic level.

Eight students included humans as part of diversity; some added parents and siblings, while others included different cultures among people. After the visit, there were no further additions to these concepts. It seems that students believed that humans are an important component and benefactor of biodiversity, a provider of ecosystem services: a finding that concurs with those of Yorek et al. (2008).

From the post-visit PMMs, three students included phrases such as ''*liking'* the guide's explanation. Three who wrote about '*want to go to IAA again'* also included words like '*it was interesting'*. This gives an overall idea of the potential of the PMMs to gather data on students' appreciation of a visit. Furthermore, some students added a few details about the plants and animals on their PMMs such as '*the sailors made holes on the shell of the tortoise to extract oil to cure diseases*', '*the plants with red veins is for tortoises not to eat them*', '*the male fody head feathers turn red to attract females when it is in love*' or '*the dung of the tortoises on IAA fertilizes the soil*'. These details were explicitly described during the tour by the guides' exposé and therefore indicates how the influence of the social interactions with guides shape visit experiences by enhancing visitor satisfaction and knowledge acquisition (Falk & Dierking, 2013, p 164).

A qualitative analysis of the PMM gave insight into students' prior knowledge of biodiversity mainly as 'different types ' of plants and animals. Knowledge of diversity at the ecosystem level was not common in students' prior knowledge, and that of genetic diversity was absent. Furthermore, out of the four students who included nature or environment as part of diversity, only one described pollution, indicating that most students approached the conception of biodiversity mainly through the ecological literacy lens and did not make many references to biodiversity and society aspects or their emotional connectedness with nature.

Completely absent on the PMM (both pre and post) was the concept of 'ecosystem balance'. Only one student wrote about species protected by the law on her PMM before the visit, and that same student made additions that nature reserves prevent the extinction of species after the trip.

Thus, most students did not think much about the use of biodiversity resources by society while writing their PMMs.

An examination of only the PMMs, without considering interview probing, indicated that students' experience of their visit and the exhibits they encountered promoted knowledge gain, especially about endemic plants and animals and extinct animals. Learning gains across the group seemed to be a direct consequence of the visit to the nature reserve. The main conceptual additions collectively for the group were 'extinct' and 'rare' animals and 'endemic' or 'endangered' plants. Students frequently wrote names of endemic and extinct species encountered on IAA, indicating a recall of the exhibits. Thus, the PMM is useful in providing a rough idea of students' prior knowledge and the exhibits favouring learning. An analysis of the interviews follows to investigate students' understanding of biodiversity from the three lenses used as an analytical framework: ecological literacy, biodiversity and society and nature and self.

6.4 Analysis of the semi-structured interviews – A hybrid approach

In this section, I analyse the semi-structured interviews of the 13 students conducted before and after the visit by including discussion during the photo-elicitation and probing using the Personal Meaning Maps. As the researcher, I focused on what information can be generated from the data rather than what I expected to derive from the data, thereby espousing inductive methodologies. On the other hand, I faced the challenge of being confronted with a broad concept: biodiversity. To overcome this challenge, as the researcher, I made the choice, as described by Swain (2018) to consider different aspects of biodiversity learning which were regrouped under three lenses 'ecological literacy', 'nature and self' and 'biodiversity and society' as per Table 6.1 above. The lenses acted as pre-conceived themes under which I regrouped inductively derived codes from the interviews. I adopted the hybrid approach to theme development which incorporates both deductive a priori template of themes and the data-driven inductive approach for coding (Fereday & Muir-Cochrane, 2006). This integrated approach to the coding process retains the benefits of inductive analysis while developing a structured output and has been adopted by other scholars (Swain, 2018; Yukhymenko et al., 2014).

The first step in the analysis was the development of a code manual based on the analytical framework (the three lenses in Table 6.1 above). For example the pre-established theme, 'Ecological literacy lens (EL) -the importance of biodiversity' regrouped all codes that relate to how students described the importance of biodiversity during the interviews. This acted as an organizing framework for the coding process. The pre-established themes are described in Table 6.5 below.

Table 6.5: Manual of pre-established themes based on the analytical framework

Pre-established themes	Description of pre-established themes	Aspects of the lenses	Lenses of biodiversity learning
EL-Concept of biodiversity	How students defined or understood the concept of biodiversity	Understanding of biodiversity concept	Ecological literacy
EL-Importance of biodiversity	Relates to uses and importance of biological resources	Understanding of the importance of biodiversity	Ecological literacy
EL – Endemic-extinct	How students refer to extinction and endemic species	Understanding of endemic species and extinction	Ecological literacy
EL – conservation	What learners relate which are part of the conservation practices	Awareness of conservation practices	Ecological literacy
BS –impact	Learners awareness of the negative impact of ecosystems	Awareness of the negative impact of human activities on ecosystems	Biodiversity and Society
BS- bats	What learners say regarding the culling of bats	Awareness of the current debates surrounding the endemic bats of Mauritius	Biodiversity and Society
BS-dodo	What students say regarding the reason for the extinction of the dodo	The factors leading to the extinction of the dodo	Biodiversity and Society
NS – Appreciate	How students relate to nature	Appreciation of the intrinsic value of natural environments	Nature and Self
NS – Ethics	What position do students take regarding the ethics of preserving species	Learning the ethics of preserving nature/biodiversity	Nature and Self

Having decided on the pre-established themes, the interview transcripts were then inductively coded through a bottom-up process: I extracted meaningful segments of interviews, inductively assigned codes to them and grouped them into common categories (Vaughn & Turner, 2016). In Figure 6.2 below I illustrate how the coding of interview transcripts was conducted. During the post-interview, the student Joana while referring to the extinction of the dodo explained that the dodo went extinct due to both predation and colonisation. The inductively derived codes (Dutch, French and predators) were grouped into emergent themes (Colonisation and Predation). These themes were then organised as per the pre-established themes which were Ecological literacy: understanding the reason for the extinction of the dodo. I obtained a total of

160 codes, including those related to knowledge and interest. See the rest of the codes in Appendix 10.8. The codes were then grouped into emergent themes shown in Figure 6.2.

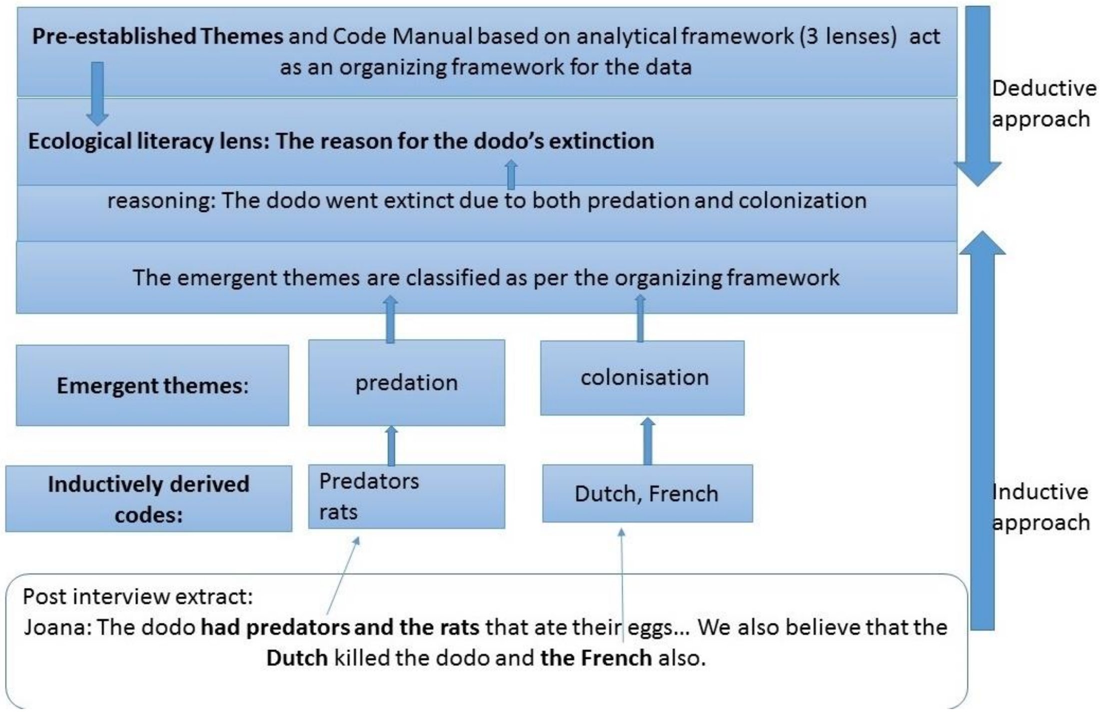


Figure 6.2: Example of hybrid coding of interviews transcripts

As I worked through the analysis, I made notes on the answers that each student was providing both before and after the visit. Before the visit, Joana explained that the dodo is a big bird, with small wings that went extinct following colonisation by the Dutch. As shown in Figure 6.2. above, after the visit the student Joana explained that the dodo went extinct due to both predation and colonisation. This indicates that she learnt about predation an additional factor that led to the dodo's extinction as a result of the visit. Using the same reasoning, I made notes on the type, depth and level of details in the answers that students provided for each aspect of the three lenses that I used to investigate what students learnt about biodiversity. The results using the three components of the analytical framework as subheadings are presented below.

6.4.1 Results from the analysis of interviews from the 'Ecological Literacy' lens.

Understanding of the concept of biodiversity

Using the PMMs as a basis for questioning during the interviews, it was found that students conceptualised the phrase 'diversity of living things' largely in terms of different types of plants and animals including domestic animals and humans that are part of 'nature'. An extract of Pascal's interview illustrates this:

Interviewer: "When you hear biodiversity or variety in living things, what comes to your mind?"

Pascal: "nature, plants and animals"

Interviewer: "ok what you mean by nature?"

Pascal: "plants: cactus give water, Ayapana give medicines" (Pre int: Pascal, line 33)

All students had considerations for domestic animals concurring with the findings of Yorek et al. (2008). Students' described the personal connections they made with the sea before and after the visit elaborating on its aesthetic, cultural and economic significance such as the nautical tourist activities and the Mauritian culture of going for regular seaside ? a leisure activity. For example, Sonia described the sea as: '*Beautiful, the sand is fine, it's not black like other countries, the water is clear in most places* '. Further probing was required and I asked 'what is found in the sea'? The answers were largely restricted to fish and algae for most students. After the visit, the additional example was corals. This indicates that students did not directly or intuitively associate life in the sea as part of biodiversity except for fish but acknowledge their beauty, economic and cultural significance.

The pre- and post-visit knowledge of biodiversity for most students were limited to diversity at the species level. Before the visit, four students described differences among species in terms of feeding habits and characteristics of animal classes. The number of students who described ecosystem diversity increased from four to seven after the visit.

Among the group before and after the visit, students had three levels or depth of understanding of the concept of biodiversity: (i) those who restricted their conception of biodiversity at the species level (ii) those who described variability among species in terms of characteristics and mode of reproduction and (iii) those who in addition to these two also recognised diversity among ecosystems. For ease of comparison I classify these different depth of knowledge into three knowledge levels based on students' answers relative to one another before and after the visit: knowledge level 1 is the lowest level of knowledge and level 2 is better than level 1 and knowledge 3 is the highest or deepest level of knowledge and understanding. In this case, a recognition of both species and ecosystem diversity is considered knowledge level 3. At the end of section 6.4.1 in Table 6.7 below I provide a summary of the different knowledge levels of students before and after the visit for the four aspects of learning under the ecological literacy lens. I use the same logic to develop knowledge levels for each aspect of learning under the biodiversity and society and nature and self lens.

Understanding of the importance of biodiversity

The most frequently occurring codes which were regrouped into categories are shown in Table 6.6.

Table 6.6: Importance of biodiversity: coding before and after the visit

Example of interview extracts	Codes	Categories	Code frequency before the visit	Code frequency after the visit
Interviewer: why did you write that plants serve as habitats? Kelly: each animal has a habitat…the birds that live on trees and the geckos live on certain trees.	**plants as habitats**	**Habitats**	**4**	**10**
Selvina: There was a lizard called Telfair, and it helps in pollen.. it carries pollen everywhere	**Pollination**	**Dispersal, dissemination and pollination**	**0**	**8**
Shreena: I learnt that the bats ..help plants reproduce and get fruits and that Telfair Skink does the same thing and that tortoise also when it eats helps us.	**Reproduction** **Dispersal**	**Species have ecological roles**	**6**	**15**
Interviewer: Do you think we need to cut down trees in Mauritius? Ryan: no because it's good for us, we get rain and air to breathe	**Rain** **Air (oxygen)**	**Biodiversity provides ecosystem services such as food, medicines and oxygen**	**12**	**15**

Before the visit, students' conception of the importance of biodiversity was largely restricted to the notion of biodiversity as important to humanity for providing services such as food, medicines and clean air (10 students) as shown in Table 6.6 above. Students' responses on the importance of biodiversity were from a human-centred perspective.

After the visit, the ecological role of species was recognised more frequently. For example, there were eight records of pollination and dispersal descriptions after the visit and there was no mention of these concepts before the visit. Overall, the visit enabled students to shift their conception that 'biodiversity is important only to benefit humans' towards an increased understanding of each species an important ecological role in nature. However, the knowledge gain was not uniform. Similar to the knowledge of the concept of biodiversity described above, the different answers from students were categorised into three knowledge levels before and after the visit as shown in Table 6.7 at the end of this section.

Learning area: understanding of endemic and extinct species

Before the visit, two students could understand neither the terms 'endemic' nor 'extinction', but acknowledged that the dodo has 'disappeared'. Three students could explain one of the two concepts providing the ebony as an example of endemic plants while eight students could explain both terms. The dodo was the only example of extinct species and the pink pigeon and ebony were the only examples of endemic species provided by students indicating a limited awareness of names of extinct and endemic species of Mauritius.

Following the visit, both on the PMMs and during the interviews, all students added one or more examples of extinct and endemic species encountered on IAA. For example, ten codes related to the extinct owl, nine to the extinct tortoises and six to the extinct parakeet. Other examples provided were of the blue pigeon and giant skink. Students largely described these extinct species during photo-elicitation and as aspects of the visit that they remembered. For example, Selvina remembered that '*long ago there were owls in Mauritius and a Big parakeet, long-necked tortoise* …' The knowledge gain about endemic species was similar with 26 mentions of pink pigeon, 13 of the Mauritius fody as well as plants such as ebony (14 codes) and endemic plants that exhibit heterophylly by developing leaves with red veins (20 codes). I consider the examples of extinct and endemic species mentioned by students to be a direct result of the visit on IAA since these species were encountered as exhibits and described by the guide.

However, providing examples of these species indicates knowledge of their existence, but does not signify a conceptual understanding of the terms 'extinct' or 'endemic'. In Table 6.7 I provide details about the three different knowledge levels of students before and after the visit.

Learning area: Awareness of conservation practices

Since the preservation of biodiversity is crucial to halt its loss, and the IAA nature reserve is an example of conservation in action, I considered investigating students' awareness of conservation practices. Before the visit, six students were ignorant of human interventions to protect species; the rest were aware of some interventions to save endangered species, for example, Pascal mentioned the Panda and the Kestrel as species '*saved*' from extinction. Thus seven students demonstrated an awareness that species are conserved but could not explain that the reasons for conservation which are to prevent extinction and maintain ecological balance.

There was an increase in the number of codes related to conservation practices from 10 before the visit to 31 codes after the visit. The visit, contributed to an increase in awareness that humans are protecting species demonstrated by nine students who provided examples such as artificial tortoises nests on IAA and plant propagation activities in the nursery. However, the majority of students did not elaborate on the underlying reasons for conservation measures. After the visit, only two students described that conservation is important to prevent extinction, for example, Sonia explained: "*If there were not nature reserves, there would be more plants and animals that would have gone extinct*".

In Table 6.7 below I summarise how the knowledge levels of students in the group changed for the ecological literacy lens before and after the visit.

Table 6.7: Knowledge levels of students before and after the visit for the Ecological Literacy Lens of biodiversity learning

Aspects of learning under the 'Ecological literacy' lens		Knowledge level 1	Knowledge level 2	Knowledge level 3
Understanding the concept of biodiversity		Biodiversity is different types of plants and animals. Some examples also include humans and domestic animals	Biodiversity is different types of plants and animals. They have different characteristics either in terms of their mode of reproduction, feeding or body shapes.	Biodiversity is about plants and animals which are different. They have different characteristics either in terms of their mode of reproduction, feeding or body shapes. The plants and animals live in different ecosystems.
Number of students	Before the visit	5	4	4
	After the visit	4	2	7
Understanding of the importance of biodiversity		The student shows little or no awareness of the importance of biodiversity. The student does not mention anything about ecosystem services or ecological processes.	The student show awareness of ecosystem services provided to humans such as food, shelter, medicines and nutrient recycling.	The student shows awareness of ecosystem services provided to humans such as food, shelter, medicines and nutrient recycling. The student also describes some ecological processes, such as maintaining food webs and nutrient cycles.
Number of students	Before the visit	1	10	2
	After the visit	1	7	5
Understanding of endemic species and extinction		The student does not know about endemic species or extinction.	The student shows an understanding of endemic species or extinction with at least one example.	The student shows an understanding of both endemic species and extinction with at least one example of each
Number of students	Before the visit	2	3	8
	After the visit	1	1	11
Awareness of conservation practices as a means to preserve biodiversity		The student does not show awareness of conservation practices at all.	The student shows awareness that humans are protecting species and ecosystems to protect endangered	The student shows awareness that humans are protecting species providing at least one example. The reason is to prevent extinction and to

Aspects of learning under the 'Ecological literacy' lens		Knowledge level 1	Knowledge level 2	Knowledge level 3
			species with at least one example	maintain a balance in ecosystems.
Number of students	Before the visit	6	7	0
	After the visit	2	9	2

As can be seen in Table 6.7 above, there was an improvement in ecological literacy as illustrated by the increase in the number of students who were placed at knowledge levels 2 and 3 after the visit compared to the pre-visit knowledge level. Regarding the understanding of the concept of biodiversity, it appears that student's retained their pre-visit conceptions that biodiversity is about plants and animals and after the visit, only three additional students moved to level 3 to recognise ecosystem diversity. However, students learnt the names of endemic species. This is further supported by the fact that a higher number of students (knowledge levels 2 and 3) could explain the terms endemic or/and extinct and provide appropriate examples compared to before the visit. Similarly, after the visit, three more students could describe the ecological role of species instead of restricting their understanding of biodiversity as being important only for humanity. Nevertheless, the visit enabled only two students to acknowledge that a balance in the ecosystem is needed and that is the reason conservation measures are undertaken to prevent extinction. It appears that the majority of students had gained knowledge but the extent of the learning differed for different students and different aspects of the lenses. A deeper analysis of how individual students learnt is in section 6.5.

6.4.2 Results from the analysis of semi-structured interviews from the 'Biodiversity and Society' lens

I identified three aspects of biodiversity learning under the 'biodiversity and society' lens: the extent of students' knowledge of the negative impacts on ecosystems and two contextual issues related to Mauritius: the extinction of the dodo and their awareness of the current debates surrounding the culling of the endemic fruit bats.

Students' awareness about the impact of humans on the ecosystem

Before the visit, the majority of students recognised that deforestation and pollution due to urbanisation were the main threats to the ecosystem. Four students demonstrated deeper reasoning indicating that deforestation has ecological implications such as habitat destruction that put species at risk. For example, Shreena explained: "*they have destroyed the forests to build houses* *and buildings., On top of that, they have destroyed forest habitats of animals that have begun to be in danger of extinction”.*

After the visit, six students (compared to 2 before the visit) advanced that human beings should curtail their destructive activities on the ecosystems. For example, Shreena explained:

> *Shreena: “Now I know that we need to be careful of what we are throwing in the forest because of protected animals. Man must avoid polluting the environment because later this can harm us”.(*Post int: Shreena, line 42)

I consider that following the visit, students like Shreena’s reasoning moved from recognition and awareness of ecosystem destruction towards deeper cognitive processes illustrated through her ability to critique and formulate opinions. However, Shreena’s progress was not generalised. Nine out of 13 students limited their knowledge to awareness and did not show an ability to analyse and evaluate (Krathwohl, 2002). The result is shown in Table 6.8.

The extinction of the dodo

Before the visit, all students described the dodo as a large flightless bird with a big beak and small wings as depicted in tourist souvenirs and textbooks. Surprisingly, four students did not mention that its extinction was a consequence of the colonization of Mauritius. One type of response obtained was: *the dodo, a large flightless bird* or *is extinct* has ‘*disappeared’*. Nine students provided better answers by associating the dodo's extinction, a large flightless bird, to the Dutch colonisers who killed them for food or other reasons.

The dodo's bronze model was a stopping point about which the guide spoke exclusively explaining habitat destruction and the vulnerability of the flightless dodo which laid one egg per clutch per year. After the visit, seven students explained that the dodo’s extinction was a consequence of colonisation. A third type of answer was obtained from students: the dodo, a large flightless bird, went extinct as the Dutch killed them and due to predators. For example, Anna explained: ‘*it’s not the Dutch who are the main cause for the dodo’s extinction, its predators, the rats*!’. Following the visit, three students show a deepening of factual knowledge about the factors leading to the extinction of the dodo such as predation and invasive species (rats) and being hunted by the Dutch colonisers. The results are summarised in Table 6.8 below.

Awareness of the debate around the culling of bats

Before the visit, seven students had no opinion on the culling of bats or adopted a moral and ethical stance to protecting life, with a common statement that ‘*it is not morally right to kill other living things* ’. Another group of five students indicated that bats have an ecological role in nature. After the visit, the number of students who understood that mass culling of bats might lead to its extinction increased from 1 to seven, indicating that the visit enabled students to reflect more on species' ecological roles and their risk of extinction. However, five students retained their pre-visit moral stance that the bats have the right to life. The detail of the knowledge regarding the debate around the culling of bats is provided in Table 6.8.

Table 6.8: Biodiversity and society lens –knowledge levels for each aspect of learning

Learning aspects for 'Biodiversity and society' lens		Knowledge level 1	Knowledge level 2	Knowledge level 3
Awareness of the negative impact of human beings in ecosystems		The student does not show an awareness of past and/or current human activities that threatened the environment/ecosystem such as pollution, deforestation, urbanization	The student demonstrates awareness of human activities that destroy ecosystems and the resulting negative impact on the environment such as reduced forest cover, impact on nutrient recycling or species loss	The student demonstrates awareness of human activities that destroy ecosystems and the resulting negative impact on the environment. Therefore it is necessary to curtail this to protect ecosystems
Number of students	Before the visit	7	4	2
	After the visit	4	3	6
knowledge on the extinction of the dodo		The student thinks the dodo was a large flightless bird that is 'extinct' or 'disappeared' or 'no longer exists '	The student knows the dodo was a large flightless bird that is extinct as it was killed or hunted by the Dutch and other colonisers	The student knows the dodo is extinct due to the impact of colonisation including hunting, habitat destruction and the spread of invasive species such as rats that predated on eggs.
Number of students	Before the visit	4	9	0
	After the visit	3	7	3
Awareness of debates on the culling of bats		The student is not aware of the debate surrounding bat culling, describing that the 'bats have the right to life' or students have no opinion.	The student demonstrates an awareness of the ongoing discussion surrounding the bats as they cause harm to planters. The student believes that bats should not be killed because they have the right to life or they have an important ecological role	The student demonstrates an awareness of the ongoing discussion surrounding the bats as they destroy fruit plantations, but they should not be killed because bats have important ecological roles. Mass culling might put the population at stake
Number of students	Before the visit	7	5	1
	After the visit	5	1	7

From Table 6.8 above, it appears that the visit enabled more students to formulate opinions about biodiversity and society issues especially regarding the mass culling of bats and the need for humans to curtail ecological damage to protect ecosystems. This is illustrated by the higher number of students with a post-visit knowledge level 3. However, only three students managed to explain that the dodo's extinction was also due to predation indicating that the other 10 students retained their prior conceptions that the Dutch killed the dodo leading to its extinction.

6.4.3 Results from the analysis of semi-structured interviews from the 'Nature and Self' lens

The 'nature and self' lens of biodiversity education is mostly concerned with how students developed affect and enjoyment to engage with nature and what moral stance they adopted on preserving life.

Learning area: Appreciation for nature

Before the visit, it could be deduced that five students were neither involved in nor showed any personal appreciation for nature since their leisure activities were not related to nature activities nor watching nature-related programmes on TV or social media. They only described the seaside as being a place for leisure. Two students were involved in activities such as trekking or environmental clubs, yet six students showed more than appreciation and engagement. They enjoyed learning about nature. Following the visit, four students jumped from little or no appreciation to enjoyment to be involved in nature experiences such as trekking activities. Nine students described having enjoyed the trip since they 'learnt' many things, indicating that the visit positively increased students' appreciation and enjoyment for and learning about nature. The knowledge levels of the students are shown in Table 6.9 below.

Learning area: Ethics of preserving species

Students' opinions on the morality of conserving species and the role of human beings in the whole biodiversity debate were investigated. Before the visit five students restricted their opinion to the moral rights of living thing to exist. Eight students added that human beings need to protect species for example Tom exclaimed: "*bats have the right to life, and we must not kill them we should protect them.*" However, after the visit, three students pushed their reasoning further by adding that human beings must protect species since they have ecological roles, indicating that they made the connection between the importance of protecting life both for moral and ecological reasons. For example, Shreena described: *"on earth one needs another...we need trees, trees need animals, each one needs the other to survive. Trees give us air and water; animals help trees to reproduce"*. This type of answer was not recorded before the visit indicating that the visit enabled some students to make deeper reflections on the ethics of species protection. I provide details about knowledge levels in Table 6.9 below.

Table 6.9: Nature and Self Lens - learning areas and description of knowledge levels

Learning areas for 'nature and self' lens		**Knowledge level 1**	**Knowledge level 2**	**Knowledge level 3**
Appreciate the intrinsic value of natural environments		The student shows little or no appreciation for nature.	The student shows appreciation for nature and experiences nature through activities.	The student shows appreciation, experiences nature and enjoys learning about nature.
Number of students	Before the visit	5	2	6
	After the visit	0	4	9
Learning the ethics of preserving nature/biodiversity		The student thinks that all life has the moral right to exist or has no opinion about all life forms should exist.	The student shows awareness that all life has the moral right to exists and humans have the moral duty to protect them	The student shows with reasons, an awareness that all life has the moral right to exists and humans have the moral duty to protect them since we depend on balanced ecosystems for the survival of mankind
Number of students	Before the visit	5	8	0
	After the visit	3	7	3

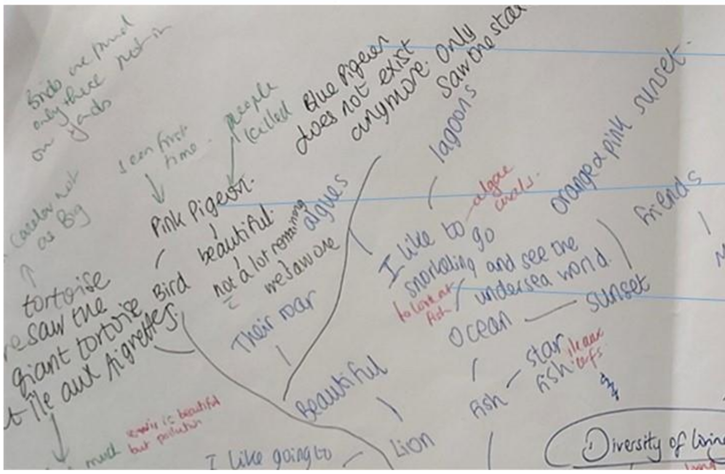
Before and after the visit, the students in the group had different depths of knowledge. Some demonstrated surface knowledge whereas others had deeper reasoning and understanding. This was illustrated by their ability to synthesise and analyse different information as shown in this section through the different knowledge levels. This highlights the idiosyncratic nature of learning in informal spaces which may sometimes be superficial and sometimes deep. The analysis in this section provided an overall idea of knowledge gain for the group of students but not for individuals. In the next section, I investigated how individual students learnt.

6.5 How much did individual students learn?

6.5.1 A deductive analysis of interviews and PMMs to assess knowledge gain

I investigated the knowledge gain for individual students by using the knowledge levels identified in Tables 6.7, 6.8 and 6.9 above as a rubric to deductively code the interview transcripts and PMMs. Considering one student at a time, I used pre-defined codes representing each learning aspect and lens of biodiversity education. Figure 6.3 below is an example of how the interview transcripts and PMM were deductively coded. I then listed all the codes obtained for each student (considering both PMM and interviews) and assigned knowledge levels to them as per the rubric.

Segment of conversation from pre-visit Interview	Codes assigned to the segment	Categorisation according aspects of learning
Anna: *'plants are for us to eat and make medicines'*	EL-importance-ecosystem service (food and medicines)	Ecological literacy lens -importance of biodiversity-Knowledge level 2



Code: PMM-post-visit – extinction-example	**Category:** Ecological Literacy lens aspect-extinct species -Knowledge Level 3
Code: PMM-post-visit – endemic species-example	**Category:** Ecological Literacy lens aspect-endemic species -Knowledge Level 3
Code: PMM-pre-visit – experience nature - snorkel	**Category:** Nature and self lens aspect-experience-Knowledge Level 2

Figure 6.3: Coding process for PMM and Semi-structured interviews

The section of the student's PMM in Figure 6.3 shows that she can give examples of both extinct and endemic species after the visit, and this is reflected in the interview; she was assigned knowledge level 3 for the learning aspect ' understanding of endemic species and extinction' for the ecological literacy lens. Similarly during the pre-interview when asked about the dodo, another student, Joana said '*it was a big bird with a large beak and small wings the Dutch ate the dodo which has now disappeared* '. Thus, in the lens 'biodiversity and society', the learning aspect 'the extinction of the dodo', Joana was attributed to knowledge level 2. After the visit, she said '*it's not true that the French and Dutch killed the dodo. They had predators, and the rats that ate their eggs and predators killed them*'. Thus, the post-visit knowledge level for this learning aspect was promoted to knowledge level 3 as Joana could now explain the impact of colonisation including hunting, habitat destruction and the spread of invasive species such as rats that predated on eggs of the dodo. Using similar reasoning, all interview transcripts were coded, and each student was attributed knowledge levels for each aspect of learning.

The procedure I followed for coding knowledge levels for each of the aspects under each lens was deductive with pre-conceived codes. The development of well-defined knowledge levels enabled me to remain rigorous in my procedure. I also requested one of my friends who has more than 12 years experience in teaching Biology at the secondary level to use the knowledge levels as a rubric and re-code a section of my interviews and PMMs. We discussed the knowledge levels and for each student we had a complete agreement as to the level to be attributed. In the sections below, I report the results obtained from this analysis.

6.5.2 Results from the analysis

To compare students' knowledge gain as a result of the visit, their knowledge levels were converted into scores: for example, score one represented knowledge level 1. For each student, I summed up the knowledge scores for each aspect of learning falling under the three lenses as per Tables 6.7, 6.8 and 6.9. I then calculated a mean pre and post-visit knowledge score for each individual. This gave an overview of each students' knowledge about the three lenses of biodiversity. The result is shown in Appendix 10.14. I plotted the mean pre-visit knowledge score and the mean post-visit score for the students as shown in Figure 6.4 below to get an insight into the change in knowledge. The small sample of 13 students did not allow for statistical tests.

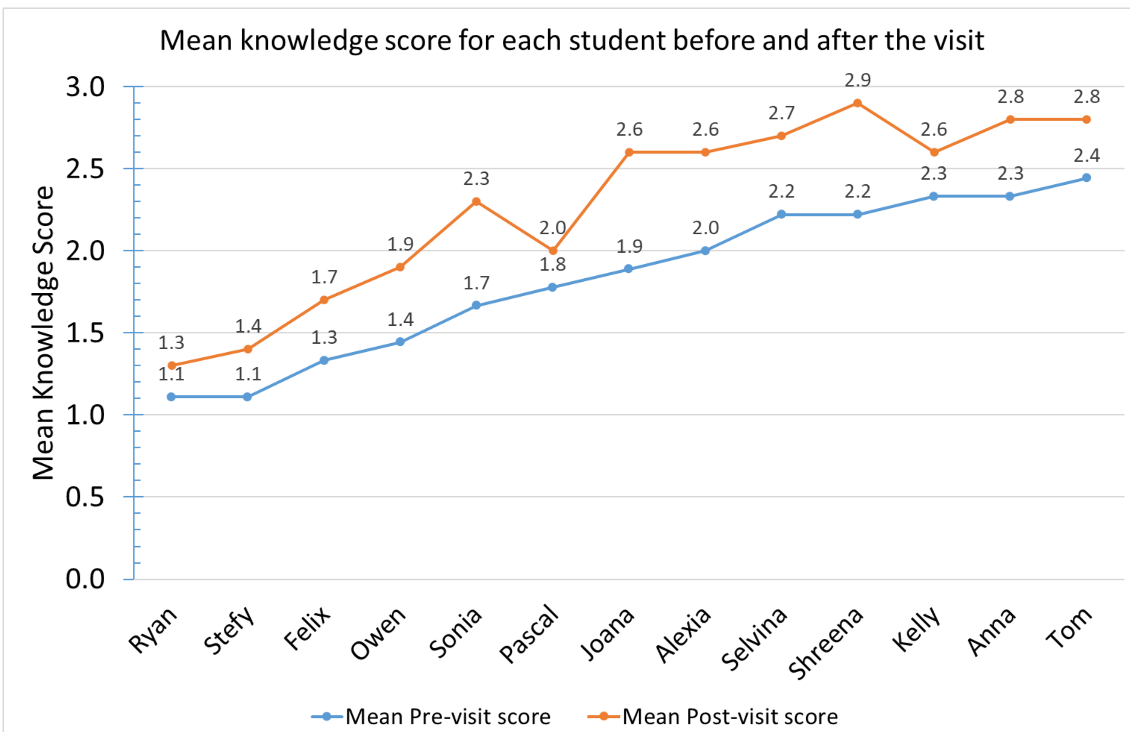
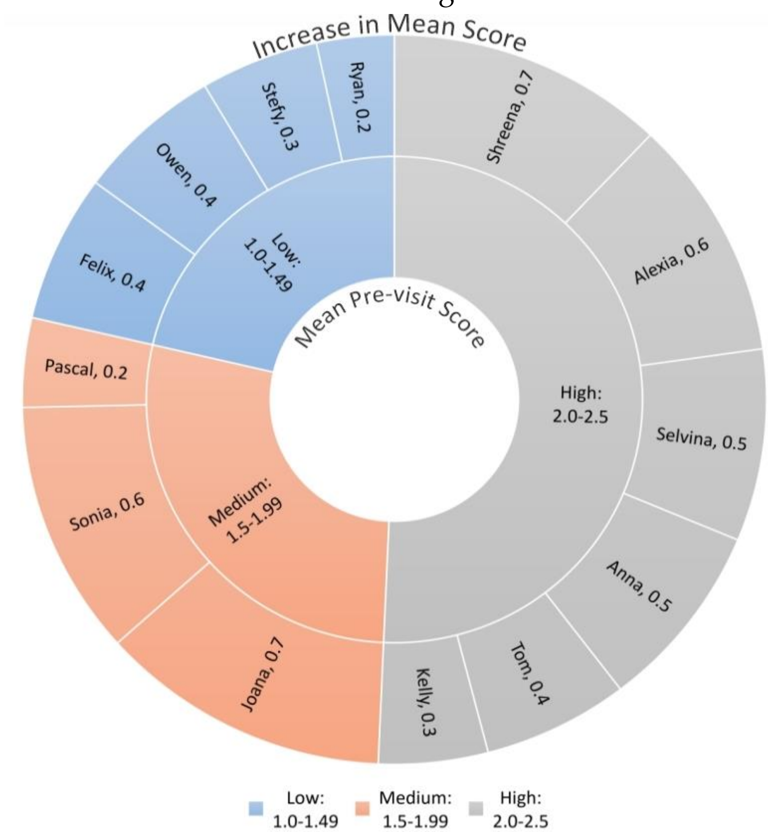


Figure 6.4: Individual students' change in mean knowledge score

Figure 6.4 above gives a graphical representation of how the 13 participants fit across the learning continuum. The x-axis starts with the student Ryan who had the lowest mean pre and post-visit score. Across the group, pre-visit knowledge scores varied widely from a score of 1.1 to 2.4 on a scale of 1 to 3. This indicates a diversity of entry knowledge level of biodiversity among the participants in this study. The graph also shows that the post-visit knowledge score for each student was higher than his/her pre-visit knowledge score and provides evidence that all students learnt something about biodiversity due to their visit. However, certain students learnt more than others, and it would be interesting to investigate how and what each student learnt considering his/her prior knowledge. To this end, I superimposed the mean prior knowledge score and the mean increase in the score as shown in Figure 6.5.



Classification of students as per their mean pre-visit score and knowledge gain

Knowledge Level	**Score**
Low:	$1 \leq$ Score < 1.5
Medium:	$1.5 \leq$ Score < 2.0
High:	$2.0 \leq$ Score ≤ 2.5

Figure 6.5: Individual students' pre-visit knowledge score and corresponding mean change in knowledge scores

Figure 6.5 shows that the mean increase in knowledge score was irrespective of students' prior knowledge score (high, medium or low). Therefore, it is not a norm that students who enter an informal learning setting with higher knowledge will learn more than those at the lower end of the knowledge continuum. To identify the extent of learning and compare inter-individual learning, I developed a grid as an extension of Figure 6.5 above to categorise each student across a learning continuum, based on his/her pre and post-visit knowledge. The grid is shown in Table 6.10 below where squares A, B, C and D represent pre-visit knowledge scores and squares a, b, c and d represent post-visit knowledge scores ranging from 1 to 3.

Table 6.10: Categorisation of individual students' across a learning continuum based on their prior knowledge

Post-visit mean score	**d**	2.6-3.0	**Ad**	**Bd**	Kelly Selvina Shreena Tom Alex **Anna** **Cd**	**Dd**
	c	2.0-2.5	**Ac**	Pascal Sonia **Joana** **Bc**	**Cc**	**Dc**
	b	1.6-2.0	Felix **Owen** **Ab**	**Bb**	**Cb**	**Db**
	a	1-1.5	Ryan **Stefy** **Aa**	**Ba**	**Ca**	**Da**
	Square		1-1.5	1.6-2.0	2.0-2.5	2.6-3.0
			A	**B**	**C**	**D**
		Pre-visit mean score				

The empty white squares from Table 6.10 show that there was no decrease in knowledge scores, indicating that the visit did not inculcate significant misconceptions or misunderstandings among participants regarding biodiversity. The blue coloured squares (Aa) represent those students whose knowledge remained low (score between 1 and 1.5) before and after the visit. Even if, these two students, Ryan and Stefy, in the Aa square, appeared to have limited knowledge of the biodiversity both before and after the visit, their knowledge about biodiversity increased slightly as shown in Figure 6.4.

The pink squares in the grid Table 6.10 represent the students who had higher post-visit knowledge scores than their pre-visit knowledge. All students in the pink squares progressed at least one level up compared to their pre-visit knowledge. Students in the Ab squares, Felix and Owen, had a low prior knowledge score (mean score of 1 to 1.5), but managed to progress one level up towards a medium knowledge in their post-visit score (mean score of 1.6 to 2.0). This indicates that it is possible for students who have limited prior knowledge about a topic to exit an informal learning programme with more knowledge than their entry-level knowledge. Students whose entry-level score was average or medium (score 1.6 to 2.0) (Pascal, Sonia and Joana) can readily move one level up the grid and were situated in the Bc category. Six students had comparatively higher prior knowledge (pre-visit score 2.0 to 2.5) about biodiversity, and they also moved to a higher mean post-visit score ranging from 2.6 to 3.0 in square Cd. Therefore, irrespective of their prior knowledge, all students exit the intervention programme with more knowledge than the entry-level knowledge score.

The advantage of Table 6.10 is that it enables the regrouping of students who had similar learning gains and prior knowledge together. This technique was proved to be very useful by Lelliott (2007) for an in-depth study of students' learning about astronomy in informal learning settings. The changes in knowledge scores aligns with the learning aspects of the three lenses of biodiversity learning that I used as an analytical framework. However, I explored how each student learnt with respect to his/her prior knowledge and investigated how the nature of this knowledge differs among students. Therefore, I chose to write a short portrait of the students whose names are written in blue in Table 6.10. To understand how individuals learn, I first considered the Personal Meaning Maps written by each student hereunder.

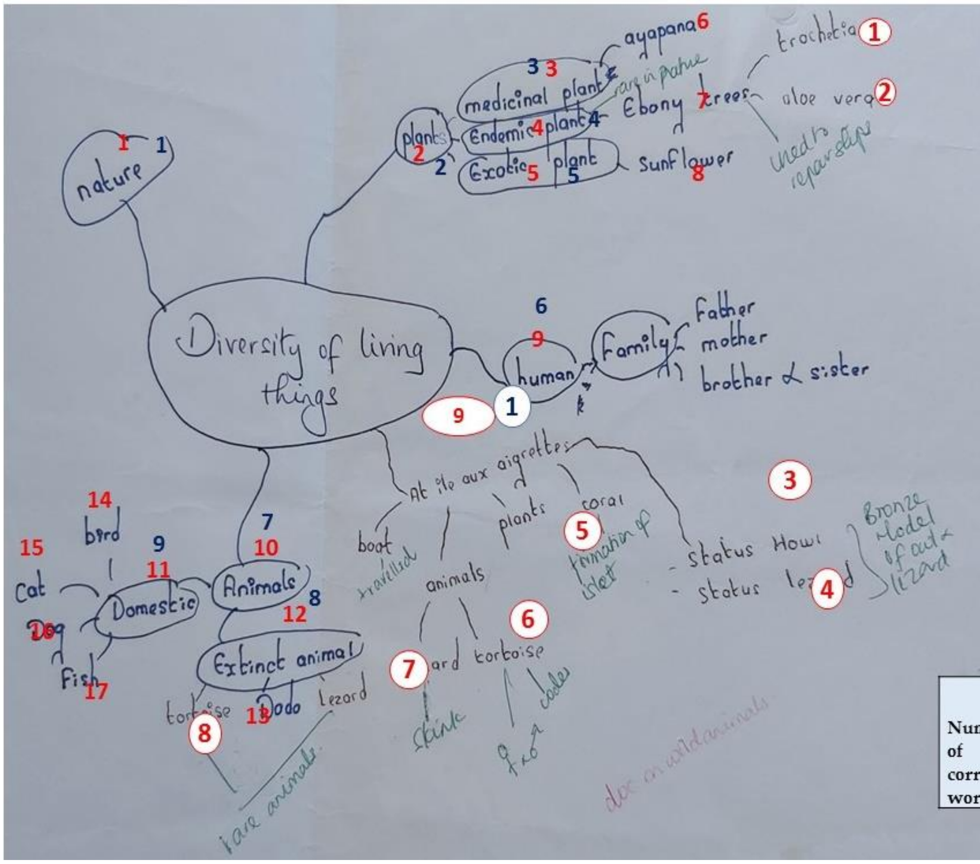
6.5.3 Biodiversity related words and concepts

In section 6.3, I did a qualitative analysis of the 13 PMMs to gain an insight into how the group of students conceptualised 'diversity of living things '. In this section, I intend to examine how individual learners learnt concerning his/prior knowledge. I adopted the method of analysis of PMMs put forward by Falk (2003) to assess how individual students learnt and the variation in knowledge gain across the group.

Falk (2003) recommends directly counting the number of words/phrases (vocabulary) and concepts related to the central phase. Vocabulary enrichment enables expansion of comprehension through words that illustrate specific concepts such that words act like 'hooks and glues' tying ideas and concepts together (Rupley et al., 2012). Therefore, an increase in the number of words relating to biodiversity on the PMMs would mean a corresponding increase in the extent of learning (Falk, 2003). For example, plants, dogs, leaves, humans, bats, reproduction, eggs, feeding, seeds are examples of words that I counted as correct vocabularies since they represent different aspects of living things. In this section, I did not count the words related to feelings or affect but rather made notes about them for each student, which I used in Chapter 7 on interest and learning.

Novak and Canas (2008) describe concepts as a '*perceived regularity in events or objects…designated by a label*'; therefore, a concept is a word/phrase representing a scientific idea illustrated by words having a shared meaning. An increase in the number of appropriate concepts would represent an improvement in how the student organizes scientific information in his/her knowledge structure. I adopted a systematic way of counting the number of concepts and sub-concepts: written words were regarded as a concept only if they represent a scientific idea for example 'reproduction', 'endemic', 'sexual reproduction '. Examples of concepts representing examples of plants such as sugarcane, or animals such as lion, were disregarded.

Thus, examining the words and concepts on PMMs before and after an intervention might provide insight into conceptual learning. The coding process is illustrated in Figure 6.6 below.



Key

2 –words before the visit

1 Additional words after the visit

5 concepts before the visit

2 additional concepts after the visit

Blue ink – participant's writing before the visit

Black ink – Participant's writing after the visit

Red ink – My writing before the visit

Green ink – my writing after the visit

Number of correct words	Before	17	Number of appropriate concepts	Before	9
	After	26		After	10
	New	9		New	1

Figure 6.6: Counting words and concepts on PMMs

The following rules were followed to ensure rigour during the coding of the PMMs

- Count words/concepts written twice as one.
- Words/phrases were considered correct when they represented living things, part of living things, behaviours of living things and abiotic factors since biodiversity comprises the variability of all life on earth at species, genetic and ecosystem levels (United Nations, 1992).
- 'Humans', a living thing was considered a 'correct' word, but words like family, culture and siblings are not considered representative of biodiversity.
- Examples of concepts were disregarded. Only concepts representative of scientific ideas were considered.
- In this part of the analysis, students' feelings were not counted as correct words and concepts related to biodiversity, but I made notes for further reference.

Results

Given the small sample of 13 students, I did not conduct statistical tests apart from calculating means and standard deviations (std) presented in Table 6.11 below.

Table 6.11: Mean number of words and concepts written on the PMM for the group

	Pre-visit PMMs	Additions in post-visit PMMs
Words	Mean: 20.1, std: 16.9	Mean: 9.4, std: 4.8
Concepts	Mean: 7.7, std: 4.5	Mean: 4.4, std: 2.1

The high variability (illustrated by the high standard deviations) in the pre-visit number of words and concepts shows that the prior knowledge of students differed considerably. Similarly, there was a wide disparity between the number of additional words and concepts. The findings reflect two aspects: firstly the participants arrived on IAA with different levels of conceptual and vocabulary knowledge which in turn influences subjective visit experiences and the meaning that each student makes out of these experiences (Falk & Dierking, 2013, p 94).

Words

I plotted a graph to show the distribution of the number of words and concepts written by each student in Figure 6.7. For ease of comparison, I plotted the x-axis of the graph, starting with Ryan who had the lowest pre-visit words and ended with Sonia who had the highest pre-visit words.

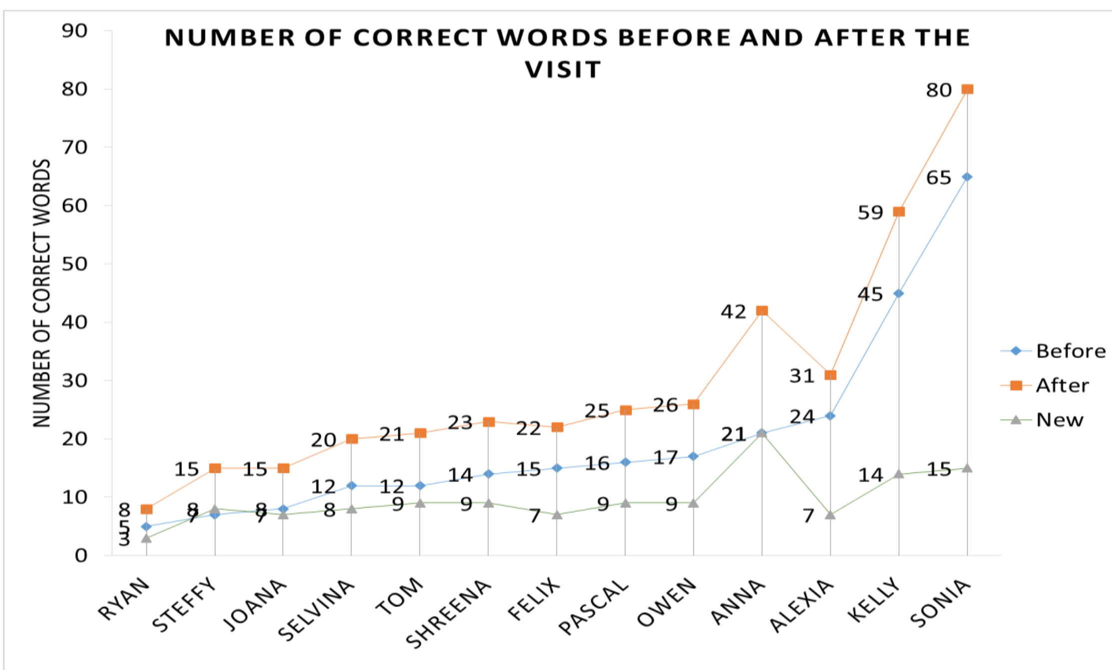


Figure 6.7: Number of correct words related to biodiversity written by each student

The trend was that students (Anna, Kelly and Sonia) with a high number of pre-visit words (above 20), made more additions (above ten words) to their PMMs. On the contrary, those who had the lowest number of pre-visit correct (less than 10) words such as Ryan, Stefy and Joana made fewer additions. This suggests that students' additions in terms of correct words on the PMM are dependent on pre-visit correct words used by the students, therefore their prior knowledge.

Concepts

However, conceptual additions do not appear to depend on the pre-visit concepts as shown in Figure 6.8 below. For ease of comparison I plotted the graph's x-axis starting with Ryan and Selvina who had the lowest pre-visit concepts and ended with Kelly who had the highest pre-visit concepts.

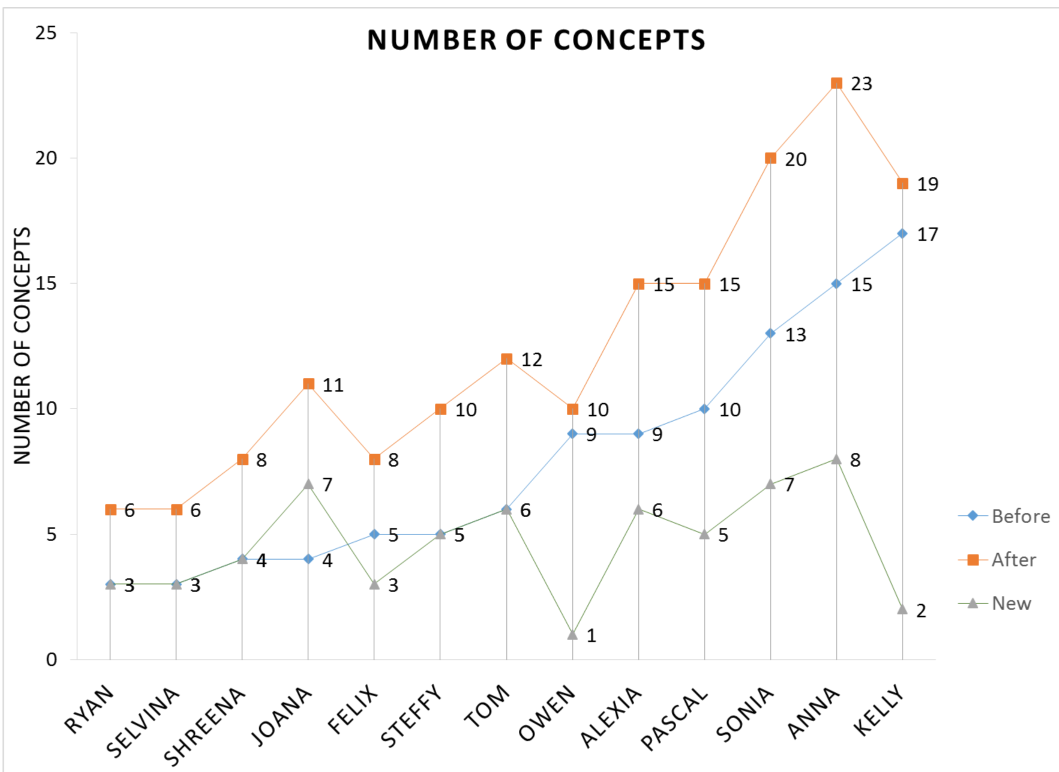


Figure 6.8: Number concepts related to biodiversity written by each student

Students such as Anna and Kelly with similar high pre-visit concepts, (more than 10), differed in the number of additions they made: Anna had eight additional concepts while Kelly added only two concepts. Students such as Ryan with a lower number of pre-visit concepts appear to make fewer additions but this is observation cannot be generalised. The student Joana is the only student who had more additional concepts in her PMM compared to her pre-visit PMM. The range of additional concepts (from 1 to 8) added by students across the group further supports the idea that learning gain is not similar in all students. Overall, all students exhibited an increase in the number of concepts in their post-visit PMM compared to their entry number of concepts, thereby indicating that everyone learnt at least one additional concept.

Following the visit, all students showed an improvement in their vocabulary associated with biodiversity. Vocabulary enrichment enables better comprehension of concepts through words that illustrate concepts (Rupley et al., 2012). In that case, it can be claimed that students deepened their comprehension of existing concepts already present in their memory as illustrated by the addition of new words/phrases. Furthermore, new conceptual additions were less frequent. They seemed independent of the number of pre-visit concepts written on the PMM, indicating that a student's new conceptual learning might not be dependent on his/her existing prior knowledge of concepts. These findings support the idea that visitors are more likely to confirm their pre-existing understandings in informal learning settings than build new knowledge structures (Falk & Dierking, 2013, p 94). However, the small number of PMMs analysed (13) is a limitation preventing the confirmation of this claim. The two graphs above give a rough idea of how each student progressed in knowledge and helped me build the word portraits described hereunder.

6.6 Portraits of selected students

Word portraits are a type of vignette used in social science research representing a participant's character and experience (Spalding & Phillips, 2007). Vignettes have been widely used as a data collection instrument. They have recently been proved to be useful as a tool in action research, enabling the researcher to tell a reflective story of participants (Pitard, 2016) while documenting their experiences. I wrote portraits of chosen participants to report their learning experiences. As a means to ensure rigour and trustworthiness, I remained guided by the following rules to construct each portrait:

- One participant was chosen based on their position (Aa, Ab, Bc and Cd) in the learning categorisation table developed in Table 6.10, representing students below average, average and higher than average level of learning before and after the visit.
- At least one student was chosen from each Scout group, and if I had to choose between two or more students, I chose the ones who had a more elaborate PMM.
- I developed the portraits from the rigorous analysis of the data collected through observation, PMMs and interview transcripts and less from my personal reflections of the data to ensure trustworthiness and avoid researcher bias.
- The portraits are focused more on biodiversity learning rather than interest.

6.6.1 A portrait of Stefy

Stefy was chosen as a representative of the Aa category according to the learning grid in Table 6.12 below. As per my analysis, her pre-visit knowledge of biodiversity was low with a mean pre-visit score of 1.1, and she appeared to have gained little from the trip. However, she showed slight progress through a post-visit knowledge score of 1.4, as shown in Table 6.13. I attempted to bring out Stefy’s limited knowledge gain through the next portrait.

Table 6.12: Stefy's position in the learning categorisation table

Post-visit mean score		2.6-3.0	**Ad**	**Bd**	Cd	**Dd**
		2.0-2.5	**Ac**	**Bc**	**Cc**	**Dc**
		1.6-2.0	**Ab**	**Bb**	**Cb**	**Db**
		1-1.5	**tefy** **Aa**	**Ba**	**Ca**	**Da**
			-1.5	1.6-2.0	2.0-2.5	2.6-3.0
	quare					
		Pre-visit mean score				

Table 6.13: Stefy's knowledge scores for the learning aspects falling under the three lenses of biodiversity learning

Ecological literacy lens				**Nature and self lens**		**Biodiversity and Society lens**				
Understanding the concept of biodiversity	**Understanding the importance of biodiversity**	**Knowledge of the terms endemic and extinct**	**knowledge of conservation practices**	**appreciation, experience and learning about nature**	**view on the morality of conserving species**	**understanding of the negative impact of man on the ecosystem**	**awareness of the bat debate**	**knowledge of the causes of the extinction of the dodo**	**Mean Pre-visit score**	**Mean Post-visit score**
2	2	2	1	2	1	1	1	1	1.1	1.4

Stefy is a 15-year-old girl who attends an all-girls catholic, private but state-aided secondary school which shows a yearly average pass rate of 15.79%. Based on the school's yearly performance in national examinations (described in the methodology section in Appendix 10.2), she would be an average student. At school, she enjoys French, English and literature classes but feels ‘bored’ during biology, physics and maths lessons. Her spare time is spent juggling between Scouts meetings, singing lessons and adolescent TV shows, and listening to songs on YouTube.

I would qualify Stefy’s PMM as very basic: before the visit ‘diversity of living things’ was branched into five concepts ‘marine life’, ‘plants’, ‘animals’ (branched into ‘birds’ and domestic animals such as cats and dogs), ‘family’ and ‘human beings’. This amounted to seven correct words (as a reminder: all words, human beings and human relationships were counted as one). After the visit, she made additions of eight new words/phrases (endemic, ‘cardinal’, ebony, tortoise, environment, pink pigeon, red veins and eggs in a nest) and five new concepts (i) eggs, (ii) male and female (iii) environment (iv) endemic (v) plants with red veins – heterophylly) as shown in Figure 6.9 below:

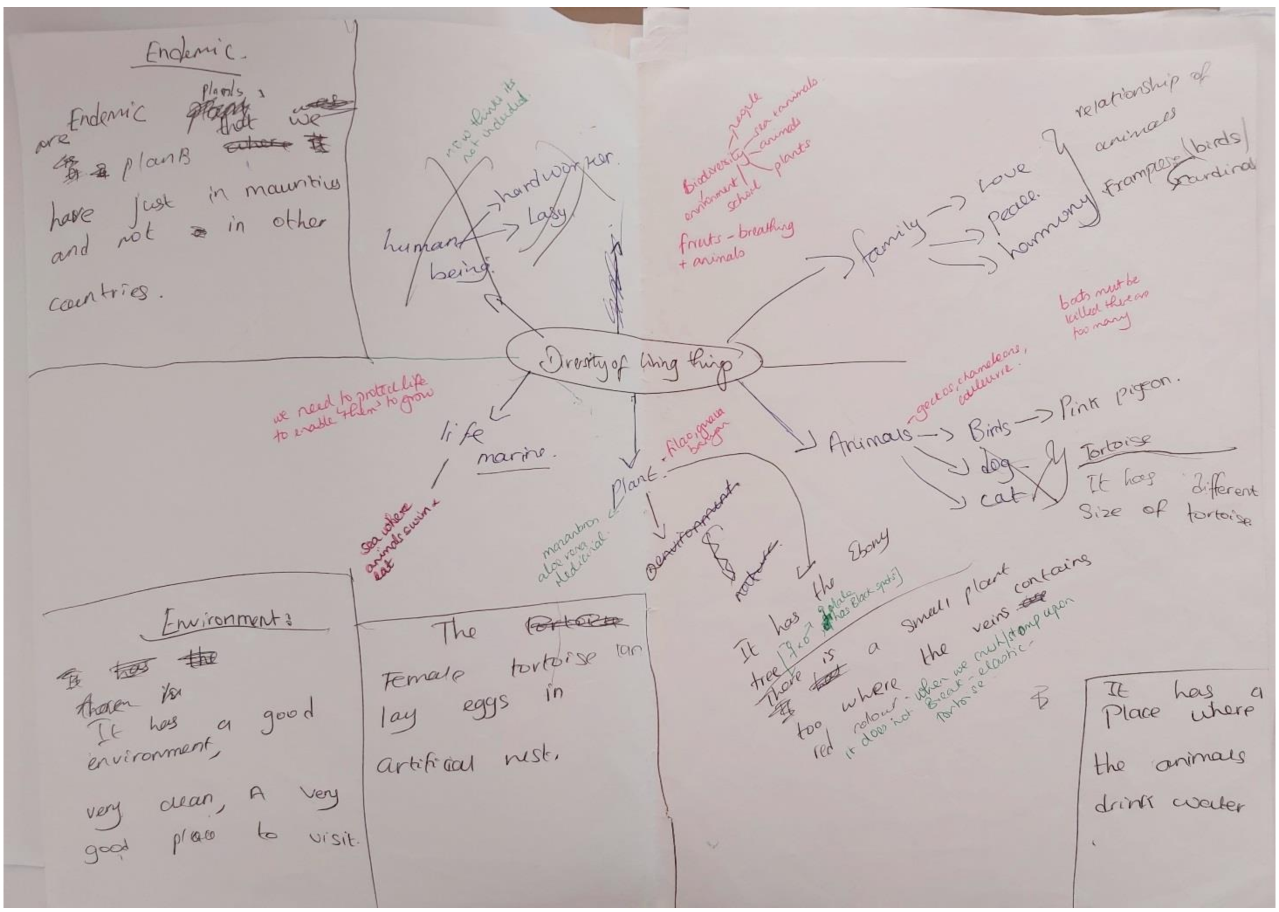


Figure 6.9: Stefy's Personal Meaning Map

Stefy’s knowledge score progressed from 1 to 2 for two learning aspects of the ecological literacy lens: understanding the concept of biodiversity and understanding endemic species and extinction. During her pre-visit interview, Stefy explained that the diversity of living things is about: '*Environment, the animals, school, plants and people and the sea and animals that live in the sea'*. Stefy knew that there are animals that swim in the sea, but the sea means 'swimming' at 'Pereyberre' public beach to her. Thus, her pre-visit knowledge score was 1 for the learning aspect 'understanding the concept of biodiversity ', which appears to be limited to a description of biodiversity as types of plants and animals including humans and domestic animals. This score progressed to 2 after the visit since she could now explain that biodiversity comprises 'endemic plants', giving examples both in her PMM and during the interview of different types of plants and animals that are different in terms of their shape, size and mode of reproduction. For example, Stefy explained during the post-visit interview: '*small plants where veins have red colour'* and *'there are the male and the females in ebony. The males… it's easy to recognize because there are black spots on it, while the females do not have many black dots...that's all I remember!'.* Furthermore, in the PMM, Stefy crossed out her previous writing that diversity is about '*hard workers and lazy human beings'* since she now thought it was not correct. Thus, Stefy showed an improvement in her understanding of biodiversity and re-visited her prior conceptions.

Another concept which Stefy appears to have learnt is about endemic species. During her pre-visit interview, when probed about species unique to Mauritius, she gave wrong examples of exotic or introduced species such as Filao, guava, and chameleon. She claimed to have heard of the term 'extinct' but did not know what it means. However, after the visit, Stefy dedicated space in her PMM where she wrote '*endemic'*, elaborated as '*plants we have in Mauritius and not in other countries '*. During the interview, she explained: '*endemic is linked to biodiversity '* and that the '*ebony'*, the *'plants with red veins'* and the '*skink'* are examples of '*endemic'*. She made no mention of the term 'extinction', and even if she provided a photograph of Mauritius's extinct owl, she only said *'it's a bird, but it's different'*, but she explained that '*it has disappeared*'. The dodo was *a bird with small wings which could not fly but could run quickly'*. Therefore after the visit, Stefy showed a thorough understanding of the term endemic. Still, it appears that the term 'extinction' was not very clear in her mind even if several extinct species were encountered and explained during the guided tour. Thus, her knowledge score progressed from 1 to 2 for understanding endemic species and the extinction of the ecological literacy lens. When questioned about the reasons for choosing the photographs she submitted, she described the photos as '*interesting*', or it's *beautiful'* or *'I wanted a picture'*, without further elaboration.

Nevertheless, in the post-visit PMM, Stefy made some interesting additions illustrating that she was able to remember the exhibits encountered on IAA: '*the female tortoise lays eggs in an artificial nest*', '*the ebony is an example of a plant'* and the '*pink pigeon is an example of a bird'*. Thus, she had five other conceptual additions ((i) eggs in nest, (ii) male and female (iii) environment (iv) endemic (v) plants with red veins – heterophylly). During the interview, she explained:

Interviewer: "What do you remember about the visit?"

Stefy: "I saw tortoises, there was a box of sand there. They explained that the female tortoise lay their eggs there. There were skink lizards, and there was also pink pigeon, we saw the small birds at the time of reproduction the males...half its upper body turns red-orange, and the female remains olive green

Interviewer: What is this bird called?"

Stefy: "uh,… I wrote down its name (trying to remember) here it is cardinal" (referring to her PMM) (Post int: Stefy, line 16)

Stefy recalled her experience of smelling the leaves with the scent of the apple or the orchids, and the seedlings having a red-veined mid-rib:

Interviewer: "Ok, small plants where veins have red colour… what do you mean by this?"

*Stefy: "…. The small leaves have red veins, and when we crush it, it will not break, it is elastic. These plants are linked to the tortoises, and if tortoises walk on them, they will not break. Because tortoise often walks on them, they are elastic". (*Post int: Stefy, line 62)

However, Stefy's recall of exhibits appeared to be limited to her sensory experience on IAA. Still, she could not give thorough explanations that illustrate an understanding of biodiversity-related terms and concepts. For example, she remembered walking on the seedlings that are 'connected' to the tortoise but she failed to explain that the 'red veins' are warning signals of being poisonous to discourage tortoises from grazing the leaves. Furthermore, after the visit, she maintained that we need to protect all life because '*no one would want to die*' and that '*trees and animals need a place to live* '. However, her views on the bat culling appear contradictory to the idea of '*no one would want to die*' as she thought that bats need to killed '*because there are too many* '.

Before the visit, Stefy understood, that forests and trees provide human beings with medicines, wood pulp and pure air to breathe. She was attributed a knowledge score of 2 for 'understanding the importance of biodiversity of the ecological literacy lens'. After the visit, she remembered other plants like '*Mazambron'* and *'Aloe Vera'* which are used for medicinal purposes demonstrating an awareness of the importance of biodiversity only for the ecosystem services provided to humanity (knowledge score 2), but there was no mention of ecological processes such as nutrient recycling, the ecological role of species and interaction in nature and extinction.Furthermore, it appears that Stefy has a blurred awareness of conservation measures describing IAA as '*a place where they breed plants and animals*' without specifying that the reason is to protect them and prevent extinction.

Thus, Stefy is an example of a student who entered IAA with limited prior knowledge and learned little about biodiversity. It appears that her learning of concepts related to biodiversity such as conservation measures, sex differentiation in plants and animals and reproduction remained very fuzzy and unclear, demonstrated by her inability to elaborate on underlying ecological reasons and implications of these concepts. She demonstrated learning through recalling and classifying and less analysing and evaluation (Krathwohl, 2002). Her recall was restricted to the names of exhibits and some of her experiences on IAA. Thus, I would consider that Stefy's additional knowledge has been gained as a result of her visit to IAA. Stefy is an example of a student whose affective and conative learning experiences mattered more than her cognitive learning. I give further details about such kinds of learning in Chapter 7.

6.6.2 A portrait of Owen

Owen is a student representative of the Ab category as per the learning grid in Table 6.14. My analysis revealed a low pre-visit mean knowledge score of 1.4 and a post-visit knowledge score of 1.9, as shown in Table 6.15.

Similar to Stefy, Owen appeared to have gained little from the visit. Still, given that his entry knowledge score was higher than students of the Aa category, he managed to move one level up the learning classification table towards the Ab category. Through the following portrait of Owen, I will bring out the differences in Owen's knowledge compared to Stefy and Ryan, representing the Ab category.

Table 6.14: Owens's position in the learning categorisation table

Post-visit mean score	**D**	2.6-3.0	**Ad**	**Bd**	Cd	**Dd**
	C	2.0-2.5	**Ac**	**Bc**	**Cc**	**Dc**
	B	1.6-2.0	Owen **Ab**	**Bb**	**Cb**	**Db**
	A	1-1.5	**Aa**	**Ba**	**Ca**	**Da**
			1-1.5	1.6-2.0	2.0-2.5	2.6-3.0
	Square		A	B	C	D
		Pre-visit mean score				

Table 6.15: Owen’s knowledge scores for the learning aspect falling under the three lenses of biodiversity learning

Ecological literacy lens				Nature and self lens		Biodiversity and Society lens				
Understanding the concept of biodiversity	Understanding the importance of biodiversity	Knowledge of the terms endemic and extinct	knowledge of conservation practices	appreciation, experience and learning about nature	view on the morality of conserving species	understanding of the negative impact of man on the ecosystem	awareness of the bat debate	knowledge of the causes of the extinction of the dodo	Mean Pre-visit score	Mean Post-visit score
1	2	3	2	3	2	1	1	2	1.4	1.9

Owen attends a private state-aided secondary school with an average pass rate at SC and HSC level 68.68%. The 14-year-old has a keen interest in the practicals on grafting and cuttings during Agriculture classes. Apart from the Scout meetings, Owen attends regular basketball training in a club and enjoys watching wildlife documentaries which he did not remember much, demonstrating evidence of appreciating nature by watching TV programmes. Thus, for learning objective ‘appreciating the intrinsic value of the natural environment’ of Nature and self lens, Owen was attributed a score of 2. This knowledge score progressed to 3 following the visit, since he seemed much impressed by his visit to IAA and even tried to search for the animals found there on the internet. Owen also progressed in the knowledge score (from 1 to 2) for two additional aspects namely (i) awareness of conservation practises as a means to preserve biodiversity – Ecological literacy lens and (ii) the extinction of the dodo – Biodiversity and society lens.

Compared to Stefy in the Aa, category, Owen’s pre-visit PMM was slightly more structured, as shown in Figure 6.10. Before the visit, there were 17 correct words which increased to 26 in the post-visit PMM. There were nine pre-visit concepts on the PMM (nature, plants, medical plants, endemic plants, exotic plants, humans, animals, extinct animals and domestic animals). I considered ‘corals’ as the only additional concept after the visit, which illustrates the islet's formation. All the other additional words written by Owen were deepening of already existing concepts. He further illustrated endemic plants with examples such as *Trochetia spp* and *Aloe vera* and extinct animals with words like an owl and extinct tortoises and lizard (skink).

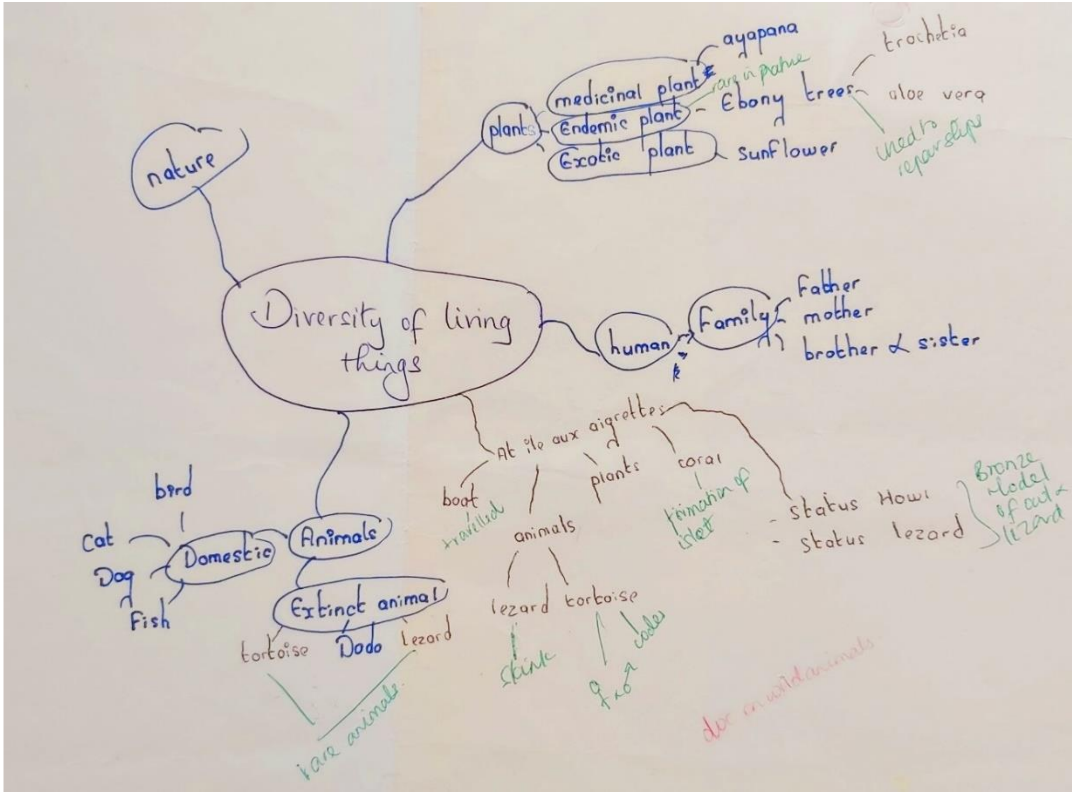


Figure 6.10: Owen's Personal Meaning Map

For the boy, the visit contributed to a deeper understanding of the existing concepts of endemic and extinction through additional examples. Based on the criteria that I used to allocate knowledge scores (Table 6.7, 6.8 and 6.9) both before and after the visit, Owen had a knowledge score of 3 for understanding the concept of endemic and extinct species of the ecological literacy lens of biodiversity learning. For the same lens, Owen also showed progress in his awareness of conservation practices moving from no awareness (knowledge score 1) to an awareness that human beings are conserving species and ecosystems to protect endangered species with at least one example (knowledge score 2). Owen described 'rare species found on IAA', including the pink pigeon and the skink during the post-visit interview. He described the '*tortoises with numbers on the carapace to identify them*' as an example of human intervention to protect species.

Furthermore, Owen also modified his pre-visit description of the dodo as a '*big bird that has gone extinct*' and specified in the post-visit interview that the '*dodo has gone extinct as the Dutch killed them for food'*. Thus, for this learning aspect, Owen moved from a knowledge score of 1 to 2. The change in knowledge scores for these three aspects contributed to Owen moving to a higher level (towards Ab) in the grid that I used to classify students across a learning continuum.

However, just like Stefy, Owen (less talkative though) seemed to remember the exhibits on IAA mentioning encounters with pink pigeon, the owls, the skink and the rare ebony trees. However, he could not elaborate on the exhibits and when probed his answer was '*I don't know'*. For the biodiversity and society lens, regarding the awareness around the culling of the Mauritian bats, and the negative impact of human beings on the ecosystem, his knowledge remained unchanged with a score of 1. Before and after the visit, Owen described pollution of the environment due to urbanization stating the construction work in the context of the Metro project in Mauritius but could not give examples of harm caused to the environment such as reduced forest cover species loss. He explained that bats should not be killed since '*they have the right to life just like us human beings*' without any indication of awareness of the media's debates over the conflict of interest regarding the mass culling.

Furthermore, Owen's understanding of the concept of biodiversity was restricted to biodiversity is about '*different types of plants, animals (including endemic species) and humans*' without explaining differentiating characteristics in terms of body shapes or reproduction modes. Thus, I would consider that Owen is a student who entered and exited IAA with limited prior knowledge but managed to learn something and especially deepened his conceptual understanding of endemic and extinct species through examples. His mean knowledge score after the visit increased by 0.5. Based on the grid that I developed, he showed progress one level up the learning continuum when comparing the 13 students of the study. However, I would not qualify Owen as somebody who made significant learning gains than the students I describe hereunder. His learning was mostly through exemplifying.

6.6.3 A portrait of Sonia

Sonia is a student in the Bc category as shown in Table 6.16. Her entry-level knowledge score was average (1.7) and her post-visit mean score of 2.3, therefore higher than the average shown in Table 6.17. She demonstrated a change of 0.5 in mean score just like Owen, but she had a high entry-level knowledge score which could explain why she reached the greater than average knowledge level. Sonia had an elaborate PMM as shown in Figure 6.11 below. She an example of a student whose knowledge score changed from 1 to 2 and 2 to 3 for four learning aspects.

Table 6.16: Sonia's position in the learning categorisation table

Post-visit mean score	**D**	2.6-3.0	**Ad**	**Bd**	Cd	**Dd**
	C	2.0-2.5	**Ac**	Sonia **Bc**	**Cc**	**Dc**
	B	1.6-2.0	**Ab**	**Bb**	**Cb**	**Db**
	A	1-1.5	**Aa**	**Ba**	**Ca**	**Da**
			1-1.5	1.6-2.0	2.0-2.5	2.6-3.0
	Square		A	B	C	D
		Pre-visit mean score				

Table 6.17: Sonia's knowledge scores for the learning aspects falling under the three lenses of biodiversity learning

Ecological literacy lens				Nature and self lens		Biodiversity and Society lens				
Understanding the concept of biodiversity	Understanding the importance of biodiversity	Knowledge of the terms endemic and extinct	knowledge of conservation practices	appreciation, experience and learning about nature	view on the morality of conserving species	understanding of the negative impact of man on the ecosystem	awareness of the bat debate	knowledge of the causes of the extinction of the dodo	**Mean Pre-visit score**	**Mean Post-visit score**
3	2	3	2	2	2	2	3	2	1.7	2.3

Sonia is a 14-year-old girl from the Girl Guides group. She attends a fee-paying secondary school with an average pass rate of 82.63%. Seemingly a conscientious student, Sonia claims not having much time for leisure activities as she would rather concentrate on her studies. However, she does watch films and chats with her friends on social media. At schools, Sonia enjoys going to the laboratory during science classes for the 'experiments'. After being coerced by her parents to join the club, she has started to develop a liking for Scout meetings and activities.

Sonia drew an elaborate PMM, where she wrote many details about the 'diversity of living things ' as shown in Figure 6.11 below. I allocated her a score of 3 for the area of understanding the concept of biodiversity before the visit. Her description of biodiversity was largely about different types of plants and animals and their inherent characteristics that distinguish species and animal groups including mode of reproduction, feeding behaviours, habitats and ecosystems. She even gave examples of hierarchically branching of each concept with more general concepts at the top and specific sub-concepts below. I note that the two students, Stefy and Owen, did not mention either the characteristics of living things or ecosystems.

The PMM of Sonia before the visit had 65 words and 13 concepts, to which she added 15 new words and seven new concepts (nature reserves, 'rats ate eggs', 'extinction', tortoises sensitive shell, 'scientists save species', 'leaves smelling like apples', past exploitation of tortoises for its oil) after the visit. These new conceptual additions are related to the content of the guided tour and its stopping points. She specified "*IAA is a nature reserve where scientists work to prevent extinction, the leaves of an endemic plant smell like apple and in the past sailors overexploited the endemic tortoises, digging holes inside its sensitive carapace to extract oil which they used as a cure against scurvy*". Thus, I would consider Sonia's conceptual additions on the PMM to be due to her IAA encounters, and she demonstrated a recall of some details that the guide spoke about.

Furthermore, Sonia made progress regarding three learning aspects. Firstly she re-visited her previous conception that *'bat should not be killed as they have the right to life'* (knowledge score of 1) to '*No, bats should not be killed, if we kill them all, it will become extinct, and maybe there are some interesting things about the bats that we could not discover because they have become extinct* (score 3)'. Through her answer, Sonia specified that mass culling might lead to extinction. The 'interesting things' that are yet to be discovered might be the ecological and intrinsic value of bats as a species in the ecosystem. Sonia also progressed from a knowledge score of 1 to 2 regarding the knowledge areas on the negative impact of human beings on the ecosystem. After the visit she recognized that urbanization and construction put species at risk of extinction. However, she did not mention the dire need to prevent or halt these anthropogenic activities causing harm to the ecosystem.

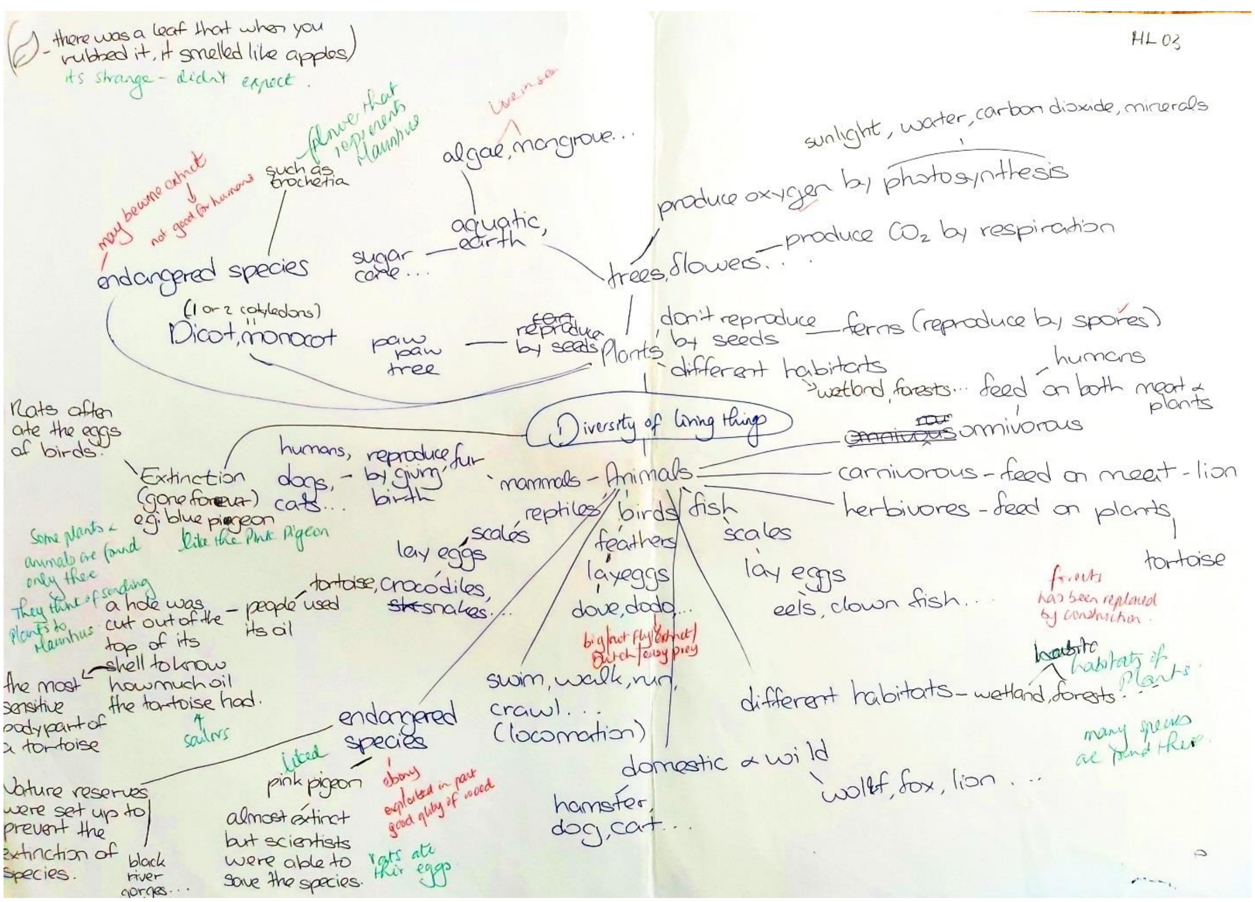


Figure 6.11: Sonia's Personal Meaning Map

Similarly, she attained a knowledge score of 2 after the visit, regarding the learning area about the ethics of preserving nature and biodiversity of Nature and Self lens. Her thoughts on the issue moved from '*all life forms have the right to exist*' (score 1) to '*human beings must protect them*' (score 2) as illustrated by her descriptions of the pink pigeon which '*scientists bred*' or '*killing of bats might lead to extinction, so we should not kill them*'. This shows a certain ability to analyse and evaluate the knowledge gain. However, she was unable to specify that 'extinction' upsets the balance in nature, which is essential for humanity's survival. Her focus seemed to be on the importance of species for humanity rather than on species' ecological roles. Nevertheless, even before the visit, Sonia appeared to have a clear understanding of the concepts of extinction, as illustrated below:

Interviewer (referring to the PMM): "Here you wrote endangered species. What are endangered species?"
Sonia: "It means that there are not too many, they may become extinct"
Interviewer: "What is extinction?"
Sonia: "They are no longer on earth, all have died"
Interviewer: "Why is this bad?"
Sonia: "It's like if we need it, hmm like a cow, it gives us food, if it goes we would not have food"
(Post int: Sonia, line 55)

She also had an idea of the conservation practices illustrating the pink pigeon, an example of an endangered species that was bred in captivity to prevent its extinction.

Sonia is an example of a student who recalled quite a few details of the exhibits and discussions with the guide that happened on IAA. She already had a good knowledge of certain biodiversity-related concepts (extinction, conservation, endangered species) which she exemplified and reinforced her previous conceptions further. For example, she could associate the '*Blue Pigeon as being extinct that could not be saved like the pink pigeon*'. Thus both the concept of endangered species (saved from extinction) and extinction, as well as the appropriate examples, seem clear in her mind. This enabled her to make differentiations, comparisons and associations better than Owen thus showing a degree of analytical thinking. She further showed a reinforcement of her understanding of conservation practices by writing in her PMM that 'nature reserves were set up to prevent extinction' adding the 'Black River Gorges' as an example. Thus, Sonia arrived on IAA with an average knowledge for the three lenses of biodiversity learning and completed the visit with more knowledge. Her knowledge gain seems to be related to the content of the guided tour. Still, in addition to demonstrating her learning through exemplification, she was also able to show a deeper learning gain through some analysis and evaluation.

6.6.4 A portrait of Anna

According to the learning grid I devised, Anna is a student representative of the Cd category, as shown in Table 6.16. 'Cd' implies entry knowledge above average (2.3), even higher than the post-visit score of some students like Owen and Stefy. Anna's pre-visit knowledge about biodiversity and some areas where she appears to have learnt as a result of the visit are highlighted in Table 6.19. Anna's mean post-visit knowledge score was 2.8, as shown in Table 6.19.

Table 6.18 Anna's position in the learning categorisation table

Post-visit mean score						
	d	2.6-3.0	**Ad**	**Bd**	Anna **Cd**	**Dd**
	c	2.0-2.5	**Ac**	**Bc**	**Cc**	**Dc**
	b	1.6-2.0	**Ab**	**Bb**	**Cb**	**Db**
	a	1-1.5	**Aa**	**Ba**	**Ca**	**Da**
			1-1.5	1.6-2.0	2.0-2.5	2.6-3.0
	Square		A	B	C	D
		Pre-visit mean score				

Table 6.19: Anna's knowledge scores for the learning aspects falling under the three lenses of biodiversity learning

Ecological literacy lens				**Nature and self lens**		**Biodiversity and Society lens**				
Understanding the concept of biodiversity	**Understanding the importance of biodiversity**	**Knowledge of the terms endemic and extinct**	**knowledge of conservation practices**	**appreciation, experience and learning about nature**	**view on the morality of conserving species**	**understanding of the negative impact of man on the ecosystem**	**awareness of the bat debate**	**knowledge of the causes of the extinction of the dodo**	**Mean Pre-visit score**	**Mean Post-visit score**
3	3	3	2	3	2	3	3	3	2.3	2.8

Anna is a 15-year-old student who attends a 'star' state secondary school with a pass rate at HSC level of 100%. This indicates that academically Anna is a bright student who finds chemical reactions in Chemistry and reproduction in Biology classes at school '*intriguing and fascinating*' and who regularly watches documentaries on TV. As a Scout group member for two years, she enjoys trekking in nature and '*technology-free* ' activities with new friends and socializing. I allocated Anna a pre-visit score of 3 for the learning area 'appreciating, experiencing and learning about nature '. Anna's PMM is not as elaborate as that of Sonia but indicates a good organisation of her ideas, as shown in Figure 6.12 below.

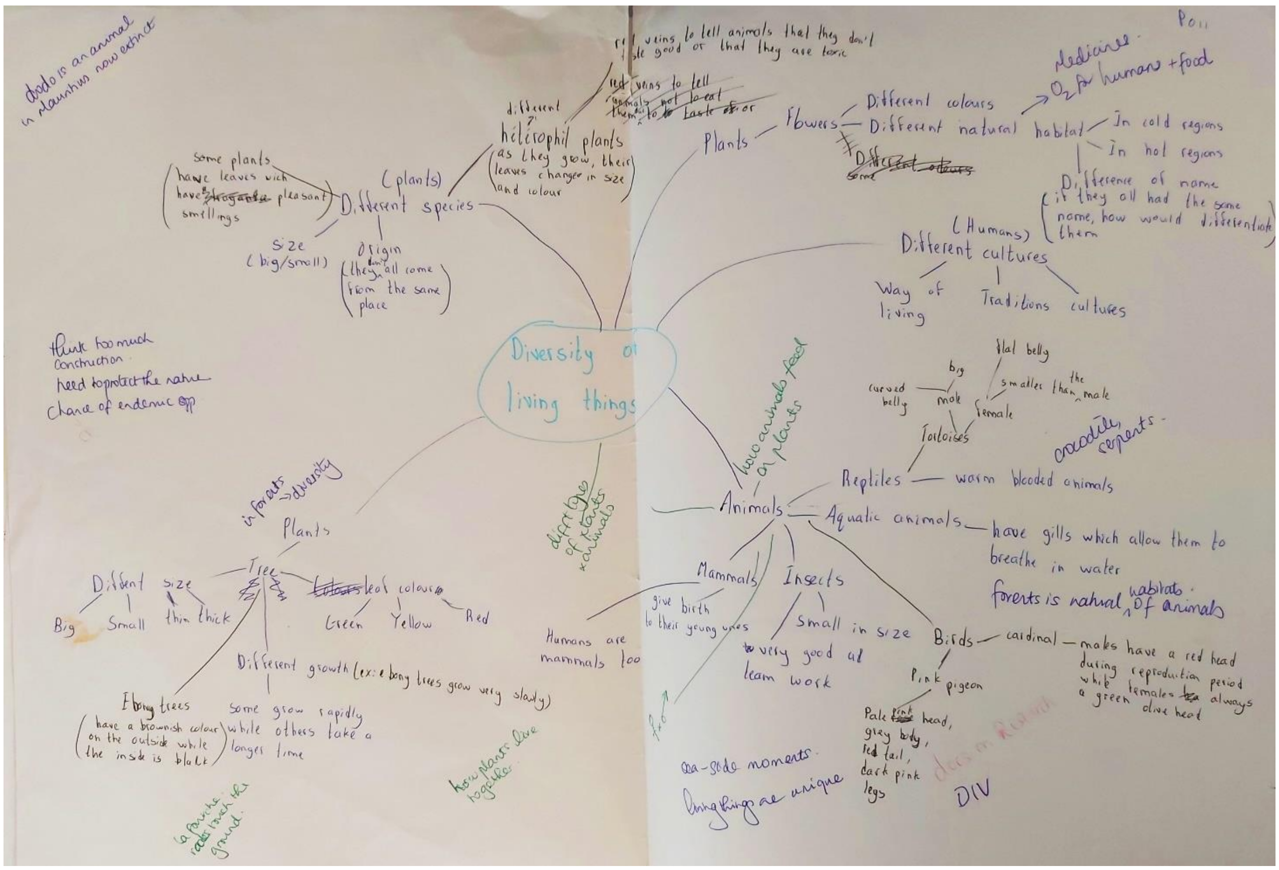


Figure 6.12: Anna's Personal Meaning Map

During the interview, I did not have to probe much, since Anna readily gave answers without asking. One example is shown below, where she readily spoke about the duty of human beings to protect our endemic species since they are threatened by human activities that cause harm to the environment:

> *Interviewer: "Can you tell me something about the environment in Mauritius?"*
>
> *Anna: "These days I think they are constructing a lot and we need to protect our nature more and make more place because this is the beauty of our island"*
>
> *Interviewer: "Why do we need to protect nature?"*
>
> *Anna: "Because we have the chance that there are many endemic plants on our island that we do not have in other countries and we need to protect them."*

Interviewer: *"What are endemic plants?"*
Anna: *"Plants that are not found elsewhere. They are found only in Mauritius"* (pre int:Anna, line 56)

Anna demonstrated a pre-visit understanding of both endemic and extinct species claiming that the "*dodo was a bird that we had in Mauritius, that could not fly away from the Dutch who were killing them for eating but unfortunately it went extinct*". She demonstrated an understanding of extinction due to human activities. She could show the link between different biodiversity concepts. For example, the negative effects of human beings on the ecosystem potentially lead to extinction, which is harmful to the environment. Thus, Anna's pre-visit knowledge construction of biodiversity appears much more organized than the other three students, illustrated through her ability to make connections between interrelated concepts. In the conception of the term 'biodiversity,' Anna specifies both on her PMM and during the interview, biodiversity is about human beings, plants, and animals that differ in their characteristics and live in different ecosystems (cold hot and cold regions). She describes that humanity's survival is dependent on many types of ecosystem:

Anna: *"There are many diversity, many types, and in an ecosystem, we need to have many types to survive."*
Interviewer: *"What do you mean by ecosystem?"*
Anna: *"Meaning everything is connected"*
Interviewer: *"How connected?"*
Anna *"Each one needs one another to survive"* (pre-int, Anna, line 108)

For two learning areas, Anna's pre-visit conception remained unchanged. She described that different ecosystems are important because '*they provide us with oxygen*', recognizing the importance of ecosystem services for human beings. She could cite the example of the 'Mauritius Echo Parakeet' which was saved from extinction due to conservation actions, but could not describe that extinction upsets the balance in the ecosystem. Thus, the concept of ecosystem balance was not very clear in Anna's mind.

Following the IAA trip, Anna added some concepts and examples in her PMM, which illustrate that the visit enhanced or re-enforced her understanding of the biodiversity concepts. For example, before the visit, Anna showed awareness of the debates surrounding the bat culling but could not specify that mass culling puts the species at risk of extinction. After the visit, she explained:

Interviewer: *"Do you think we need to kill the bats?"*
Anna: *"No, because bats form part of our ecosystem. If there are no bats, they will not be there to disperse the fruits, there will be no new plants that will grow in Mauritius."* (Post int: Anna, line 64)

After the visit, Anna understood the role of bats as fruit dispersers and the negative ecological effects of its potential extinction. She progressed from a score of 2 to 3 for the learning area 'bat debate'. Similar progress was noted for the extinction of the dodo where before the visit, she believed the dodo went extinct as the Dutch hunted them. After the visit, she exclaimed:

Anna: *"What I learnt there is that it's not the Dutch who are the main cause for the dodo's extinction! It is predators.. the dodo had small wings because in the beginning there were no predators on Mauritius and it didn't need to fly but could run very quickly!"* (Post int: Anna, line 57)

Anna's explanation was a kind of reproduction of the guide's exposé, and now Anna understood the potential negative effects of predators introduced by human beings that contribute to extinction.

It appears that some of Anna's cognitive learning was related to the affective learning she experienced as she was seemingly impressed by the information provided by the guide. For example, in her PMM she wrote about the birds' physical appearance, pink pigeon and the 'Cardinal' and stated: "*It was interesting when we were told about the 'Cardinal'… how to differentiate a male from a female. A male's head is reddish during the mating period".* She described her experience of IAA mostly in terms of what she learnt and the nature of the information obtained, which impressed her and caught her attention:

Interviewer: *"Tell me 2-3 aspects of the visit that you liked the most"*

Anna: *"It's the way the guide explained to us for us to understand, She explained how a tortoise reacts when we touch its carapace because its vertebral column is attached to it. The heterophylly of plants is how the leaves change as they grow for them to be protected against predators*!" (Post int: Anna, line 27)

Despite having a comparatively high entry knowledge, Anna is an example of a student who seemed to have grasped important details regarding the trip's exhibits. She started the trip to show both factual and conceptual understanding through exemplification and a certain ability to differentiate and critique. Her analytical and evaluation skills seemed enhanced after the trip, especially regarding the biodiversity and society lens of biodiversity learning. Furthermore, Anna was also able to explain exhibits, recall detailed explanations of the guide, tie ideas, and link different concepts, sometimes re-visiting her prior conceptions.

From the portraits of the four students, it can be found that all students learnt something from the visit. The knowledge gain was not uniform across students. Furthermore, a particular student does not progress in knowledge scores for all aspects of the three lenses of biodiversity learning. The majority of students learnt through a deepening of existing conception by providing examples of concepts rather than making conceptual additions. Furthermore, students who had higher entry-level knowledge were more likely to make connections between concepts and demonstrate opinions about biodiversity and society issues compared to those who had lower pre-visit scores. Therefore, during the visit, learning was highly individual.

6.7 Summary of findings and conclusion

Biodiversity remains a broad, multi-dimensional and complex concept that does not easily transfer to people's mind. In light of the ongoing debates about what biodiversity learning should entail, I built on the existing literature to develop an analytical framework to organise the data. I examined what students learnt about biodiversity through three lenses, namely: ecological literacy, nature and self and biodiversity and society. This framework enabled a thorough analysis of 'what' students learnt. For all the three lenses, the students as a group, gained knowledge, indicating that the visit enhanced knowledge of biodiversity. The students' prior understanding of biodiversity was in terms of variety at species and ecosystem level and not genetic levels. Students' knowledge of extinction and endemic species, as well as conservation actions, improved. After the visit, more students could make reflective discussions and produce opinions on biodiversity and societal issues and show an increased appreciation for nature.

However, biodiversity being a broad concept, what is learnt about the three lenses' biodiversity, is more complex. This is illustrated by the change in knowledge score for individual students about different aspects of learning within the three lenses. For example, a student might gain knowledge for one learning aspects but not for another. The findings reveal the complexity and idiosyncratic nature of learning in informal learning settings; some students have surface learning while others show deeper understanding, depending on their prior knowledge.

This Chapter also analysed Personal Meaning Maps, the quantitative analysis of counting words and concepts appear suitable to analyse and compare knowledge gain across a group of students. Only counting words and concepts on PMMs might give a rough idea of the knowledge gained during the visit. For a deeper analysis of the depth of learning, PMM should remain accompanied by other data collection methods.

All students exited IAA with more knowledge compared to their prior knowledge. All students made fewer conceptual additions. A deepening of existing concepts was more common as illustrated through students' ability to exemplify the concepts of endemic and extinct species. Yet the majority of new concepts grasped is irrespective of whether someone had higher or lower prior knowledge. Even those who had low prior knowledge may learn the same amount of new information compared to those who had a comparatively higher prior knowledge. Thus, compared to formal schooling, a visit to a nature reserve may enhance learning and act as a stepping stone for students with lower prior knowledge to experience and learn about biodiversity in authentic settings. However, a student's ability to grasp new knowledge is limited. This is depicted through the portraits of the students where I compare students with different entry-level knowledge. A particular student does not show progress in knowledge scores for all aspects investigated.

The findings reveal the complexity and idiosyncratic nature of learning in informal learning settings; some students have superficial learning while others show deeper understanding, depending on their prior knowledge. In the next Chapter, I identify how the students learn and make the connections between interest and learning.

7 Chapter 7: The link between Situational Interest and learning

7.1 Introduction

Having identified the triggers of situational interest (SI) in Chapter 5 and what students learnt about biodiversity in Chapter 6, in this Chapter I aim to find the link, if any, between triggers of situational interest (SI) and how learning occurred as students visit Ile aux Aigrettes nature reserve. To this end, I first investigated how students learnt about biodiversity using the Human Constructivist and affective learning approaches that I discussed in section 2.5 of the literature review. I introduced categories of knowledge construction informed by the Human Constructivist thinking and affective learning to investigate what kind of mental processes occur in the students' mind as learning occurs. I then investigated the simultaneous occurrence of triggers of SI that I identified in Chapter 5. I thus link how students learnt and the triggers of SI. The Personal Meaning Maps (PMMs), photo-elicitation and semi-structured interviews of the group of students were analysed.

In so doing, I answer research question 3: how did the situational factors of the visit influence how students learnt about biodiversity?

7.2 A Human Constructivist and affective learning approach to analyse learning of biodiversity

Informal Learning Settings (ILS) support learning which is complex and challenging to investigate given the different kinds of interaction that take place based on the physical, personal and socio-cultural context of the learner (Falk & Dierking, 2013). Therefore, the investigation of how students learn requires a framework adapted to identify the intricacies of this kind of learning. The Human Constructivist framework, though dating from 1997, is still useful to examine conceptual change regarding cognitive learning in ILS as illustrated by the work of Lelliott (2007) and Anderson et al. (2003). In Chapter 2, I discussed how Human Constructivist emphasizes and explains the process of 'meaning making' which is the acquisition and modification of concepts and concept relationships as the central activity of the human mind during learning (Mintzes et al., 1997). HC explains that during learning people may acquire knowledge both through gradual accretion of knowledge (weak restructuring) and through significant knowledge restructuring (strong knowledge restructuring). Based on Human Constructivist and conceptual change studies, Lelliott (2007) devised a coding system that accounts for cognitive, affective and conative knowledge processes in his study which I find largely applicable to mine. I, therefore, decided to adapt Lelliott's (2007) work to investigate how students learnt about biodiversity during the trip to the nature reserve. Table 7.1 below details the knowledge construction categories which were used as pre-conceived codes to analyse PMMs, photo-elicitation and interview transcripts, as described by Lelliott (2007) which I used in my investigation.

Table 7.1: Knowledge Construction categories defined in my study (adapted from Lelliott, 2007)

Knowledge Construction categories used as pre-conceived codes	The domain of 'learning'	Code antecedents from literature
Addition – a concept that is new knowledge to a learner, incrementally added.	Cognitive	Addition (Anderson et al., 2003) Subsumption (Ausubel et al., 1978, Mintzes et al.,. 1997, Pearsall et al., 1997)
Emergence – a concept that emerges from a learner's memory as a result of a subsequent experience.	Cognitive	Emergence (Anderson et al., 2003)
Differentiation – a process of modification of concept meanings.	Cognitive	Progressive Differentiation (Ausubel et al.,. 1978, Mintzes et al. 1997, Pearsall et al., 1997, Anderson et al., 2003)
Discrimination– demarcation of similarities and differences among closely related concepts	Cognitive	Merging (Anderson et al., 2003) Integrative Reconciliation (Ausubel et al., 1978, Mintzes et al.. 1997, Pearsall et al., 1997)
Recontextualisation – the understanding of a concept modified by a changed context, but "with no significant clarification of meaning" (Anderson et al.,. 2003)	Cognitive	Recontextualisation (Anderson et al., 2003)
Superordinate Learning – a new concept learnt which links to other concepts already part of a learner's cognitive structure	Cognitive	Superordinate Learning (Ausubel et al., 1978, Mintzes et al., 1997, Pearsall et al., 1997)
Body Experiences – the extent to which a body experience such as touching, walking, smelling, contributes to learning	Affective	Not described
Germane – the extent to which the learning experience is personally relevant	Affective	Germane (Alsop & Watts 1997)
Salient – the extent to which the learning experience is prominent or important in the learner's environment	Affective	Salient (Alsop & Watts 1997)
Wonder – the extent to which the learner is in awe or amazement	Affective	Germane (Alsop & Watts 1997)
Conative - the extent to which the learning experience is put into action, is controlled or trusted by the learner.	Conative	Action, Control, Trust (Alsop & Watts 1997)

The HC framework that I adapted, duly considers surface addition of new knowledge termed as subsumption in the HC framework - I used 'addition' as per Lelliott (2007) and Anderson et al. (2003) - which is a common form of learning in informal learning settings. Prior knowledge which impacts learning in the museum environment is also included through the knowledge construction category 'emergence'. Furthermore, the framework also makes provision for deeper learning such as 'differentiation', 'discrimination', 'integrative reconciliation and 'superordinate learning'. The HC integrates the various types of conceptual changes reported by scholars such as Hewson (1992) (i) assimilation when the learner makes weak changes in his/her conception (HC: subsumption, I used addition) (ii) when the learner abandons prior conceptions termed as extinction (Hewson, 1992) to accept new conceptions (HC: dissatisfaction) (iii) the regrouping or integration of different concepts into one (HC: superordinate Learning) (iv) extension or addition of meanings through HC addition, discrimination, superordinate learning and (iv) exchange of meanings through HC recontextualisation and differentiation. Thus, the framework caters for the various types and depth of learning that may occur during the trip to the nature reserve.

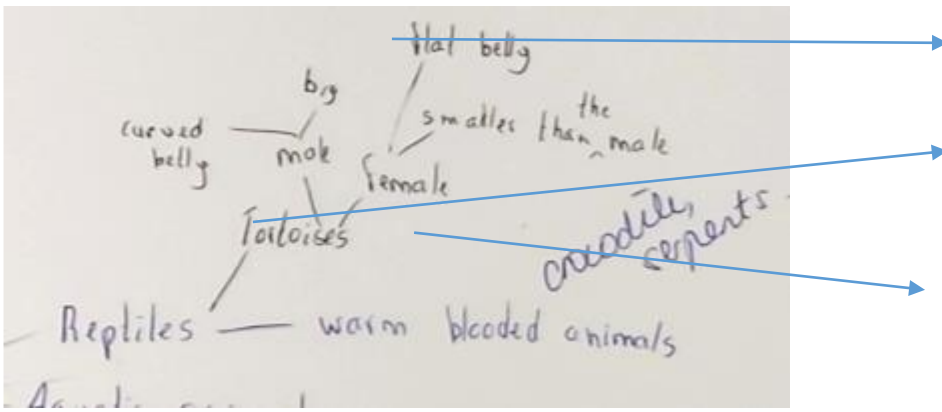
Since my study is about interest and learning, it was useful to also address the affective learning processes that occurred during the informal educational intervention. The affective learning categories that I adapted from Alsop and Watts (1997), duly consider the personal context of the learner through the knowledge construction categories germane, and salience. Lelliott (2007) introduced an additional category called 'wonder' to describe learning when participants feel in awe or amazed during a learning situation. I find 'wonder' relevant to illustrate situations whereby learners describe feelings such as agreeably surprised or enjoying learning about some information, which might be signs of SI. Additionally, I introduced a category which I termed as 'body experiences' (replacing 'enjoyable' from Lelliott, 2007) to illustrate instances where learners learnt something as a result of an experience involving their body and senses such as walking, touching and smelling. 'Body experiences' and 'wonder' represent the interaction between the personal, social context of the learner as well as the physical context of the visit (exhibits and the settings). The influence of affective learning has also been highlighted by interest researchers such as Cordova et al. (2014) who highlight the role of affective and motivational variables (including interest), in producing conceptual change. Thus, through exhibits that provoked SI due to body experiences, emotions of wonder and impressive information also enabled learning, I could unveil the underlying mechanism of this process by using the framework.

7.3 The process of analysis of the PMM, interviews and photo-elicitation

Using the pre-conceived codes described in Table 7.1 above, I deductively coded the interviews, photo-elicitation transcripts and Personal Meaning Maps (PMM) from 13 students. Each pre-conceived codes represented the knowledge construction categories from HC and affective learning defined in Table 7.1 above which were used to identify how students learn.

Analysing PMMs

As discussed in the methodology section, the PMMs were written by the students in blue before the visit and in black after the visit. Using Atlas TI Software, I coded each PMM by comparing what students wrote before and after the visit i.e. the unit of analysis was what was written after the visit in relation to what was written before the visit. In Figure 7.1 below, I provide a section of the PMM of the student Anna.



Code: Addition (flat belly, curved belly)
Code: Emergence (tortoise)
Code: Superordinate (for the addition of tortoise + male, female + belly shape)

Figure 7.1: A section of a PMM to show how it was coded for knowledge construction categories

Anna previously wrote reptiles branching out from animals (blue ink). After the visit, she added 'tortoise' as an example of a reptile, which was coded as an 'emergence' since 'tortoise' is a popular animal known to all students which Anna readily described. I considered this information as part of her previous memory. During the visit, she learnt how to distinguish male and female tortoises by examining their belly, something new to her and therefore was coded as an 'addition'. The way Anna used branches to structure the information that differentiates male tortoise from female indicates that she was able to associate new concepts and link to concepts already present in her memory ('reptiles' was written in blue before the visit) is an example of 'superordinate' learning. Using similar logic, I coded all the PMMs for all 13 students.

Analysing interviews and photo-elicitation transcripts

An extract of an interview is shown below.

Interviewer: *"How do you define an ecosystem?"*

(Before the visit) Kelly: "Living things interacting together "(pre int: Kelly, line 42)

(After the visit) Kelly: "Living and non-living things interacting together" (Post int: Kelly, line 48)

As can be seen in the excerpt above, before the visit, Kelly described 'ecosystem' just as '*living things interacting together*' but after the visit, she refined her definition of an ecosystem as '*living and non-living things interacting together* '. Kelly's post-visit addition of non-living things response shows that her understanding was modified after the visit. Therefore, this was coded as 'emergence': the understanding of the concept of an *ecosystem* which was modified and retrieved from her previous memory following the intervention programme. To avoid repetition, I illustrated the detailed coding for each knowledge construction category together with presentations of findings in section 7.4.

The challenges faced in the coding process

Distinguishing closely related Human Constructivist knowledge construction categories such as 'addition' and 'emergence' was a challenge since one cannot be completely sure about what concepts were new or were already present in students' knowledge structures. Therefore, all new concepts that were discussed during the guided tour were mainly coded as 'addition'. Words forming part of our common vocabulary or vernacular language (for example plants, sea, tortoise) that students mentioned only after the visit, were classified as 'emergence'. 'Differentiation' and 'recontextualisation' seemed to be quite similar and interlinked. Therefore, I coded for differentiation when students clearly reported that they were dissatisfied with their prior knowledge. Recontextualisation was coded for when students clearly stated that the knowledge gain was directly a consequence of the visit. A colleague reviewed of the coding of data from two students for intercoder reliability and we discussed the logic I applied for the coding and found that we had 90% similar codes indicating a high consensus. This pushed me to analyse how the knowledge construction categories interacted as I show in section 7.5.

7.4 Results of the analysis of both the PMM and the pre- and post-visit interviews

After deductive coding of both the PMM and the pre and post-visit interviews, the frequencies of occurrence of codes representing each knowledge construction category was counted. This gave an idea of which HC and affective learning knowledge construction category occurred more frequently. The results in Figure 7.2 are presented below. The blue bars are codes occurring during the interview only, the orange emerged from PMMs and the grey ones are the sum of codes that occurred both during the interviews and PMMs together.

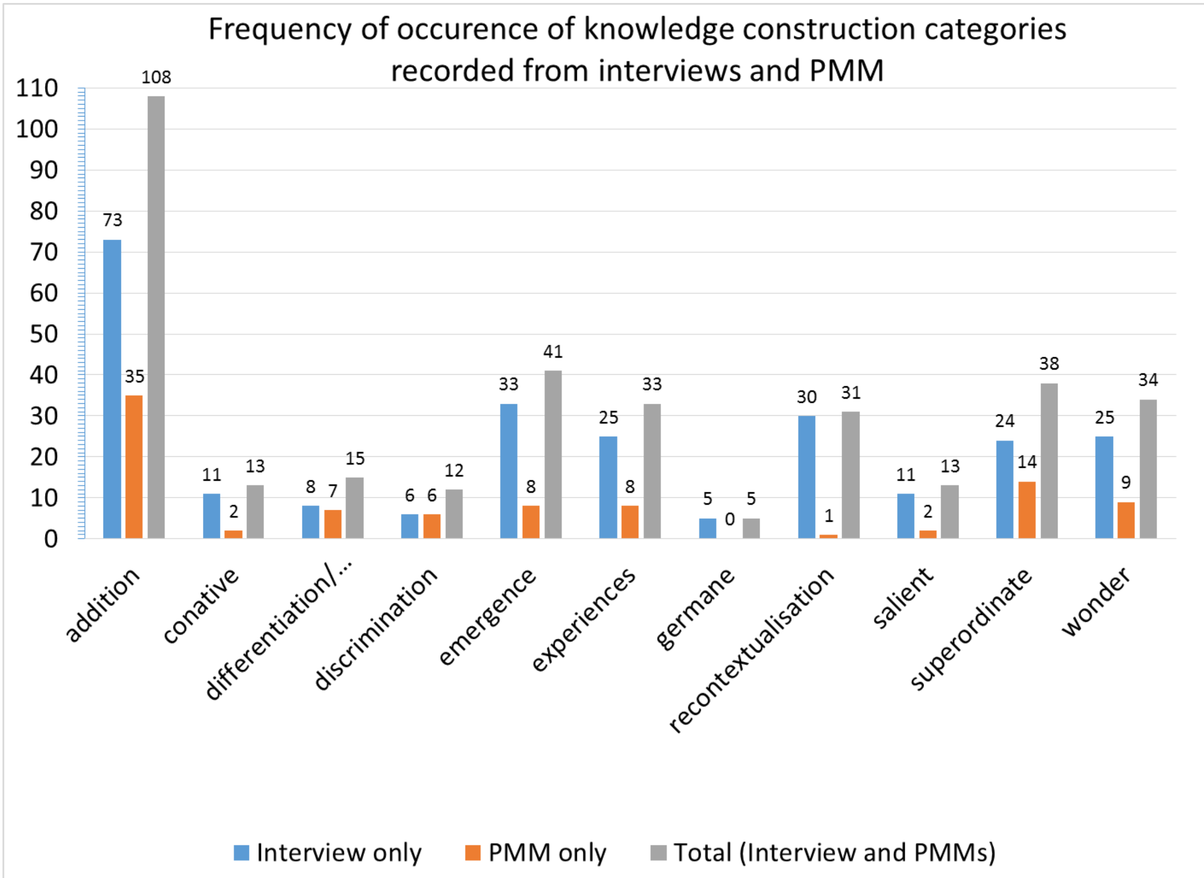


Figure 7.2: Frequency of occurrence of codes for each knowledge construction category identified for the group of students during their interviews and on their Personal Meaning Maps after the visit

As can be seen in Figure 7.2, the category addition was the most frequently occurring code with 108 instances indicating that students learnt new, less inclusive concepts as a result of the visit. This was followed by the code representing 'emergence' with 41 instances, whereby after the visit, students were able to recall a few concepts from their previously stored memory. These included concepts such as tortoises, reptiles, birds etc. A total of 38 instances of superordinate learning was recorded with students linking two or more new concepts to concepts already part of their knowledge structure. An example of superordinate learning is when students described the males in the Mauritius fody developing red plumage during mating seasons to attract females. These students, showed evidence of integrating several concepts such as mating, courtship, sex differentiation in birds, to illustrate their understanding of the reproduction of the Mauritius fody. Thus, the trip to IAA contributed to the growth of cognitive learning among the group of students. Weak forms of knowledge restructuring were by far the most common form of learning compared to strong knowledge restructuring. Among the affective learning categories, experience and wonder were the highest occurring codes which were more prominent in the analysis of semi-structured interviews compared to the PMM about which only a few students wrote about their feelings. There was little evidence of students finding information gained as 'germane' that is personally relevant to them as illustrated by only 5 instances.

As can be seen in Figure 7.2 above, while interviews seem to capture and reveal more instances of learning, it is the combining of the two methods of data collection (PMMs and interviews) that enabled a more comprehensive capture of data compared to using only one method alone. In the following section, the result for each knowledge construction category are presented and discussed. I supported the results with coded excerpts from interviews and photo-elicitation. Additionally, because the focus of this Chapter is to identify the link between triggers of SI and learning, I will also highlight the triggers of interest to tease out the linkages between the two i.e. triggers of SI and learning.

7.4.1 Cognitive Learning

Cognitive learning: Addition

'Addition' was the highest recorded knowledge construction category (108 instances)whereby students showed incremental addition of new concepts to their knowledge structures following the visit. I provide an interview extract to illustrate addition.

Pre-interview -	*Interviewer: "What are endemic species?"*	
	Stefy:	*"No… I don't know" (*Pre int: Stefy, line 62)
Post-interview-	*Stefy:*	*"Endemic means plants that are found on our island and it's not found in other countries."* (Post int: Stefy, line 56)

Before the visit, Stefy did not know the meaning of 'endemic species' and following the visit, she could explain the concept and provided a photograph of the endemic skink of Mauritius. Considering that a new concept (endemic) was added to Stefy's cognitive structures and that she also provided a photograph, illustrates that her understanding of the concept was linked to aspects of the visit that caught her attention during the visit. Similar linkages were seen with other instances of addition where students displayed accretion of knowledge regarding endemic plants and animals as well as extinct animals which were the exhibits towards which interest was directed. The results are in accordance with that of Lelliott (2007) and Anderson et al. (2003) who found that 'addition' was the most common form of knowledge gain in their studies. A deeper investigation of the link between the knowledge construction categories, exhibits and situational factors is conducted in subsequent sections of this Chapter.

Cognitive learning: Emergence

I considered 'emergence' after the visit when students mentioned words or phrases that are part of common and basic vocabularies for example male, female, forests, plants, tortoises, assuming that students knew about these words which they did not mention before their visit, but easily explained during post interviews. As shown in Figure 7.1 above in her PMM, Anna added tortoise to the concept of a reptile, thereby showing that after the visit, she clearly associated the tortoise as an example of a reptile. 'Tortoise' was retrieved from her memory and linked to the higher-order concept of 'reptile'. Emergence was frequently associated with the tortoises and in addition, students described detailed information about tortoises' lifespan and this aspect was considered as the trigger of SI 'size/number' and 'impressive information'. The tortoises form part of the most popular photos submitted by students as described in Chapter 5. Therefore emergence also appeared to be linked to the situational factors of the visit that elicited SI. Emergence was recorded 41 times and was exceeded by far by addition with a frequency of 108 codes, indicating that students learnt new concepts more frequently than retrieving from their memory, however, the 41 instances of emergence show that students do revisit their prior knowledge.

Emergence could be linked to what Falk and Dierking (2013) describe as the impact of prior knowledge as part of the personal context of the learner which influences learning in informal learning settings. If elements of prior knowledge are included in such guided tours, students would be better able to make sense of the content presented to them through scaffolding of information.

Cognitive learning: Differentiation

I coded for differentiation only when students said that their previous idea or knowledge changed. A total of 15 instances of differentiation was recorded. Five of eight of these examples were recorded when students discussed the bats. For example, Selvina re-visited her established knowledge that all bats could see only at night:

Interviewer:	*"Is there a specific animal that you want to tell me about?"*
Selvina:	*"Hmm bats, since I was small, they said that bats can see only at night (*previously established concept/knowledge*) but now I know that a species of bats can see both during the night and day (*modification of prior knowledge*)"(*Post int: Selvina, line 76*)*

Furthermore, before the visit, Selvina agreed that bats should be killed as they cause damage to plantations. After the visit she seemed dissatisfied with her preconceptions and disagreed with the mass culling due to the ecological role of bats as according to her "*bats help in carrying pollen and in the reproduction of plants and it has its own roles in nature*". The information about the ecological role of bats, was also coded as impressive information that triggered SI. Therefore, the trigger of SI impressive information might be associated with a modification of prior knowledge and hence learning through differentiation/dissatisfaction.

Cognitive learning: Recontextualisation

I coded for re-contextualisation when I noticed that students' conception changed directly resulting from the 'context', that is, what was presented during the visit to the nature reserve. I found 31 examples of recontextualisation including one in the PMM compared to Lelliott (2007) who found only a few examples in his study.

For example, Joana explained how her understanding of the extinction of the dodo was changed during the post-visit interview:

Joana: *"They said that it was the Dutch that killed the dodo but it's not true. They had predators and rats that ate their eggs. There were also predators that killed them…"(*Post int: Joana, line 24)

Similarly, students showed re-contextualisation while describing exhibits which caught their attention such as the tortoises, the endemic pink pigeon, extinct animals. These exhibits and their associated information triggered SI and enabled students to refine or expand their prior conceptions. Since these exhibits also caused SI due to their impressive information, novelty and strong emotions, it is likely these triggers may also permit students to review their prior knowledge.

Cognitive learning: Discrimination

Discrimination has been coded when students were able to demarcate similarities and differences among concepts by merging two or more concepts to explain the newly encountered phenomenon. I considered the 'newly encountered' phenomenon as the encounters made during the guided tour since it was a first-time visit for all participants. I illustrate with the following interview extract:

Example : *Interviewer:* *"Why did you write 'Bois de Rose'?"*
Kelly: *"It's an endangered species of Madagascar"*
Interviewer: *"Can you explain?"*
Kelly: *"First of all 'Bois de Rose' cannot be exported because it is endemic to Madagascar and Ebony also cannot be exported because it is endangered."*(Post int:Kelly, line 61)

Kelly demonstrated her ability to compare the examples in terms of their similarities by specifying that ebony is endangered just like the "Bois de Rose" of Madagascar. Twelve such examples were recorded in the interviews and PMM after the visit. By describing the ebony, Kelly also demonstrated learning by the HC addition. Discrimination was also recorded together with knowledge constructions such as emergence and addition, indicating that certain knowledge construction categories either produces or enhances another deeper knowledge category. There are further details in Section 7.5.3. If the exhibits (e.g. the ebony) that also triggered SI enable learning by discrimination, it indicates that SI may be also linked to a deeper kind of cognitive processing as students compare and contrast making cross-connections between different concepts, showing deep analytical reasoning (Anderson et al., 2003).

Cognitive learning: Superordinate learning

The principal feature of superordinate learning is that a newly learnt concept also includes other concepts, some of which may already be known to the student. It involves strong restructuring in knowledge structures to make sense of the information learnt. Several times the knowledge construction categories 'addition', 'emergence' and 'differentiation' led to superordinate learning in my study. The interview extract below illustrates this:

Shreena: '*I thought that we must kill the bats, but when we went there, I learnt that the bats also do 'transmission' of plants, fruits, like they help plants to reproduce and get fruits and that Telfair Skink does the same thing and that tortoise also when it eats, it helps nature*.' (Post int: Shreena, line 30)

First Shreena's interview extract indicates dissatisfaction with her previous conception that bats should be killed (coded as 'differentiation'), second by 'transmission' she appeared to mean 'dispersal' conducted by bats, Telfair skink and tortoises. The comparison she made of these three animals (coded as discrimination), the way she explained how bats are important for the ecosystem and similar to other species, (coded as 'addition') and therefore bats should not be killed is an example of superordinate learning. She showed a clear understanding of the ecological roles of species which was enhanced as she encountered 'the impressive information ' about the bats. Thus, SI triggered by impressive information may lead to deeper learning.

I documented 38 instances of superordinate learning during the coding process. This implies that only some but not all, of the additions (which I recorded 108 times), emergence (41 times) and discrimination led to superordinate learning. Thus, the guided tour favoured a high level of re-structuring and understanding of concepts only among certain students or about certain concepts related to specific exhibits such as the endemic birds, the tortoises, extinct animals etc. Three students were not able to demonstrate superordinate learning at all thereby confirming the fact that all visitors do not learn the same way and this is highly based on their prior knowledge and experience.

7.4.2 Affective learning

Alsop and Watts (1997) are of the view that learning is likely to occur when students find knowledge materials to be salient, palatable and germane. I recorded 13 instances of salience and 5 instances of germane but no example of palatable.

Affective learning: Salience

Salience was therefore coded when the learning experience was striking, prominent or evocative to students, specially when it was recorded during the photo-elicitation. One example is illustrated by the extract of the interview of Alex who was speaking about her photograph of a plant that she got interested in.

Alex: *"This is a plant with red veins. The red veins for predators not to eat them"*
Interviewer: *"Who were the predators?"*
Alex: *"Extinct tortoises."* (Post int: Alex, line 76)

Alex was able to make the connection between the development of red veins in plants to deter predators such as the tortoises, thereby indicating addition of salient, striking piece of information to her knowledge structure. Such kind of information was considered the triggers of SI impressive information and novelty, indicating close ties with learning due to saliency of learning content.

Affective learning: Wonder

Wonder was a knowledge construction category from Lelliott (2007) that I adopted to illustrate any instances where feelings and emotions were associated with learning episodes. One such example is Kelly's discussion about the pink pigeon, an endemic bird of Mauritius:

Kelly: *"I really liked the pink pigeon because it's not something that we see often in Mauritius, we do have pigeons but it's not the same thing."*
Interviewer: *"Why?"*
Kelly: *"First because its beak is pink and it's like a mystical animal that comes out of a book because an animal with a pink beak is not imaginable."* (Post int: Kelly, line 18)

Kelly demonstrated rich emotions (*mystical animal, not imaginable*) associated with her encounter with the pink pigeon, she learnt that pink pigeons are different from the pigeons found in Mauritius and learnt about the beak colour. Such knowledge additions indicate knowledge of the pink beak of the pink pigeon and might not be deep learning. Therefore the trigger of SI strong emotions occurs independent of other triggers, affective learning might occur through wonder but such knowledge gain is likely to be superficial.

Affective learning: Body Experiences

I introduced the knowledge construction category 'body experiences' to illustrate learning episodes when students describe doing, smelling or touching things, engaging their senses. As I describe in the Chapter on interest, new experiences and bodily experiences influence SI. I found 33 learning episodes associated with experiences. The interview extract below illustrates how Joana learnt about the formation of IAA from corals which she linked to remembering the body experience of tapping her feet on the ground.

> *Joana: "It means that the island was formed from the sand corals, and it's true. She (the guide) asked us to tap our feet on the ground...and when we tapped our feet we heard the same sound like on a wooden floor. It not compact like rocks!"* (Post int: Joana, line 63)

As exemplified by Joana's utterances, the act of doing some activity with their body permitted students to remember information about the exhibits presented to the students. Furthermore, she also experienced wonder while tapping her feet and the information became striking to her. Therefore in some cases, the three affective knowledge construction categories (salience, body experience and wonder) appeared to be intricately linked such that students developed affective reactions such as surprise or wonder while experiencing something like touching or smelling. Furthermore, Joana learnt that corals are not compact like rocks and that IAA was formed from corals indicating learning by addition and superordinate learning. In similar lines, wonder, surprise and body experience also form part of triggers of SI revealing a close relationship between affective learning and affective triggers of SI. Thus, affective triggers of SI when occurring together with impressive information may lead to deeper forms of learning.

Another example of learning by wonder and experience occurring together with SI is when Stefy described: "*I liked the orchid. It's beautiful and it smelled good, they made us smell*". Though I would not consider Stefy's smelling of the orchid as an example of a deep level of learning or strong restructuring, it does illustrate how bodily experiences help students to remember about exhibits, which are the objects of interest.

Affective learning: Germane

Out of all the affective knowledge construction categories, germane was least frequently observed with only five examples indicating that most students did not find the knowledge gain as personally relevant. One recorded example is of Tom who explained during the pre-visit interview, that he enjoyed watching wildlife documentaries and showed a degree of prior interest in learning about animals. During the post-visit interview he explained:

> *Tom: "In Biology class, we were told that we could duplicate cells etc. Our guide said we can re-do the DNA, duplicate the cell from the dodo's bones. We were told that the cousin of the dodo still exists, I asked myself whether we can take its cells and duplicate it so that one day our children and our grandchildren may see the dodo"* (Post int: Tom, line29)

Tom was able to link the information provided by the guide that the DNA of the dodo is present in its bones which are conserved in a museum abroad. He processed this information to explain the possibility of getting dodos back through genetic engineering (though he did not explain it in correct biological terms). The fact that he enjoys learning and researching about animals, made the information about the dodo's cousin or preserved DNA personally relevant to him and consisted of a learning episode due to 'germane' information. This 'germane' information is also new and 'impressive information' representing triggers of SI. Germane would also be an example of what has been described in the literature as a valuable component of SI such that one might be interested if he/she attributes a value to the learning situation (Harackiewicz & Hulleman, 2010) and in this case, the value is the personal relevance of the information.

7.4.3 Conative learning

The conative dimension of learning examines how learners are motivated to use the information gained to 'act' further. It was not possible in my research to identify specific concepts, exhibits or information from the tour that empowered learners to take further action. However, I was able to see whether the visit to the nature reserve holistically motivated changed behaviours among students: I got 13 examples of motivation for changes of behaviour among students. For example, Shreena was motivated to visit other islets around Mauritius she stated wanting to visit because "*this one also is interesting. This one also is a protected island, there also they are restoring the forest habitats for animals so as not do destroy it*". Shreena thus used the knowledge gained about protected species on islets and expressed her 'desire' to know more because it might be 'interesting', thereby demonstrating a motivated action. Shreena also described how she would change her behaviour during subsequent Scout outings by not throwing Chinese guavas in the forests, since they are invasive species.

Thus, even though I could not understand which type of knowledge or exhibits which information motivated further action, it was found that the overall visit experience produced conative learning. Therefore the whole context of the visit that captured interest might have influenced conative learning.

7.5 The interaction among knowledge construction categories.

I showed in Chapter 5, that strong emotions, body experiences and novelty are affective triggers of SI. These also contribute to affective learning as shown in the above section. Furthermore, affective triggers of SI are linked to the trigger of SI impressive information, which comprises of the content of the learning materials. In section 7.4, it was found that both weak and strong knowledge constructions may occur when students learn about contents that impress them and produce affect. I, therefore, examined how the affective and cognitive learning categories interacted to situate the role of affect and interest in promoting learning. To this end, I used the co-occurrence function in Atlas-Ti to identify how codes related to knowledge construction categories co-occur. The codes with the highest frequencies of co-occurrences are shown in simplified form in Figure 7.3.

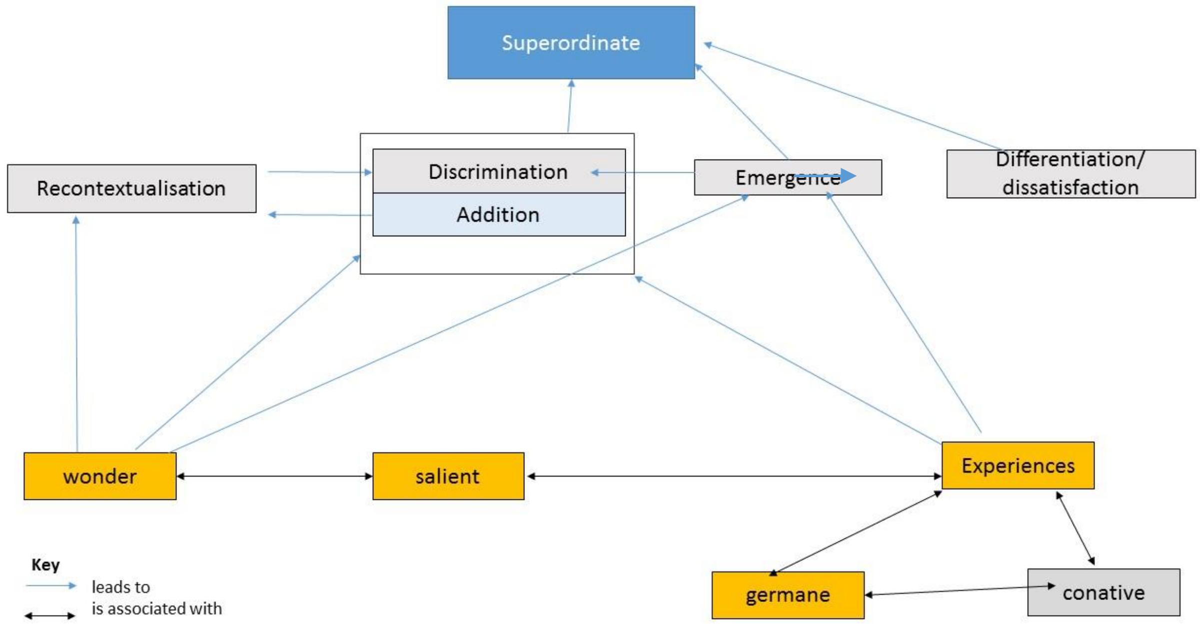


Figure 7.3: The interaction of the knowledge construction categories

The concept map used by Mintzes et al. (1997) shows that superordinate learning 'results in' progressive differentiation and integrative reconciliation (I used discrimination). It was difficult to show in my study whether superordinate learning 'results in' or 'derives from' progressive differentiation and integrative reconciliation. However, my results show that there are interactions between these HC knowledge construction categories as shown in Figure 7.3 above.

Superordinate learning has been found to result from either addition, discrimination, emergence and differentiation/dissatisfaction or a combination of two or more of these knowledge categories. For example, Shreena exclaimed: "*Tortoise! Big Daddy, he is the oldest on IAA, if I am not mistaken he is 100years or something. I never thought a tortoise can live till this age but I found that a tortoise has got a long life and can live long*". She showed 'addition' by learning about the lifespan of the tortoise but also 'differentiation' by showing dissatisfaction with her previous conception of not being able to imagine that a tortoise could live for 100 years. Her dissatisfaction was also linked to the trigger of SI size/numbers, novelty and the strong emotion of surprise. When considered together, addition and differentiation produced a higher order of knowledge construction, superordinate learning resulting from a 'significant re-ordering of cognitive structures to produce conceptual change that we typically experience in insightful moments' (Mintzes & Wandersee, 2005). Insightful moments are illustrative of SI, therefore Shreena's SI might have contributed to her learning by strong knowledge restructuring (superordinate learning). Furthermore, the rich emotions she experienced due to the novelty aspect of the information represented learning due to wonder and salience as well as the trigger of SI strong emotions. This SI triggered by affect, is likely to lead to both affective learning and strong re-ordering of cognitive structures provided the learning content is also rich and impressive for students. Thus, learning in informal settings is not always superficial especially when considering how different cognitive and affective processes come together during the learning experience.

As a next step in the analysis, I examined how students with different prior knowledge learnt through the HC and affective knowledge construction categories. In Table 7.2 below, I present the knowledge construction categories for the four students about whom I wrote portraits in section 6.6.

Table 7.2: Human Constructivist and Affective learning knowledge construction categories for portrait students

Knowledge Construction categories	**Stefy**	**Owen**	**Sonia**	**Anna**
	Position in Table 6.8 across the learning continuum: **Aa**	Position in Table 6.8 across the learning continuum: **Ab**	Position in Table 6.8 across the learning continuum: **Bc**	Position in Table 6.8 across the learning continuum: **Cd**
Frequency of Knowledge constructions categories				
Addition	7	3	11	13
Emergence	1	1	4	9
Total frequency of weak knowledge restructuring as per HC framework	**8**	**4**	**18**	**22**
Differentiation	3	0	1	0
Discrimination	0	0	0	2
Recontextualisation	1	2	3	5
Superordinate learning	3	0	1	7
Total frequency of strong knowledge restructuring as per HC framework	**7**	**2**	**5**	**14**
Total Frequency of Affective knowledge constructions	**4**	**1**	**4**	**10**

From Table 7.2, it can be seen that Stefy, having a very low prior knowledge score, had a total of 8 instances of weak knowledge restructuring by 'addition' and 'emergence'. She had a total of 7 instances of strong knowledge restructuring. On the other hand, Sonia and Anna had the highest number of learning episodes by 'emergence' and 'addition', representing weak restructuring of their knowledge structures. The student Anna who had the highest entry knowledge level scores also had the highest number of both strong and weak HC knowledge constructions. She also had the highest number of 'super-ordinate ' learning and affective learning knowledge constructions, compared to the other three students.

The results suggest that for the group of participants in my study, the students who had lower pre-visit entry knowledge level tend to gain new knowledge mostly through a weak restructuring of knowledge structures and their frequency of affective learning knowledge construction is relatively low. The students who have a high entry knowledge level tend to develop more affective learning knowledge constructions (or possibly SI), helping them easily make connections and establish linkages between different less inclusive concepts to produce a more holistic and systemic understanding. This is illustrated through their high frequency of strong HC knowledge constructions. A possible explanation is that students with higher prior knowledge develop strong emotions since they make connections with what they already know. They find the new information more relevant to their existing conceptions. On the other hand, those who had low prior knowledge cannot integrate the large amount of new information gained into their existing knowledge structures. Stocklmayer and Gilbert (2002) advance that sometimes the novelty of information may leave the student perplexed, or overwhelmed, yet this claim still needs to be tested. Nevertheless, it might be useful if practitioners aim to promote affective learning among students so that they are better able to connect and integrate different concepts concerning their prior knowledge. This might yield stronger forms of knowledge restructuring.

In section 7.4, I focused on how students learnt and made connections between knowledge construction categories and triggers of SI. There were episodes when knowledge constructions were not linked to interest. Therefore, learning does not occur exclusively due to interest. I also highlight how affect may lead to strong knowledge restructuring in some cases. In the next section, the affective dimension of learning especially interest will be discussed in-depth with respect to learning.

7.6 Association between the triggers of situational interest and knowledge construction categories

In this section, I make the association between how students learnt based on the HC knowledge construction categories and the triggers of SI. To this end, the co-occurrence function in Atlas TI was used to identify the simultaneous occurrence of codes related to knowledge acquisition (HC knowledge construction categories) and triggers of SI. The whole interview transcripts including conversations during photo-elicitation and probing using PMMs were used. An example of coding from Pascal's photo-elicitation is provided below:

Interviewer: *"What can you tell me about this photo?"*

Pascal: *"This tree has red veins because when tortoises see this they can't eat it's a kind of poison for them!"* (Post int:Pascal, line 88)

In the above interview extract, '*the tree with red veins which deters tortoises from grazing*' caught the interest of Pascal and was coded as the trigger of SI 'impressive information'. While coding for HC knowledge constructions, the same segment of the transcript was coded as 'addition' since the information was new to Pascal. Thus, there was an association or co-occurrence between the trigger of interest 'impressive information' and the knowledge construction category 'addition'. Table 7.3 below details the result for the co-occurrence analysis which I defined as weak, quite strong and strong co-occurrences based on the Code co-occurrence coefficient (c-coefficient) provided by Atlas TI. Detailed figures about the c-coefficient calculated by Atlas TI software are in Appendix 10.15.

Table 7.3: The strength of co-occurrence of codes related to interest and learning based on the co-occurrence coefficient calculated from Atlas TI.

	Human Constructivist and Affective Learning Knowledge Construction Categories										
Interest codes	Addition	Emergence	Differentiation/ Dissatisfaction	Discrimination	Recontextu-alisation	Superordinate	Body experiences	Germane	Salient	Wonder	Conative
Aesthetic experience (beauty)	Weak	Weak	0	Weak	Weak	0	weak	weak	weak	quite strong	0
Body experience (smell, touch, walk)	Quite strong	quite strong	Weak	0	Weak	weak	**Strong**	0	quite strong	quite strong	weak
Novelty (new experience)	quite strong	quite strong	Weak	quite strong	quite strong	quite strong	**Strong**	quite strong	quite strong	**Strong**	0
New learning	quite strong	Weak	Weak	Weak	Weak	quite strong	weak	weak	weak	quite strong	0
Emotions (e.g. strange, happy, impressed)	quite strong	quite strong	Weak	0	Weak	quite strong	weak	0	weak	**Strong**	0
Impressive information	**Strong**	**Strong**	**Strong**	**Strong**	**Strong**	**Strong**	weak	quite strong	**Strong**	**Strong**	**Strong**
Size	quite strong	quite strong	Weak	quite strong	quite strong	quite strong	quite strong	0	weak	**Strong**	0

I considered coefficients ‹ 0.1 as weak, coefficient ≥ 0.1 as quite strong and coefficient ≥ 0.2 as strong.

As shown in Table 7.3 and Appendix 15, all triggers of interest were associated with at least one HC knowledge construction category, indicating that SI does contribute to cognitive learning. The strongest correlations were found between the triggers of interest 'impressive information', 'size/numbers' and 'novelty' and all the HC knowledge construction categories. I describe how the triggers of interest were linked to learning.

7.6.1 Interaction between the cognitive triggers of interest – impressive information and novelty with the knowledge construction categories

It was found that the trigger of interest of impressive information, enabled deeper learning to occur through superordinate learning, recontextualisation and differentiation which are illustrated by the strong co-occurrence coefficient greater than 0.8 as shown in Appendix 15. The results confirm the claim made in Chapter 5, that the triggers of SI impressive information size/numbers are intricately linked to learning, through a strong form of knowledge restructuring.

Impressive information, for example the phenomena of heterophylly, sex differentiation in plants and animals represent new striking information which by nature of their saliency also create strong emotions of wonder, illustrative of SI and affective learning. Thus, students learnt by addition of new concepts (addition, super-ordinate learning) or abandon their prior conceptions (discrimination, emergence), which ultimately produced a strong knowledge restructuring. Therefore, when the nature of information is vivid and astounding and SI is triggered due to impressive information and affect, the nature of the learning is likely to be through strong forms of conceptual change.

7.6.2 New learning and aesthetic experience

Students described 'new learning' and their 'aesthetic experience' of finding exhibits beautiful as a trigger of interest. Such triggers also coincided with the affective learning construction of 'wonder' without any association with HC knowledge constructions. For example, Pascal described enjoying learning about the colours of the pink pigeon without further explanation showing limited learning. Similarly, the aesthetic experience of encountering seductive details of the trip did contribute to affective learning but not to HC knowledge constructions. Thus, the trigger of SI aesthetic experience does not promote deep learning and the knowledge restructuring is likely to remain superficial. Nevertheless, when the aesthetic experience occurred together with wonder, strong emotions and impressive information, then learning by addition and super-ordinate learning occurs. For example, Joana explained how she enjoyed learning that the Banyan tree grows beautiful root-hair like structures towards the ground to develop into new plants. Her interest was triggered due to the novelty, impressive information and aesthetic experience of seeing the plant. This learning represented strong knowledge restructuring when she learnt about the details of the Banyan tree.

7.6.3 Strong emotions and body experiences

The trigger of interest 'strong emotions' enabled learning mainly through the affective learning construction category 'wonder'. However, the HC knowledge construction categories addition, emergence and superordinate learning were also occasionally recorded. Students experienced strong emotions when they were surprised or met the unexpected, when they felt empathy for extinct species encountered for the first time or found the visit as an experience of discovery. For example, Kelly described the photograph of an empty tortoise carapace which she was holding and explained: *"the tortoise carapace, it's strange to see its skeleton, its vertebral column how it is attached and how it is inside. Because we usually see it from the outside, the carapace, with the head and tail coming out".* I considered that in her description, Kelly did not show significant expression of cognitive learning except perhaps that the tortoise has a vertebral column attached to its carapace (learning by addition) which she found strange and beautiful. Similarly, her experience of touching the carapace contributed to learning. Therefore, when the triggers of interests of 'strong emotions' and 'body experience' operate in association with each other, affective learning occurs and cognitive learning does not appear to be deep. However, when these triggers of interest operate in conjunction with other cognitive triggers of interests such as size/number or impressive information, then deeper learning such as 'superordinate' or 'recontextualisation' may occur.

7.6.4 Summary of findings on the co-occurrence of the knowledge construction categories and the triggers of Situational interest

In this section, it was found that the affective triggers SI (strong emotions, body experiences, first time experiences and encounters as well as the aesthetic experience) are likely to produce learning by 'addition'- the weak structuring of knowledge through the addition of new concepts to knowledge structures. When cognitive triggers of interest come into play such as impressive information, deeper knowledge restructuring occurs through the HC knowledge constructions recontextualisation, superordinate learning, differentiation/discrimination. Central to both the affective and cognitive aspect of interest is the trigger of interest 'novelty' which contributes to both weak and strong knowledge restructuring. This was possible through exhibit encounters. To confirm these findings, I considered investigating the role of the exhibits in influencing the interaction between how students learn and the triggers of SI.

7.7 Association between knowledge construction categories, exhibits and concepts.

As a means of triangulation I also analysed the association between the knowledge construction categories, the exhibits and concepts to investigate how different exhibits and concepts promoted learning and interest. Therefore I used the co-occurrence function in Atlas TI to identify the simultaneous occurrence of codes related to knowledge construction categories and exhibits or stopping points. Data were used from the interview transcripts, PMMs and photo-elicitation. For example, in her post-interview Joana described:

Joana: *"Endemic means in one place there are and another place, there is not, e.g. pink pigeon. We used have dodo, tortoise and big lizard."* (Post int: Joana, line 63)

Joana mentioned the pink pigeon as an example of endemic species as well as big lizard, tortoise and dodo as examples of extinct species. The knowledge construction category 'addition' that were recorded for Joana. The exhibits associated with these additions were pink pigeon (endemic birds), dodo, extinct tortoises and giant skink (extinct animals). A similar process was followed for the other knowledge construction categories.

The findings from this analysis are summarized in Appendix 16, where I detail the concepts/nature of information and exhibit categories associated with each HC and affective learning knowledge constructions. A summary is in Table 7.4 below. It can be seen that the exhibits tortoises, endemic birds, endemic reptiles and the Mauritian Fruit bats as well as the endemic plants were the most common exhibits (as shown in the photographs in Figure 7.4 below) associated with both the affective and cognitive learning knowledge construction categories. Students submitted photographs of these exhibits which they selected as aspects of the tour that were most interesting as described in depth in Chapter 5.

Table 7.4: Association between knowledge construction categories and exhibits that triggered SI

Exhibits	**Tortoise (e.g. P015-1)**	**Endemic birds (e.g. GG08-2)**	**Extinct animals (e.g. GG08-5)**	**Endemic plants (e.g. (P013-8)**	**Endemic Reptiles (e.g. GG08-8)**	**Mauritian Bats (e.g. GG08-2)**
Knowledge Construction Categories	-addition -emergence -superordinate learning -experience -wonder	-addition, -emergence -discrimination, -superordinate learning, -salience, -wonder	-addition, -discrimination -superordinate for dodo only), -salience, -wonder	-addition, -emergence, -discrimination, -superordinate learning, -salience, -experience -wonder	-addition, -emergence, superordinate learning, -experience	 Superordin ate learning Recontextua -lisation Differentiati -on

Figure 7.4: Examples of photographs representing each category of exhibits: P013-8: endemic plant (red veins), GG08-5: extinct bird (Extinct blue parakeet), GG008-2: endemic bird (pink pigeon), GG02-6: endemic bats, GG08-8: endemic reptile (Telfair skink) and P015-1: tortoise

All the exhibit categories described above featured among the 10 photos that 'caught the attention' of students during the visit as a means to illustrate what triggered their SI. Therefore, SI no doubt promotes learning, sometimes surface learning and sometimes deeper.

As shown in Table 7.4 above, all categories of exhibits promoted learning through at least one knowledge construction category of HC indicating that exhibits that triggered SI contributed to some degree of cognitive learning and restructuring of knowledge. The knowledge construction category 'addition' and at least one affective learning category (wonder, experience, salience) were recorded for all exhibits. The only exception is the Mauritius fruit bat which produced cognitive but not affective learning. This indicates that all the exhibits that triggered SI among students enabled them to learn about new less inclusive concepts by addition.

Emergence was not recorded for the category of extinct animals except for the dodo, indicating students' lack of knowledge of extinct species before the visit. Since students added the extinct species to their conceptions, the visit contributed to their learning about these extinct animals. However, emergence was common for tortoises and endemic plants and animals which students linked to their prior conception of reptiles, animals and plants.

All exhibits that triggered SI due to impressive information, enabled the development of superordinate learning indicating that students were able to integrate two or more new concepts into their knowledge construction of higher-order concepts. For example, students learnt about the endemic bird, the Mauritius fody, which was new to them They described how to distinguish males from females (the males are usually greenish-grey and develops a red head during mating seasons, as a means to impress females). As they learnt, they integrated several concepts (sex, plumage colour, mating seasons, courtship in birds) into a logical form of reasoning showing a deep level of understanding. Thus, when SI is triggered due to impressive information, deeper knowledge restructuring occurs and students are likely to learn by superordinate learning.

7.8 Association between the triggers of interest and exhibits

Having identified how each exhibit, promoted learning, the next step was to identify the triggers of SI associated with each exhibit. This process was described in detail in Chapter 5 on interest. I summarise the exhibits and the associated situational factors that captured interest in Table 7.5 below through the contents of the shaded cells.

Table 7.5: Association between triggers of interest and exhibits summarised

Main triggers of SI	Tortoises	Endemic Birds	Extinct Animals	Endemic plants	Endemic Reptiles	Mauritian Bats
First Time experience	Seen for the first time	Seen for the first time	Seen for the first time	Seen for the first time	Seen for the first time	
Body Experience	Touch the carapace			Smell, touch		
Size/Numbers	Age, large size		Impressed by large size	Small leaves	Large size	Large
Impressive Information	Ecological roles, lifespan, males and females	Mating in Mauritius fody		Red Veins, history of ebony, uses of plants		
Strong emotions, Empathy, surprise	Surprise	Wonder	Empathy towards extinction and surprise		Surprise	

From Table 7.5 above, it can be seen that all exhibits triggered both cognitive and affective components of SI, the only exception being the Mauritius Fruit bats. The cognitive triggers of interest were impressive information and size/numbers. These were linked to students remembering information and vividly describing biodiversity-related concepts such as ecological roles of animals as pollinators, dispersers, decomposers as well as sex differentiation, mating behaviours, heterophylly in plants and its association with the tortoise. The trigger 'size/numbers' enabled students to recall figures such as the lifespan of tortoises and their age of the baby tortoises before they are translocated away from IAA. It also helped them to remember about the extinct animals displayed on IAA through real life-size bronze models which impressed them through their large sizes, not familiar to the students. Thus impressive information enabled students to remember their learning experiences.

The affective components of SI such as first time, strong emotions, body experiences and beauty helped students recall events and feelings which they associated with various exhibits. These included students' emotions of surprise and enjoying beauty for example 'beautiful birds and plants'. They also remembered encounters while physically engaging with exhibits such as touching the carapace of the tortoise thereby showing understanding of the concept of 'carapace' which they integrated into their knowledge structures as part of their biodiversity-related vocabulary. It can be found that all the triggers of interest resulted in learning but to different extents. Therefore the next step in the analysis was to find the intersection between the triggers of SI and knowledge construction categories drawn from the Human Constructivist and Affective learning framework.

7.9 Association between the triggers of interest and knowledge construction categories.

It was challenging to identify a direct association between the triggers of interest and knowledge construction categories. The commonality between these triggers of SI and learning was the exhibits. The exhibits were the object towards which interest was directed as per the Person-Object Theory of interest (Krapp, 2002) and that fostered learning. Thus, the results are presented in Table 7.6 below by bringing in and merging the findings from Table 7.4 and Table 7.5 above to identify how interest and learning about these exhibits are associated.

Table 7.6: Association between exhibits, triggers of SI and knowledge construction categories

Exhibits	How the exhibits triggered SI	How students learnt about the exhibits from the HC and affective learning knowledge construction categories
Tortoises	First time (novelty) Size/numbers Impressive information Body Experience, emotions	Addition, emergence Superordinate learning experience, wonder
Endemic Birds	First time (novelty) Impressive information Beauty	Addition, emergence, discrimination Superordinate learning, salience, wonder
Extinct Animals	First time (novelty) Size/numbers Emotions Beauty	Addition, discrimination (superordinate for dodo only), salience, wonder
Endemic plants	First time (novelty) Impressive Information Beauty, Experience	Addition, emergence, discrimination, superordinate learning, salience, wonder, experience
Endemic Reptiles	First time (novelty) Impressive information Experience, Emotions	Addition, emergence, superordinate learning, experience
Mauritian Bats	Impressive information	Differentiation/dissatisfaction, recontextualisation, superordinate learning

The following associations were found between the triggers of interest and knowledge construction categories:

1. The trigger of SI 'first time' (novelty) describes the fact that students' interest was elicited as they were visiting and encountering exhibits and concepts for the first time. From Table 7.6 above, the trigger of interest 'first time' always produced learning about exhibits by addition. When 'first time' co-occurred with the trigger 'impressive information' including size/numbers, then superordinate learning occurs.

2. Learning by emergence, discrimination, recontextualisation and/or differentiation has been noted when interest was triggered towards several exhibits due to the situational factor 'impressive information', indicating that 'impressive information' produces several kinds of conceptual change. These kinds of conceptual change are: addition of new concepts (addition), retrieval of concepts from memory (emergence), modified understanding of concepts (recontextualisation and differentiation), integration of several new concepts into the main concept (superordinate learning) and recognition of similarities and differences among concepts

(discrimination). This finding concurs with the findings from the analysis of the co-occurrence of the triggers of SI and Knowledge Construction categories in section 7.6.

3. Affective triggers of interest occurred for all exhibits except the Mauritian Fruit bats and each time an affective trigger of interest come into play, an affective knowledge construction category was noted such as wonder, experiences and salience, concurring with the findings in section 7.6.2 and 7.6.3. Furthermore, when the affective triggers of interest occur together with cognitive triggers such as impressive information about exhibits, the knowledge construction category addition is observed. This indicates that deep knowledge restructuring is possible due to affect especially when the information is striking and salient.

4. It is not possible to make a bold confirmation on exactly how one specific trigger of interest produces a specific knowledge construction category. This is because the triggers of interest and knowledge construction category operate in a complex dynamic interaction as shown in Chapter 5 and section 7.5. However, there is no doubt that impressive information as a trigger of interest leads to both weak and strong restructuring of knowledge and the affective triggers of interest promote surface learning by addition and less deep learning.

7.10 Summary of findings

As a summary of the findings, I produce a schematic representation of the interplay between the triggers of SI and how students learn as shown in Figure 7.5.

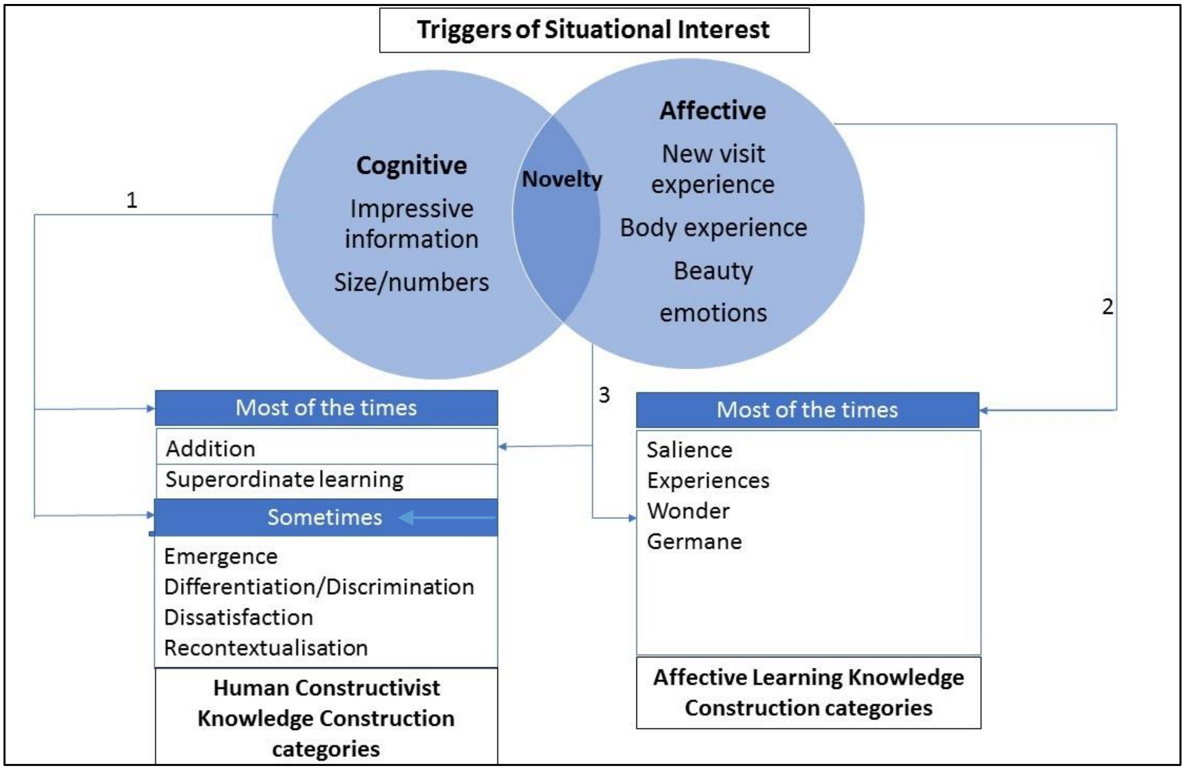


Figure 7.5: Schematic representation of the interplay between the triggers of Situational Interest and Human Constructivist and Affective learning Knowledge Construction categories.

As discussed previously, the cognitive and affective triggers of interest are intricately linked, intersecting at 'novelty'. According to Rotgans and Schmidt (2014), when students encounter something novel, they become consciously aware of the gap in their knowledge and this increases SI. They are more likely to devote their attention to the information provided and hence undergo changes in their knowledge structures.

1. The cognitive triggers of interest 'impressive information' and 'size/numbers' result in learning by addition and superordinate learning most of the time. It also produces one or more of the other HC knowledge construction categories such as emergence, discrimination, differentiation and recontextualisation, indicating deep learning. The reason might be because impressive information is likely to be striking and rich. Such information successfully captivates attention, permitting students to add and review their prior conceptions and hence promote stronger forms of knowledge restructuring. Furthermore, impressive information coupled with novelty permit students to revisit their prior knowledge, producing learning through emergence and differentiation. Therefore, it is likely when the cognitive trigger of interest 'impressive information' occurred together with affective responses to the nature of information, students were able to integrate their thinking, feeling and acting as illustrative of meaningful learning (Bretz, 2001).

2. Most of the time, the 'affective' triggers of interest enable learning through the affective learning categories described by Alsop and Watts (1997). This leads to the question, are the 'affective' triggers of interest described in literature equivalent to the 'affective' learning categories such as 'salience', 'germane', 'experiences' and 'wonder'? Even if the findings in this study cannot answer this question, they do provide evidence that affective triggers of interest lead to affective learning even if it is a shallow restructuring of the knowledge structures.

3. The affective triggers of interest most of the time result in the weak restructuring of knowledge – learning by addition and affective learning. Sometimes affective learning also leads to learning by superordinate learning, emergence and differentiation but this is not a generalised observation. However, affect produces deep learning when the information content impresses students or causes a challenge to prior conception, thereby promoting conceptual change as discussed by Cordova et al. (2014).

7.11 Discussion

7.11.1 How do students learn?

Using the Human Constructivist approach to analyse how students learn indicated that the knowledge construction category 'addition' (or subsumption from HC) seems prominent in my study with 108 examples of 'addition', that is, weak restructuring of cognitive structures from new, less inclusive information. Mintzes and Wandersee (2005) write that this form of knowledge accretion is the most common form of meaningful learning in science. This argument has been shown to be partly correct since 'addition' exceeds the other knowledge construction category by far. Mintzes and colleagues also describe that these less inclusive concepts may be easily forgotten over time progressively when the learner makes significant modification of concepts meanings. However, in my study, I found that in cases where, 'addition' leads to 'superordinate learning' which is a deeper integration of concepts in the knowledge structures of students, the seemingly 'weak restructuring' of the mind might produce a more significant restructuring. This is especially prominent when other knowledge construction categories like 'recontextualisation', 'differentiation' and 'emergence' come into play. Thus, even if 'addition' and 'emergence' are the most common form of 'weak' learning observed in informal learning settings they often provide the stepping stones in a chain of reactions that ultimately leads to deeper learning as described in section 7.5.

The proponents of HC proposed the framework to analyse conceptual change in school settings where the teacher introduces concepts, sub-concepts and examples, all needed for organized content delivery. The informal education intervention that I studied, provides the maximum information about endemic and extinct species and their conservation, all within a maximum of two hours. As described in Chapter 4, during delivery emphasis was on certain concepts for example the tortoise, the red veins and extinct animals such that there is much scaffolding and re-encounters with some concepts compared to others. Thus, a learner might have constructed knowledge in terms of 'addition', 'emergence' and 'differentiation' reaching a higher-order of knowledge constructions such as superordinate learning and discrimination for some concepts but not for others. These findings reinforce the Human Constructivist view that learning can sometimes be significant and deep resulting in restructuring of knowledge and sometimes be evidenced by more surface increments of concepts, especially in informal learning settings, as described by Anderson et al. (2003).

7.11.2 Affective triggers of interest and affective learning knowledge construction

The affective learning knowledge construction categories such as salience, wonder and experience seem to occur when there are affective triggers of interest, such as body experience, strong emotions and beauty. Thus there is an unsurprising connection between affective triggers of interest and affective learning. The fleeting phenomena of students being momentarily in awe, surprised or experiencing something is analogous to SI. This momentary SI may sometimes (not always) result in deeper learning among learners in informal learning settings, especially when the content is also impressive to students. Furthermore, the visit influenced conative learning in terms of motivating further action such that students desired to conduct research or discover more places like IAA.

Alsop and Watts (2003) argue for an increased consideration of affect as a precursor for conceptual change during science learning in addition to cognitive dimensions. They integrated three ingredients (germane, salient and palatable) to the affective dimension component to which I added the knowledge construction categories wonder and experiences. The affective triggers of SI that I describe appear to result in learning produced from wonder, experiences and salience of the content and might represent a form of 'tacit' learning'. This is the most subtle form of informal learning operating at the subconscious level based on personal experience and emotion that is unique to each learner (Boileau, 2017). Therefore the minimum level of conceptual change that affective triggers of interest produce are the weak restructuring of knowledge that occurs as a result of addition of new less inclusive concepts through the knowledge construction addition. What Alsop and Watts (1997) describe as 'affect' and its importance to yield conceptual change might simply be the affective triggers of interest that result in learning. However, this supposition is yet to be tested and further researched.

When the affective triggers of interest occur in conjunction with other triggers such as impressive information, size/numbers and first time (novelty), other deeper knowledge construction occurs such as superordinate learning and discrimination as is the case for the endemic birds and tortoises. There is no doubt that affective triggers of interest result in conceptual change and therefore this calls for educational institutions to explore affective learning in educational interventions

The knowledge construction category 'salience' illustrative of striking information might be equivalent or linked to the triggers of interest 'impressive information'. This link suggests that the onset of interest and learning may be influenced by a multitude of reasons. Therefore, the inherently striking or impressive information might produce SI due to emotions and experiences, which in turn leads to learning.

7.11.3 Novelty, affect and cognition

All exhibits triggered SI among students due to their novelty aspect coded as 'first time', such as learning or encountering something new (except the Mauritian fruit bats which is not new to students). Novelty triggered interest due to both the emotionally new experiences and the new learning experiences indicating that novelty might be the driving force that gears students attention making them consciously aware of the gap in their knowledge (Rotgans & Schmidt, 2014). The nature of the information presented to students being new, impressive and striking is likely to captivate the attention of students such that learning becomes intuitive and emotionally driven, characterizing informal learning (Boileau, 2017). Thus, students were able to integrate new concepts into existing conceptions through dissatisfaction thereby showing signs of abandonment of prior conceptions which indicates conceptual change. Cordova et al. (2014) proposed that when prior knowledge conflicts with the scientific information presented, learners are more likely to pay attention to the alternative conception and undergo conceptual change, especially when presented with refutation text. In the case of this guided tour, the refutation text might be analogous to the new and impressive information which was also salient and instilled affective reactions of wonder enabling students to review their prior conceptions. Thus, while students receive information that impresses them, they are faced with a learning opportunity that triggers their conceptual involvement through thoughtful discourse leading to cognitive activation (Förtsch et al., 2017). According to the authors, cognitive activation triggers SI and promotes conceptual learning among students. Students therefore undergo a strong transformation in their knowledge structures as illustrated by incidences of HC - superordinate learning, recontextualisation and differentiation. These HC knowledge constructions were recorded when interest is triggered due to novelty, strong emotions, body experiences together with impressive information. Informal learning settings which emphasize engaging the mind, senses and emotions could also aim at stimulating SI by presenting impressive information to visitors, as strong knowledge restructuring and therefore deep forms of learning.

7.12 Conclusion

This Chapter aimed at identifying the relationship between the factors that triggered SI and how students learnt as they visit the IAA nature reserve. The use of Human Constructivist and affective learning knowledge construction categories proved useful to document how students learnt. From the analysis of the dynamics of operation between the triggers of interest and knowledge construction categories, it can be found that the cognitive triggers of interest were more likely to result in both strong and weak knowledge restructuring. This is because impressive information by its nature also favours emotional responses that gears individuals' focused attention to the content and potentially promotes cognitive activation that favours learning. The triggers of interest also permit conceptual change to occur as learners add and break connections between concepts and/or substitute one concept with another based on their prior knowledge as illustrated through the instance of HC knowledge construction emergence and differentiation. Prior knowledge is challenged since novel and impressive information present alternative conceptions to students leading to conceptual change (Cordova et al., 2014). The importance of prior knowledge is crucial in shaping how students learnt, determining how students will integrate new information into their existing structures.

In several cases, weak restructuring (addition and emergence) forms the basis for deeper learning such as superordinate learning, differentiation and re-contextualisation. These cases were particularly prominent when the cognitive triggers of SI such as impressive information and size/numbers come into play. Therefore, deep forms of learning do occur during informal learning experiences even if they are not as frequent as weak forms of learning.

The affective triggers of SI such as 'aesthetic experience' and 'strong emotions' seem to be intricately linked to the affective knowledge construction categories such as 'wonder', 'salience' and 'experiences' as well as the HC knowledge construction category 'addition'. Yet when affective and cognitive triggers of SI (impressive information) operate in conjunction, deeper learning occurs such as superordinate learning. Therefore, practitioners could aim at refining the content of presentations during guided tours by introducing vivid and striking information that promotes both interest and deeper learning. The analysis also highlighted that affective and cognitive triggers of interest have complex dynamics of operation as discussed in Chapter 5 and therefore the way that they influence learning will be of similar complexity.

It is therefore recommended that for meaningful learning of science to occur affective and cognitive learning experiences are equally important, as the affective component involves the triggering of SI. Thus, as described by Bretz (2001):

> '*meaningful learning underlies the constructive integration of thinking, feeling, and acting, leading to human empowerment for commitment and responsibility'(Bretz, 2001; p1112)*

This will be possible only when students are able to connect across the three domains of learning - affect, cognition and psychomotor. The psychomotor domain was not investigated in this study, except for body experiences, but the findings reveal that an intricate interplay between affect and cognition both at interest and knowledge level.

In the next Chapter, I summarise and discuss the findings of this thesis including the theoretical, methodological findings.

8 Chapter 8: Discussion, recommendations and conclusion

8.1 Introduction

The focus of my study was an investigation of students' experiences of a visit to a nature reserve, emphasising triggers of situational interest (SI) and learning about biodiversity. In Chapter 4, I presented the context of the visit, where I described the guided tour, including the exhibits and biodiversity concepts encountered by students. In Chapter 5, I identified the factors that triggered SI. In Chapter 6, I identified what students learnt about biodiversity. Finally, in Chapter 7, I linked how students learnt to the triggers of SI.

In this Chapter, I start by highlighting findings related to interest and learning, indicating the answers to my three research questions namely (i) What are the situational factors of a visit to a nature reserve that stimulate interest among students? (ii) What do students learn about biodiversity as a result of their visit to a nature reserve? (iii) To what extent do the situational factors of the visit identified influence learning of biodiversity among students?

I will then discuss the results which provide an improved understanding of the nature of interest and learning. I also present methodological findings, especially regarding the affordances of Personal Meaning Maps (PMMs) and photographs as data collection instruments. I reflect on the Contextual Model of Learning in informal learning spaces, highlight the contributions of this research and reflect on the research process before making recommendations and conclusions.

8.2 Summary of findings

Triggers of SI

This study aimed to investigate students' experiences of their visit to IAA, focusing on SI and learning of biodiversity. The first question raised was: Has situational interest been triggered and if so, what are the objects towards which interest was directed? In Chapter 5, I show there was a momentary spike in an individual's attention, illustrative of SI among students. This interest was directed towards different exhibits and contents as the students navigated through the guided tour, such that the object towards which interest was geared was constantly changing. Thus, interest in 'biodiversity' was not clear cut, but there were multiple objects of interest related to biodiversity.

Interest was directed towards different aspects of biodiversity-related content such as tortoises, extinct animals and biodiversity-related concepts such as heterophylly and sex differentiation. The common factors among exhibits and contents that captured students' SI or situational factors were 'aesthetic experience', 'body experiences', 'strong emotions', 'impressive information', 'size/numbers' and 'novelty'. I also found that these triggers of interest occurred in conjunction with one another and not in isolation, thereby adding to the body of literature on SI. Therefore, while studying SI through naturalistic observational methods as proposed by Renninger and Bachrach (2015) in an educational context, especially in informal learning settings, one should consider situational factors simultaneously.

As discussed in the literature review, interest has both affective and cognitive components. Among the situational factors, the novelty of the context of the visit and the exhibits encountered appeared to be a key trigger of SI since novelty related to both affect and cognition. The triggers of SI, aesthetic experience and body experience strong emotions related to individuals' experiential states while being in a state of interest. The cognitive factors that trigger interest were size/numbers and impressive information about the exhibits and content of the tour. However, I showed in Chapters 5 and 7 that affect and cognition were indissociable. This indicates there is an abundance of opportunities for affective learning during the guided tour. The argument that having fun and enjoyment precludes learning does not stand good (Stocklmayer & Gilbert, 2002) since enjoyment is often a manifestation of situational interest. Situational interest is linked to learning leading to both cognitive and affective learning.

Learning about biodiversity

This field trip was unrelated to formal schooling and students were in the role of Scouts during their leisure activities. Several learning episodes were noted where students connected new knowledge gained to their previous conceptions about biodiversity-related content, some of which resulted from school learning or the media. Therefore, science learning occurs as one navigates through different social roles and cuts across different contexts (Bell et al., 2009). Biodiversity being a concept full of complexities, *what* students learnt about biodiversity could be very broad and challenging to assess. In Chapter 6, building on existing literature and the content of the guided tour, I proposed and analysed what students learnt about biodiversity through three lenses' ecological literacy, 'biodiversity and society' and 'nature and self'. These lenses could act as a new guiding framework for future researchers desiring to investigate *what* students learn about a broad concept: biodiversity. For most students, understanding the term biodiversity, the importance of biodiversity and their knowledge of endemic and extinct species, and conservation practices increased after the trip.

Similarly, the participants' ability to formulate opinions about biodiversity and societal issues improved, and they could display greater connection with nature. The increase in knowledge was associated with the exhibits that triggered SI. Therefore field trips to natural settings have great potential to foster the learning of biology or biodiversity among students during their leisure or out-of-school activities. Learning is enhanced when the information they encounter is vivid, impressive, salient and stimulates emotional arousal.

It was found that students' prior knowledge of biodiversity influenced post-visit knowledge of biodiversity such that each student exited IAA with more knowledge. However, irrespective of the entry knowledge, a student's ability to capture and assimilate new information during a one hour trip will remain limited. Feeding a large amount of information to a student, hoping that more information means more learning would not be effective in a one-off intervention. However, providing a wide array of information related to different exhibits for a group of students might enhance learning among more students across the group. Even if certain exhibits captured the attention of all students, the different participants still have a personal choice to focus their attention towards specific exhibits as shown by the individual choice of photographs. Therefore, while investing in resources, practitioners might consider a balance in providing the right amount of information that suits the needs of a diverse number of students without overburdening individual students.

Interest and knowledge constructions

In Chapter 7, I investigated how meaningful learning and conceptual change occurred using the Human Constructivist (HC) and affective learning knowledge construction categories. It was found that weak forms of knowledge constructions such as addition, were by far the most common form of learning and not to be neglected or underestimated. In many instances, these weak forms of knowledge constructions when added together became the foundation for strong forms of knowledge constructions to occur and therefore, deeper forms of learning. The cognitive triggersof interest (e.g. impressive information and size/numbers) permitted the students to recall biodiversity concepts and details about exhibits which contributed to conceptual change resulting in deeper forms of learning such as superordinate learning and recontextualisation. SI caused by affective factors (bodily experience and strong emotions) produced learning through both Human Constructivist and affective learning knowledge construction categories, as shown in Chapter 7. Still, this kind of learning is likely to remain superficial producing incremental addition of new concepts representing weak conceptual change (Mintzes et al., 1997). However, deeper forms of knowledge restructuring occur when both affective and cognitive (impressive information) triggers of SI work together as shown in Chapter 7. Thus, the situational interest that is elicited by cognitive triggers leads to strong forms of knowledge restructuring during learning.

Limitations

The participants in the study appeared to have varied preferred leisure activities such as sports and music but I could not specifically identify whether students had a prior interest concerning biodiversity which might have impacted their subsequent interest during the tour. Furthermore, the visit's impact on the students' experiences seems to have extended beyond the visit as illustrated through conative learning instances where students signalled their intentions to change their behaviours in nature during subsequent Scout outings. However, one limitation of the current study was that I did not conduct an in-depth investigation of post-visit behaviours or how SI and learning were sustained over time. An area for further study might be an investigation of interest and knowledge retention over time.

I acknowledge that the interview protocols did not successfully capture the issue of relevance, a possible explanation for the low instances of germane found in section 7.4.2. Therefore, probing the personal relevance of content and its link to the value component of interest might inform future research.

Data collection instruments

In this study, I utilised auto-photographs and photo-elicitation as data collection tools to stimulate recall of knowledge gained and feelings experienced by students during the guided tour. Autophotographs and photo-elicitation are promising techniques because even timid students became more at ease to describe their emotions and experiences illustrative of interest. Through this method, I was able to find how individual students had different preferences for different exhibits during a 'walk and talk' type of guided tour during which the students had limited opportunities to express themselves. I could identify the trigger of interest 'beauty' while analyzing the data from the participants' perspective using the interpretive engagement framework. Therefore, I encourage a more widespread use of visual data, including auto-photographs and photo-elicitation, to capture visitors' experiences during informal learning programmes and even during school science learning. I would also recommend the interpretive engagement framework as a rigorous method of analyzing visual data.

Through these findings, summarised above, I provide answers to my research questions below:

1. What are the situational factors of a visit to a nature reserve that stimulate interest among students?

The situational factors identified that triggered SI are novelty, body experience, strong emotions, size/numbers, impressive information (encompassing ecology and biodiversity concepts) and aesthetic experience which operate simultaneously. Novelty is related to both the emotional experiences of the visit and to knowledge gained. The triggers are associated with different exhibits such as the tortoises, endemic and extinct plants and animals, and biodiversity-related content presented to students during the tour. Therefore, there were several objects of interest during the tour and interest was triggered multiple times.

2. What do students learn about biodiversity as a result of their visit to a nature reserve?

Students learn about the exhibits and associated content presented to them by the guide. Their experiences of the content are influenced by the nature of the information provided to them. The knowledge gained about biodiversity may be classified in three aspects:

(i) Ecological literacy: Among the group, some students had an improved understanding of the concept of biodiversity and its importance. An increase in knowledge of endemic and extinct species and conservation measures was noted among a few individuals.

(ii) Biodiversity and society issues: Among the group, a few students were better able to formulate opinions of biodiversity and society issues, demonstrated through an increased understanding of human-induced extinction, the consequences of bat culling, and human's effect on the ecosystem.

(iii) Nature and self: Among the group, some students demonstrated an increased appreciation and willingness to engage and learn about nature. There was also an increased recognition that humans have the moral duty to preserve biodiversity.

Nevertheless, learning was not uniform across the group such that a particular student does not gain knowledge equally in all three aspects.

3. To what extent do the situational factors of the visit identified influence learning of biodiversity among students?

The situational factors that triggered interest could be regrouped under cognitive (impressive information, size/numbers) and affective factors (body experiences, aesthetic experiences and strong emotions). The affective triggers of SI promoted learning via weak restructuring of cognitive structures. The cognitive triggers of interest lead to a stronger restructuring of knowledge structures where different, less inclusive concepts are integrated and linked to deeper understanding. Cognitive and affective learning intersect and the novelty aspect might be a common factor. Furthermore, it appears that affective triggers of SI have close ties with affective learning.

8.3 Discussion of findings

The findings have several implications for theory, especially concerning our understanding of the structure and development of SI and how the different factors that trigger SI function. The findings also enhance our understanding of the nature of learning (especially about biodiversity) during a visit to an informal learning place such as a guided tour to a nature reserve. This study has also revealed the promises of data collection methods such as Personal Meaning Maps, auto-photography and photo-elicitation. I provide a discussion of the findings and the methodological findings hereunder.

8.3.1 Understanding the structure and development of interest

In my study, it was found that interest becomes directed towards different exhibits at different moments in time during the visit. The most successful exhibits at capturing interest were the tortoises, the extinct animals and the endemic plants and animals. It appears that interest is triggered several times during the trip. As per literature, SI is always directed towards an object or content often referred to as the 'object of interest', and this is called the 'content specificity' of interest (Krapp & Prenzel, 2011; Hidi & Renniger, 2006). The first time one's interest is elicited towards an object is the triggering phase of SI (phase 1- TSI). However, I found that during the whole visit, interest is shifted towards different exhibits at different points in time such that the triggering phase happens repeatedly, and interest is directed towards different contents. If interest is triggered a second, third, fourth time and so on, a question arises: Is it still Phase 1 of SI or has Phase 2 of SI - the Maintained Situational Phase, been reached? I attempt to answer this question by proposing that the shift from Phase 1 to Phase 2 is happening within the one hour tour itself by considering the content-specificity or the objects towards which interest is directed and the notion of continuous and discontinuous events (Azevedo, 2018) hereunder.

Krapp and Prenzel (2011) emphasise the need to investigate the object's structure towards which interest is directed e.g. interest in an object, a topic, subject/domain, an activity or a context. In the guided tour, each exhibit that causes the triggering phase of SI represents the content of interest as an 'object' of interest. However, the 'context' of the visit, which comprises different exhibits and settings, becomes a second object of interest in the form of an event or context. Thus, during the guided tour, the objects of interest might constantly change as the visitor makes new encounters with new exhibits. There are multiple objects towards which interest is directed contributing towards the visitor's overall experience. This is an important finding since research on SI in informal learning programmes has more often focused on the overall effects of field trips (Dohn, 2013; Vainikainen et al., 2015). These studies seem to focus on domains or subjects or the context which are the objects of interest, while the findings in my study reveal that the 'structure of the object of interest' is not static but rather of a dynamic nature. The object of interest is constantly changing but at the same time, the context or the visit (the overall effect of the environment) is also contributing to elicit interest.

Scholars have communicated the importance of considering the full repertoire of an individual's activities while studying interest (Azevedo, 2018) and learning (Bell et al., 2003). Azevedo (2018) contrasts continuous events (the full set of activities during one's life course) and discontinuous events (momentary, isolated events) which shape an individual's interest. The notion of continuous and discontinuous events can be transposed over what occurs during the guided tour: each exhibit that triggers interest may be considered a discontinuous event while the overall context of the guided tour and the visitor experience is the continuous event forming part of the 'repertoire of activities' that the visitors engage during the one and a half-hour guided tour. Thus, the nature of the interaction or experiences that a visitor undergoes during an informal learning intervention is not simplistic or superficial but deep and complex for consideration by researchers investigating interest in naturalistic settings such as a visit to nature reserve.

The findings also give an insight into the transition process from TSI to MSI (Hidi & Renninger, 2006), which has not been adequately investigated. It is found that interest (for different exhibits) is being triggered multiple times during a short period (an hour or so). The first time that interest for an object is triggered is Phase 1 of SI, the TSI, which 'catches attention'. After the first occurrence of SI by the first exhibit (a discontinuous event), students encounter more novel exhibits that trigger their interest. The second time that interest is triggered (even if it is for a different object/exhibit but still within the boundaries of the context of the guided visit) and the subsequent re-occurrences of interest, might represent characteristics that Hidi and Renninger (2006) describe as 'adequate support', 'focused attention' and 'persistence'. These characteristics lead to and characterise phase 2 of interest development- Maintained SI. This time interest is directed towards the context of the visit. The multiple instances of this triggering process might engage students in searching for information that serves as an intrinsic reward, activating the brain's circuitry that supports further engagement (Renninger & Hidi, 2020). Thus, there is a possibility that the individual is already moving iteratively from Triggered SI towards the Maintained SI phase during the one and a half-hour guided tour itself. Individual exhibits are discontinuous events that lead to TSI, but when viewed holistically, the context of the visit (including the different types of exhibits, the seductive details and the environment), is a continuous event that leads towards MSI. The Contextual Model of Learning (CML) supports these claims, and the model emphasises the importance of the physical (exhibits, layout), social and personal context (interest) in shaping the museum experience. In Figure 8.1 below, I propose an illustrative model of the transition between Triggered SI to Maintained SI, which contributes to our understanding of SI as per the Four-Phase Model of Interest Development.

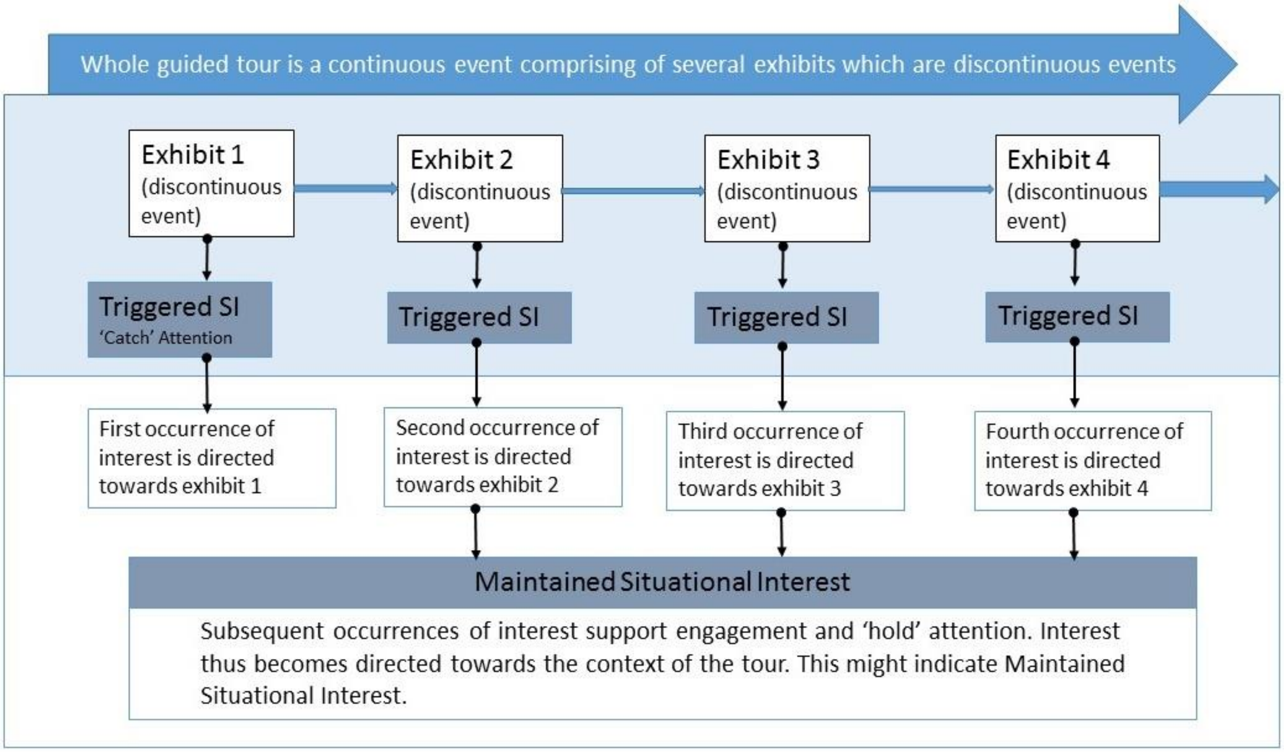


Figure 8.1: Proposed Model on the operation of Triggered Situational Interest and Maintained Situational Interest during the guided tour

The proposed model can be described as follows:

i. When put together the single discrepant events of encountering different exhibits (objects of interest) might be integrated within a bigger continuous event representing the whole guided visit
ii. Each exhibit individually represents an object towards which interest is directed. Each exhibit individually becomes responsible for the triggering phase of interest (Phase 1).
iii. The first exhibit represents the first occurrence of interest: the triggering phase or Triggered SI.
iv. The second, third and fourth exhibit, also trigger interest due to their inherent individual qualities. When the individual exhibits are considered within the whole situation of the guided tour, interest becomes directed towards the context of the visit, which might indicate a Maintained Situational Interest phase. The second, third and fourth time that individual exhibits trigger interest might be 'adequate support' or 'persistence' described by Hidi and Renninger (2006) and become precipitating events that lead to Maintained Situational Interest.
v. Overall during the guided tour, there might be a shift from TSI to MSI and then back to TSI and MSI in an iterative manner within the timeframe of the guided tour.

Figure 8.1 above, is a fine-grained representation of the Four-Phase Model of interest development which deepens our understanding of the transitioning from Phase 1 to Phase 2, especially regarding time, such that there might be a fuzzy boundary between the ending of Triggered SI (phase 1) and the onset of Maintained SI (phase 2). The MSI phase has been reported to be a consequence of the TSI and to be onset with time. For example, Huann-shyang et al. (2013) were sceptical about confirming whether their participants reached the MSI phase after weeks of intervention. The current findings when positioned within the frame of existing literature (e.g. Azevado, 2018) support a possibility that the transition from TSI to MSI as per the Four-Phase Model of Interest Development (Hidi & Renninger, 2006) might occur within a short time frame of a visit, especially relating to the *context* of the visit, where there are live exhibits. Therefore, I advocate a careful consideration of the notion of time while discussing the transition from TSI to MSI. However, the applicability of this model to other informal settings requires caution specially in exhibitions that explore the same science concept through different exhibits.

8.3.2 The operation of the triggers of interest

By the operation of the triggers of interest, I imply how different triggers of interest function. It was found that the different factors that trigger interest occur concurrently and are intricately linked, as described in Chapter 5. For example, students' interest is triggered because a particular exhibit or new information is beautiful and impressive. This causes strong emotional arousal in the student who might experience surprise or satisfaction. Thus, the different triggers of SI that operate simultaneously are 'aesthetic experiences', 'body experiences', 'strong emotions', 'impressive information' and 'novelty'. Novelty intersects in both affective and cognitive triggers of interest connecting to all other factors that caused SI. Since the triggers of interest appear meshed and webbed into one another and comprise affective and cognitive aspects, I discuss them concurrently, highlighting the interplay between interest, affect and cognition.

The interplay between novelty and affect

In the current study, I have been able to identify the intricacies of how some triggers of SI operate, especially concerning novelty. Students experienced two forms of novelty as they encountered exhibits as discussed hereunder.

Firstly some students encountered exhibits of plants and animals that they had heard about before but never seen in real life which constituted what Barto et al. (2013) describe as a relative novelty. The unexpected encounter with real plants and animals produced elements of surprise and delight, for example, Kelly describes: *I have seen tortoises in Casela, but this is the first time I saw a tortoise which is so big.* Tortoises are not new for Kelly, but the size of the tortoise she saw on IAA is new and challenges her existing knowledge, showing that even relatively novel experiences can produce affect and surprise since it is beyond one's expectation.

Secondly, it was found that students encountered plants and animals that they had never heard of or seen before, representing a complete novel experience – absolute/extreme novelty (Barto et al. 2013). While learning about the existence of certain animals and plants, students encountered new information about these organisms for the first time. For example, a student exclaimed: '*it is the first time I learned about the leaves with red veins* '. The phrase 'first time' indicates extreme novelty which is likely to lead to surprise and delight especially when the learning goal is quite brief (D'Mello & Graesser, 2011). Other cases of extreme novelty occurred when students encountered models of extinct animals such as the giant skink or saddle-back tortoises. These animals were completely new to students. Learning about their extinction produced empathy as they know that their desire to see these animals alive would never be fulfilled as described by Shreena about the owl: '*I am sad I have not been able to see it alive*'. This unfulfilled desire might form part of the negative emotions (Ainley et al., 2002) described in the literature that contribute to the triggering of SI. Therefore, 'novelty' as a trigger of SI contributes to elicit strong emotional arousal and ultimately learning. Sandifer (2003) showed that technological novelty and exhibits that stimulate the senses have a higher attention-holding power. My findings seem to agree with Sandifer's, but they also highlight the importance of novelty and emotions in eliciting interest.

I described all instances of students engaging with exhibits for the first time using their five senses as 'body experiences'. For example, it is the first time that they encountered a leaf smelling like a green apple. Most of the time, scholars have described these as hands-on experiences; the idea of hands-on (Holstermann et al., 2010) being a popular connotation in informal places where visitors are participants in science experiments and interactive exhibitions. This study found that SI for exhibits was triggered by more than 'hands-on' with students showing physical engagement through smelling, seeing and touching exhibits. It was full of sensory experience, and hence I use the term 'body-experiences'. Therefore, engaging students through sensory experiences and engaging their whole body is an effective way of eliciting situational interest especially during guided tours to nature reserve, where visitors have limited independence of movement.

Furthermore, SI was triggered by the aesthetic experience of encountering both the exhibits forming part of the visit and seductive details. Seductive details represent an aesthetic experience that does not form part of the guided tour, as described in Chapter 5. The findings concur with those of Huann-shyang et al. (2013), who found that integrating aesthetic experiences during teaching increased the development of SI in learning about science. Both the 'body experiences' and 'aesthetic experience' which are affective triggers of interest contributed to learning, but the nature of this learning is superficial as discussed below.

Novelty, affect and cognition

In Chapter 7, I used the Human Constructivist (HC) and affective learning knowledge construction categories that I adapted from Lelliott (2007) to identify how learning occurs through conceptual change. In section 7.9, I made the association between the knowledge construction categories and the triggers of interest to identify the links between learning and interest. It was found that the affective triggers of SI (body experiences, aesthetic experience and strong emotions) and the affective knowledge construction categories (wonder, salience, germane and bodily experiences) seem to be linked, meaning that interest and affective learning are connected. For example, the affective learning knowledge construction category 'wonder' was noted 34 times to represent learning episodes. Students experienced wonder, illustrating that if interest is triggered due to an aesthetic experience (causing wonder), learning may occur. Similarly, 33 episodes of learning due to 'bodily experiences' were noted whereby the students' senses were involved in touching, smelling or walking. SI was triggered by the factor 'body experience' that contributes to learning. This means that the affective triggers of interest and affective learning are closely related to a student's learning experience. Therefore, the inclusion of affective learning experiences for visitors during guided tours is of essence for enhanced engagement, creating amazement and wonder.

There is a possibility that what Alsop and Watts (2003) describe as affective learning in science could be affective triggers of SI that ultimately produce learning for the following reasons:

It appears that the triggers of interest 'aesthetic experience' and 'body experiences' identified in this study represent a 'synaesthetic experience', an experience which Root-Bernstein (2002) describe as one in which the senses are intermingled to create a complete mind-body experience, with sensory and emotional effects on our mind. This kind of experience has often been referred to as a hands-on, minds-on approach in informal learning context (Stocklmayer et al., 2010). Root-Bernstein (2002) argues that an aesthetic experience is a form of cognition especially among scientists who tend to think emotionally and sensually using visual and aural images and sensations helping them develop a fascination for their subject of study. In my study, the emotional effects are illustrated by the close relationships identified between the triggers of interest' strong emotions' and 'aesthetic experience' frequently aroused due to the 'novelty ' of the context as described in section 7.6. Furthermore, cognition was noted through the connection between the affective triggers of SI and affective learning knowledge constructions as shown in Chapter 7. The findings therefore support the claim that science education and learning cannot be dissociated from feelings (Alsop & Watts, 2003) and that affective triggers of interest play an important role is supporting affective learning by stimulating emotions and sensory experiences.

Nevertheless, the association between affective triggers of interest with the Human Constructivist knowledge constructions was weak, as shown in section 7.6. However, stronger forms of learning occur when both affective and cognitive triggers of interest occur together. The trigger of SI 'body experience' has a quite strong association with the HC knowledge constructions 'addition' and 'emergence' which are 'weak restructuring' of knowledge structures characterised by incremental, cumulative and limited change (Mintzes & Quinn, 2007). This indicates that interest and learning caused by affect might result only in weaker forms of learning which are superficial and might easily be forgotten over time (Mintzes & Wandersee, 2005). Yet, the importance of weak knowledge restructuring stimulated by affective triggers of SI should not be overlooked. As shown in Chapter 7, weak knowledge restructuring often forms the basis for stronger knowledge re-restructuring (such as superordinate learning, discrimination and differentiation). Knowledge restructuring during conceptual change is discussed further.

8.3.3 Interest, affect and knowledge acquisition

Some of the factors that elicited SI also led to learning, such that interest generation is linked to cognition. I chose the phrase 'impressive' information instead of ‘knowledge acquisition’ (Dohn, 2010) to describe the trigger of interest associated with the acquisition of information which by its nature is salient, striking and thought-provoking.

The impressive information that includes ecology/biodiversity concepts and phenomena encountered on IAA illustrates one common aspect:

Students were consciously aware that they were learning something new and enjoying the act of learning new things since they were all visiting for the first time. For example, Tom stated: “*I enjoyed learning about the Male Fody, which changes its plumage colour…”* This impressive information triggered students' SI. Their knowledge acquisition is linked to the enjoyment of learning new things (producing strong emotional arousal), indicating the complexity of the inter-relationship between the factors that caused interest: affect, novelty and knowledge acquisition.

Furthermore, as shown in Chapter 7, impressive information tends to be largely associated with stronger forms of knowledge restructuring such as 'differentiation' and 're-contextualization’. According to Human Constructivist knowledge construction categories used, when interest is triggered due to impressive information, a deeper form of learning occurs. Yet a thought-provoking question would be: what comes first, SI or learning? The relationship between knowledge acquisition, emotions and SI might be theoretically explained as follows using the example of Tom's explanation of the Mauritius fody.

When Tom encounters a novel discrepant piece of information (the male fody changes its plumage colour during mating season), his interest is triggered as he experiences delight or surprise due to the nature of the information. He enjoys learning something new, indicating emotional arousal. Since emotions tend to be quite brief (D'Mello & Graesser, 2011), Tom's attention is readily shifted from his enjoyment towards the information thereby producing engagement. He is likely to assimilate the completely new information in his knowledge structures. This is evidenced by the fact that weeks after the visit to IAA he still remembers details about the information, for example '*it is the male that changes colour not the females'*. He also links different new concepts he learnt on IAA (males and females, Mauritius fody, change of plumage colour and mating seasons) to produce a deeper understanding of mating behaviours in Mauritian fodies. Such interplay between affect and cognition has been described as the 'epistemic affect' (Radoff et al., 2019) - the feelings people experience while doing science and include the feelings of 'finding pleasure' in finding out about unknown/mysterious things. These feelings instil the desire to learn more which is an indication of interest. In this case, Tom was consciously aware that he was learning new things, and this helped him derive pleasure from learning. Thus, it might be claimed that when SI is aroused in the wake of new discrepant impressive information, there is momentary emotional arousal which readily shifts the learners' attention towards the object of interest making him/her conscious of his knowledge gap and produces readiness to learn more (Rotgans & Schmidt, 2017). The result is learning about a new piece of information that becomes ingrained in an individual's knowledge structures who are not likely to forget the information easily. Thus, interest and emotional arousal precede learning such that SI, as triggered by impressive information, is more of a driver of the learning process than a product of learning.

As discussed above, it is found that the triggers of SI are intricately linked in a mesh-like network, as shown in section 5.5, and contributes to learning. I consider that SI triggered by strong emotions, body experiences, novelty and specifically impressive information, is likely to create an ecology in the learner's mind. Conceptual change occurs through strong restructuring of the knowledge structures as evidenced by the strong association between the trigger of SI 'impressive information' and the Human Constructivist knowledge construction categories shown in section 7.6. Novelty seems to be the thread that ties the other SI triggers, which produces learning, as discussed in Chapter 5. The students' learning experience involves triggering his/her SI through a mix of strong emotions, body experiences, and receipt of novel, rich and vivid information which is likely to make the learner consciously aware of his/her knowledge gap (Rotgans & Schmidht, 2017). This is supported by the fact that the students expressed that their interest was triggered as they learned about the exhibits for the *first time*. Such learning experiences involving interest, affect and cognition might ultimately produce metacognition, an important tool for meaningful learning illustrated by a learner's conscious awareness of his/her thinking processes (Kang et al., 2010). Metacognition and interest form part of the non-cognitive constructs that are likely to result in the conceptual change (Kang et al., 2010). Nielsen et al. (2009) advanced that students were able to demonstrate varying degrees of metacognition as they solved physics problems following field trips to an amusement park, as part of the classroom follow up activities. Follow up activities were absent in my study. Yet, conceptual changes driven by interest (as shown through the Human Constructivist knowledge construction categories), occurred as part of students' learning process. I discuss the learning through conceptual changes in the following section.

8.3.4 The nature of the learning

In Chapter 7, I was also able to examine the nature of the learning that occurs when the triggers of SI are in operationusing the Human Constructivist (HC) and affective learning knowledge construction categories as an analytical framework. These knowledge constructions are based on the premise that learners acquire and modify concepts and concept relationships whereby newly acquired concepts become integrated into or removed from those already present in their knowledge structures (Mintzes & Wandersee, 2005). Thus, the nature of learning was both in terms of acquiring new information and in terms of reviewing prior conceptions.

In my study, I found that learning does occur through both weak and strong re-restructuring of knowledge structures using the Human Constructivist Knowledge Construction Categories. The weak forms of knowledge restructuring through the addition of new but less inclusive concepts to existing knowledge structures is by far the most common form of knowledge gained as represented through 108 cases of 'addition'. The findings corroborate with Mintzes and Wandersee (2005) that learning by 'addition' is the most common form of knowledge accretion for meaningful learning of science.

Another observation is that learning by 'addition' results in 'superordinate learning' (observed 38 times). The student can link several less inclusive concepts that result in deeper understanding (Mintzes & Wandersee, 2005). Superordinate learning was observed for the same exhibits that produced learning by 'addition' for example tortoises, endemic birds and plants. Learning by ‘addition’ may seemingly be a ‘weak’ restructuring of knowledge which may easily be forgotten over time (Mintzes & Wandersee, 2005). Lelliott (2007) reports a common perception that a minimal acquisition of knowledge characterises learning in informal settings. Since learning by ‘addition' is the starting point for superordinate learning to occur, the importance of learning by 'addition' or other weak forms of knowledge restructuring should not be overlooked. Furthermore, the findings reveal that deeper learning (e.g. superordinate learning) does occur during an informal learning experience though it is less common than weaker forms of knowledge accretion.

The findings that learning by 'addition' is far more common is consistent with those of Lelliott (2007) and Anderson et al. (2003) who found that incremental learning of numerous individual facts accounts for a substantial portion of learning when a student visits science centres. This kind of learning is the direct consequence of the visit. Two facts support this:

- Firstly the students did not have any preparation related to the content of the visit by the

Scout leaders and

- Secondly, only 41 instances of learning by the emergence (retrieval of information from stored memory) were noted compared to 108 cases of addition, implying that students did gain knowledge as a result of the visit. Thus, the visit has contributed to students' learning about biodiversity.

While Rennie's statement that deep science learning probably does not occur during a science centre visit may be true (Rennie, 2001), my study suggests that a degree of higher cognitive understanding may occur for the majority of students. The findings revealed that students also learnt through the Human Constructivist knowledge construction categories – 'differentiation/dissatisfaction' (noted 15 times) and discrimination' (noted 12 times). These knowledge constructions represent stronger forms of knowledge restructuring during conceptual change (Anderson et al., 2003). Learning by 'discrimination' implies that the student can compare and contrast among similar concepts resulting in well-integrated highly cohesive knowledge structures that form the basis to make inferences and analytical reasoning reckoned by science (Mintzes & Wandersee, 2005).For example Kelly could compare and contrast between the 'Bois de Rose' of Madagascar and the 'Ebony' of Mauritius, both endemic and endangered species and protected by the law against exploitation and exportation, illustrating a comprehensive understanding of the reason for the legal frameworks that protect endangered species.

During 'differentiation' students are dissatisfied with their initial concepts and replace them with newly learnt information after they learnt by discrimination, making differentiation a representative of restructuring of knowledge structures. For example, the student Selvina modified her prior knowledge from *'bats could see only at night'* towards *'some species of bats can see both at night and during the day'* indicating dissatisfaction and replacement of her prior conception with newly learnt information. In this study, there were only 12 cases of discrimination and 15 cases of differentiation, indicating that the stronger restructuring of knowledge structures is less common than 'addition' for example, but not impossible.

As shown in section 8.3.3 and section 7.6, when interest is triggered due to affect (bodily experiences, aesthetic experiences, strong emotions and novelty), learning occurs mostly through weak forms of knowledge restructuring. However, when the trigger of SI, 'Impressive information' operates stronger knowledge restructuring in the form of differentiation/dissatisfaction, re-contextualisation, and super-ordinated learning occurs. 'Impressive information' as a trigger of SI is a powerful factor that supports deep learning.

8.3.5 The importance of prior knowledge and knowledge gain

Two knowledge construction categories that specifically addressed prior knowledge were 'emergence' and 're-contextualisation'. 'Emergence' is when the students show signs of retrieving information from their memory without substantial elaboration, recorded 41 times. 'Re-contextualisation' was recorded 31 times when the students' existing knowledge is replaced with a new one acquired as a result of the visit. I coded for re-contextualisation when students specifically mentioned that their prior views were changed due to the visit, for example, Joana describes how her prior thoughts that the Dutch killed the dodo were changed when she learnt on IAA that the dodo's extinction was also due to predators.

I recorded 'emergence' as the second most common HC Knowledge Construction category. It is a clear indication that students can relate new information gained to their existing knowledge structures during a visit to an informal learning setting. This is further enhanced when students learn through re-contextualisation during which they exchange their existing knowledge for new ones acquired as a result of the visit. Guided tours such as the one on IAA, could further engage in questioning and brainstorming sessions instead of delivering information. A two-way dialogue is encouraged instead of feeding information to visitors as per a deficit model of science communication which is not backed by scholars in the field (Rennie & Stocklmayer, 2003). The findings of relatively high cases of emergence (41) does not corroborate with those of Lelliott (2007) who found only a few cases of emergence. The challenge in coding for 'emergence' is that one cannot be completely sure that a student retrieved a piece of information from his/her memory. I conducted my coding of post-visit interviews and PMMs under the assumption that students already knew ecology/biodiversity related words that form part of the commonly spoken vocabulary and vernacular languages, such as the sea, birds, and males and females. Thus, visiting informal learning settings enables students to review and modify their prior knowledge, a kind of learning that extends beyond the boundaries of only 'weak' or limited learning.

In Chapter 6, it was found that individual students' exit knowledge levels are always higher than and dependent on their entry-level knowledge. This indicates that the visit enables all the participants to have some knowledge gain and this aspect was illustrated through the portraits of the four students in Chapter 6. However, the net gain in knowledge does not seem dependent on prior knowledge. Therefore, a student's capacity to grasp the significant amount of new information as an addition to his/her prior knowledge will remain rather limited even if he/she is presented with a large amount of information. The ceiling effect (Judson, 2012) was probable for students with higher prior knowledge explaining the limited net knowledge gain observed for these students. While revising this thesis, Staus and collegues (2021) published an article where they proposed a Person-Centred analysis to address the ceiling effect in informal education programmes which might inform future research.

8.3.6 Learning about biodiversity

Overall, the visit also enabled a deeper understanding of ecological processes and functioning. Students moved from an anthropocentric view towards recognising the intrinsic value of biodiversity such as nutrient recycling, ecological processes and species interaction like pollination, dispersal and habitatsThe deeper understanding is evidenced by, the higher number of students who, after the visit, moved from knowledge scores 1 or 2 towards knowledge scores 2 or 3 in each of the learning areas identified as per the analytical framework that I developed in section 6.4. The visit permitted students to have a concrete experience of biodiversity and its conservation *in situ*, whereby abstract textbook concepts are likely to become more vivid and relevant to the student. Helldén and Helldén (2008) found that concrete experiences of biodiversity both in school and everyday life play an important role in developing a student's ability to discern biodiversity. I investigated what students learnt about biodiversity through three lenses: Ecological literacy, Biodiversity and Society and Nature and Self.

Ecological literacy

Ecological literacy aimed to identify how students understood the term biodiversity, its importance and their knowledge of endemic and extinct species. It was found that all students conceptualise biodiversity mainly as different types of plants and animals which illustrates the recognition of diversity at the species level. All students recognised plants after the visit, indicating that the phenomenon of 'plant blindness' described in the literature (Yorek et al., 2008) did not apply to the participants in my study. The participants in my study recognised the importance of plants especially medicinal plants to provide services to humans showing a degree of recognition of the importance of biodiversity as ecosystem services in terms of provisioning and regulating services mainly for the benefit of humans. For example, ten out of 13 students recognised that biodiversity was important to mankind before the visit. After the visit, five students could also include the importance of ecological processes. Thus, students tend to have an anthropocentric approach to biodiversity, but the visit helped them better recognise its intrinsic value.

Students tend to overlook biodiversity at the ecosystem and genetic level as illustrated by only four students who described diversity at the ecosystem level before the visit. This number increased to seven following the tour to IAA. There was no mention of genetic diversity at all by students and this could have been because the guide did not emphasise genetic diversity enough. These findings of Mauritian students' conceptualisation of biodiversity as analogous to species diversity, neglecting ecosystem and genetic diversity altogether, tend to be similar to students from other countries such as Chili and Germany (Menzel & Bögeholz, 2009) and Turkey (Yorek et al., 2008). This is a void to be addressed. Therefore, it is recommended that the teaching of biodiversity by formal and informal education systems emphasise genetic diversity as well as ecosystem and species diversity while developing biodiversity educational programmes.

Students' prior knowledge indicates a lack of knowledge of local endemic plants and animals focusing their attention on exotic and domestic species as illustrated in their Personal Meaning Maps. After the visit, it was also found that 11 out of 13 students could demonstrate an understanding of both the terms extinction and endemic providing examples of each and more students could describe the importance of conservation measures. During the visit to IAA, students encountered the endemic species and witnessed conservation measures in action in an authentic setting. This is advantageous in helping them associate the terms 'endemic' and 'extinct' to the species they saw. For a student, an extinct species might be abstract and sometimes difficult to imagine in terms of size, behaviours and life history. The presence of life-size bronze models or sculptures that are artistic representations of extinct species on IAA was instrumental in triggering students' interest and stimulating recall about extinct species. Presenting life-size models of extinct species in three dimensions in the form of bronze models, metal casts and even taxidermy specimens might be a good means of showcasing to visitors what the extinct species looked like. Instead of presenting abstract textbooks, written facts, photographs or paintings of extinct animals, life-size models increase visitors' ability to visualise the species and remember them.

My study did not consider the students' socio-economic status and Mauritius being a developing country has less than 2% of its land area covered with native forests. Students are more exposed to urbanised and agricultural land reducing their daily exposure to native plants and animals. This might explain their low prior knowledge of endemic species. Knowledge of local and endemic species seem to differ across countries (Menzel & Bögeholz, 2009) and it appears the countries' level of development impact on students' knowledge of local species and students from less developed countries seem to have a higher 'traditional ecological knowledge' (Bermudez et al., 2018). This calls for an increased focus on local endemic and extinct species in the Mauritian curriculum, concentrating on contextualised examples during ecology and biodiversity.

Biodiversity and Society

The visit also enabled students to better formulate opinions and critique decisions about science and society such that they move from factual to conceptual knowledge. They could analyse, synthesise and evaluate during their learning process (Krathwohl, 2002). This was shown through the increase in knowledge scores for most students for each learning aspect of the three lenses considered in section 6.4. Such kind of reasoning where students show higher levels of thinking skills through synthesis and evaluation, though desirable for biodiversity education, has received little consideration in literature (Yli-Panula et al., 2018). Therefore, it is recommended that outdoor and classroom biodiversity education encourage learning strategies that support higher thinking skills among students.

Nature and self

In this study, I found that the trip to IAA contributed to a shift towards more students exhibiting an appreciation and enjoyment to learn about nature and recognise that human beings have the moral duty to protect biodiversity due to our dependence on a balanced ecosystem for our survival. People's appreciation for nature has been shown to enhance knowledge gain (Schneiderhan-Opel & Bogner, 2020). This might be attributed to the authentic experiences of encountering biodiversity in real life,resulting in high instances of affective learning and interest generation. For example, several times students stated 'I liked to see the pink pigeon in reality', resulting in emotional arousal of seeing the bird *de visu*. Exposing students to authentic experiences in nature might enhance their understanding of the importance of biodiversity and species interaction. A trip to IAA nature reserve or similar settings could significantly supplement and support the teaching and learning of biodiversity in schools. It is also suggested that the nature reserve puts more emphasis on helping students develop connectedness with nature (Kossack & Bogner, 2012) which is enhanced during outdoor education to foster pro-environmental attitudes and behaviour.

Analytical framework

It is highlighted that the claims regarding what students learnt about biodiversity are largely influenced by the analytical framework that I developed, especially the lenses of biodiversity learning that I proposed in section 6.4. These lenses, guided by literature, were contextualised for the Mauritian context and based on the guided tour on IAA. The knowledge scores that I used to assess pre- and post-visit knowledge and position students across a learning continuum were based on the analytical framework that I developed using the hybrid approach to coding (Fereday & Muir-Cochrane, 2006). The results could have been different had I used another analytical framework. However, the analytical framework enabled me to understand how the visit enabled students to learn about different aspects of biodiversity as they participated in the guided tour, as discussed in this section.

8.3.7 Misconceptions

Overall, the visit did not impart significant misconceptions among students. In section 6.5, I showed that students exited IAA with similar or more knowledge than before the visit. However, a few students left IAA with their prior misconceptions intact. A widely held misconception is that generally endemic species are rare. For example, when the student Owen was questioned about the skink (lizard), he described it as a *rare* animal, which is not completely incorrect. Skinks are rare in Mauritius but also endemic. Even though many endemic birds and plants are endangered in Mauritius, a lot of endemic flora and fauna are widespread. For example, out of the nine extant endemic birds of Mauritius, the 'Picpic' is common. Some endemic plants encountered on IAA such as 'Bois de Renette' (smelling like an apple) and the 'Bois de chandelle' are used in landscaping across the island. I consider that the guide could explain about identification of endemic plants, during the tour to encourage students to recognise these species. A recognition of endemic species is important for students' general knowledge and for favouring a cultural and contextualised view of science such that students may make meaningful connections with biodiversity.

Another misconception, deeply rooted among students, is situated around the extinction of the dodo. Even after the visit, students largely attribute the extinction of dodo to the Dutch who hunted them. However, students need to be aware that human-induced extinction, especially in previously uninhabited locations, were caused by (i) deforestation for cultivation and urbanisation leading to habitat destruction (ii) the spread of invasive species such as plants that outcompete endemic plants and pests such as the shrews which predate on young and eggs and (iii) some imported diseases.

Invasive species still highly threaten endemic species in Mauritius. Therefore, it would be suitable for the educational programmes of IAA to restructure the guide's explanation around the wave of extinction resulting from colonisation in Mauritius to ensure that the visitors learn about the impact of invasive species on endemic species. If visitors better understand that endemic species are threatened and deserve to be protected, they might provide more support to the resource-intensive conservation practices undertaken by MWF and other institutions.

8.4 Methodological findings

I used auto-photographs, photo-elicitation, and Personal Meaning Maps to collect data in addition to traditional data collection methods such as interviews and field observation. Even though PMM has started to be more widespread, in this thesis I filled a gap by proposing a method to analyse them systematically. Auto-photographs as actual data enhanced my investigation of SI and learning. I present the methodological findings and discuss the affordances of these methods hereunder:

8.4.1 Personal Meaning Maps (PMM)

The promising use of PMMs is that their analysis can be adapted to suit the researchers' needs and answer various research questions (Falk, 2003). One of the methodological findings in this study is that I analysed the PMMs quantitatively and qualitatively through both inductive and deductive coding. I thus, obtained different kinds of information from my data to address various aspect of the research question 2 what students learnt about biodiversity. I used three helpful techniques for analysing PMMs, which might be useful for future research.

Firstly a quantitative analysis of the number of appropriate words and concepts used by individual students before and after the visit in section 6.5.3. Here I found that conceptual addition as a result of the visit was less frequent than vocabulary extension in line with the findings of Van Winkle and Falk (2015). The important aspect of quantitatively counting the number of words and concepts is to clearly define and distinguish between what is meant by an *appropriate* 'word' and 'concept' which I discuss in section 6.5.3. This technique might be useful for practitioners to quickly assess learning gains before and after a visit both for individuals and for a group of students. However, if a study investigates experiences, emotions may be considered as suggested by Adelman et al. (2000) who used different criteria for 'emotions' while analysing PMMs.

Secondly, I conducted a qualitative analysis of the PMMs before and after the visit as elaborated in section 6.3, to gain an insight into how the group of students conceived the term biodiversity. The key in this qualitative analysis was to distinguish between main concepts (e.g. plants, animals), sub-concepts (domestic animals, endemic plants) and examples of concepts (e.g. dogs is an example of domestic animals). I used the hybrid approach to analyse PMMs for the three lenses of biodiversity education in Chapter 6.

A third way that I used PMM and interviews was in Chapter 7, where I used the Human Constructivist and affective knowledge constructions categories to code the PMMs deductively. It was found that using PMM alone to investigate learning constructions might be limiting but coupling analysis of interviews and PMMs revealed a higher frequency of knowledge constructions. The value of using PMMs as a basis for questioning during interviews is evident.

While Lelliott (2007) describes in-depth how PMMs are to be administered and utilised together with interviews, my study contributes to the literature on PMM in showing the variety of ways that I analysed the PMM. As Falk (2003) advises, the PMM is not a 'one-size fits all methodology' and is highly dependent on the researcher's goal. Yet, the flexibility might be both advantageous as well as challenging for the field. There seems to be a consensus that counting words and concepts is appropriate to compare vocabulary and conceptual knowledge due to a visit. Practitioners thus have a quick and straightforward technique to assess simple learning of new words and concepts. However, it might be more challenging to assess the depth and extent of learning through PMMs described by Falk (2003). However, supplementing of PMM with other methods is warranted, as shown in section 7.4. Therefore, PMMs may be analysed according to the researchers' needs, as shown in the current study. For example, the PMM has proved promising to Hartmeyer et al. (2017) who found evidence of students gaining science factual, conceptual and metacognitive knowledge through PMMs and interviews but not procedural knowledge.

8.4.2 Photo-elicitation and auto-photography

The auto-photographs and photo-elicitation technique described in Chapter 5, enabled me as the researcher to see through the participant's perspective (Drew & Guillemin, 2014) which I might have missed if I relied only on interviews or interviewed students using photographs that I chose. I was therefore able to capture data on SI. Photo-elicitation acted as a means for stimulated recall of information gained and feelings experienced during the guided tour when students revisited photographs they captured. Students were able to explain better their emotions and experiences associated with specific exhibits; for example, students felt empathy towards extinction.

In section 6.1, I describe in detail how visual methods might enable data enhancement. When presented with auto-photographs, students could retrieve stored information from their memories, for example, remembering the details associated with particular exhibits (e.g. heterophylly, sex differentiation, camouflage) which represented new knowledge and information that triggered their interest. Data from the photo-elicitation also contributed to findings on what students learnt about biodiversity in Chapter 6. This kind of data capture would not have been possible without auto-photographs and photo-elicitation.

The technique also enabled me to identify the different exhibits or situations that best caught their attention/interest during the tour. This was achieved by requesting students to choose only ten photographs out of the numerous photographs they captured. In Chapter 5, I show the diversity of exhibits that stimulated SI, and I could show that different students individually might have a preference for specific exhibits. I was able to claim that even if the tour was highly driven by the guide where students are not free to choose their path and attend to the exhibits physically, they have the personal choice to choose which exhibit deserved most of their attention interest. It also shows that both learning and interest in informal learning settings are of individual nature.

The challenge with the technique was in the analysis of the large number of photos submitted to me. I thereby adopted a systematic method of sorting, labelling and classifying the photographs as per Glaw et al. (2017). I overcame the challenge of analysing the photographs rigorously by adopting a robust analytical framework – the interpretive engagement framework (Drew & Guillemin, 2014) described in section 5.3, 5.4 and 5.5. I was able to analyse the photographs both from the participants' and the researcher's perspectives. For example, the identification of the trigger of interest 'beauty' was possible when students explained in their own words that the reason for their interest in the exhibit shown in the photograph was because they found it 'beautiful'. 'Beauty' (which I ultimately named 'aesthetic experience') was identified in stage 1 (participant-driven engagement) but not during stage 2 of the analysis (researcher-driven engagement). While analysing photographs 'from participants' eyes'; enable the identification of 'beauty' which could have been missed otherwise. In Figure 5.4, I summarized the data analysis, which might be used as a guideline for future researchers adopting visual data such as photographs, cartoons or drawings.

Given the advantages that auto-photographs and photo-elicitation have provided in the current study, formal education systems might also supplement their traditional assessment with photo-elicitation, especially with timid students, or students having emotional, communication and learning difficulties to assess what goes on in the student's minds. This method helps the participants to overcome their shyness since it gives the participant the impression that the focus of the study is the photographs, not the participant themselves (Blackbeard & Lindegger, 2015).

8.5 The Contextual Model of Learning - Personal, Social and Physical Context of the visit

The Contextual Model of Learning (CML) was the crucial framework that bound this research together. Interest and learning form part of the learner's personal context and the exhibits while the visit is part of the physical context. It might seem that the social context including interaction with staff/guides, described by Falk and Dierking (2013), was less prominent since I did not study group interactions. Yet, the importance of the social context is reflected in the study, illustrated through the guide's crucial role. It would be erroneous to overlook the instrumental role of the guide in this tour where visitors had limited free choice to interact with and access exhibits. Much of the information that students related during interviews was reproduced from what the guide said during the tour, indicating that the guide's message's content and delivery are decisive in shaping students' cognitive learning and SI.

During the IAA trip, the guide took a leadership role over the group of students described in Chapter 4, setting the pace for the trip, maintaining cohesion among the group and ensuring the visit was completed on time. The guide also played a crucial role as a mediator of messages, a communicative role (Randall & Rollins, 2009) to pass on the nature reserve's message to its visitors delivering the biodiversity-related content/ information about the exhibits, ecology and biodiversity conservation. The exhibits were devoid of labels as described in Chapter 4, thus everything that the student learnt could be attributed to the content provided by the guide. Furthermore, at times t he guide successfully created elements of suspense, varying her voice, which tingled the emotions of students. Such practices had a contribution in eliciting SI since SI was also ignited due to surprise and emotions.

I consider that the scripts used by the guides to communicate messages to visitors are adequate in passing essential biodiversity-related information, but they adopted mostly a kind of transmission teaching model whereby they mainly delivered content while the students listened passively. The questioning of students and waiting for their responses were almost absent. As described in Chapter 4, sometimes the guide provided a large amount of information within 30 seconds. Given that the students learn by making additions to their prior knowledge as shown in Chapter 6 and 7, it is suggested that the guides could also start a discussion with students by quickly surveying their prior knowledge and adapting their scripts, scaffolding information to enable students to reinforce or revisit their prior knowledge, thereby enhancing understanding. The findings support the equal importance of the personal, social and physical context in shaping museum experiences as per the CML.

8.6 Contributions of this research

This research has laid valuable contributions to informal learning and SI and has potential applications for theory and practice in the field. I propose how future researchers could explore the findings:

8.6.1 Contribution to theory

Close ties between factors that trigger SI

It was found that several factors trigger SI, and these are closely linked. Careful consideration of the nature of this linkage is warranted in experimental designs that control specific triggers of interest. The challenge for researchers is to identify exactly how each trigger of SI operates independently of another.

The transition between Triggered SI and Maintained SI

Another main theoretical contribution has been a deeper exploration of the Four-Phase Model of Interest Development, especially Triggered Situational Interest (Phase 1) to Maintained Situational Interest (Phase 2). The switch from phase 1 to phase 2 might operate within a fast forward timescale such that the notion of 'adequate support' and 'desire to learn more' that Hidi and Renninger (2006) describe as required for the onset of Phase 1, might be occurring within a short time frame of a visit or educational intervention. Better insight into the notion of 'time' might be obtained by considering aspects of continuities and discontinuities in events occurring during an education programme.

The nature of knowledge construction

The Human Constructivist Framework has enabled me to identify different forms of conceptual change and therefore, might be an appropriate framework to study how learning occurs especially in informal spaces. It is agreed that weak forms of knowledge restructuring are by far the most common form of conceptual change learning during informal learning experiences. However, weak knowledge restructuring forms the basis for stronger knowledge restructuring, though less frequently, during the visit. Since deeper forms of learning do occur, informal learning places which will continue to play a crucial role in supplementing learning of science in a visitor's life-wide and life-long learning activities (Bell et al., 2009).

The Four-Phase Model of Interest Development, the Contextual Model of Learning and meaningful learning

In Chapter 2, I proposed a possible relationship between the Four-Phase Model of Interest Development and the Contextual Model of Learning. Based on the findings, I refine the conceptual framework that I adopted and propose that the CML, situational interest and meaningful learning may be related, as shown in Figure 8.2 below:

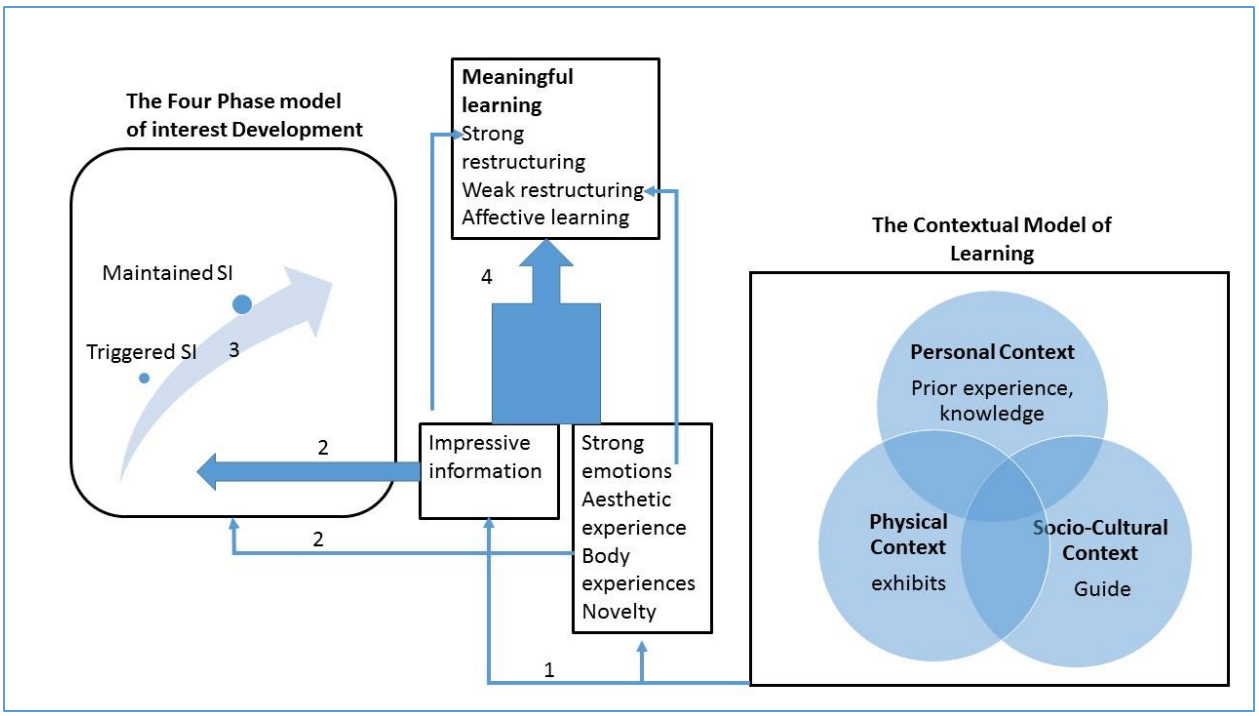


Figure 8.2: Proposed Model for the link between situational interest and learning

1. The physical context of the CML comprises exhibits and the context in which they are presented. The social context comprises the guide and potentially other students and Scout leaders. Exhibits and guides contribute to triggering SI through situational factors such as impressive information, aesthetic experience, body experiences, novelty, and eliciting strong emotions that influence the individual's context. Furthermore, prior knowledge influences interest which impacts on how students learn.
2. The situational factors cause the triggered phase of interest (Phase 1).
3. A second encounter with different exhibits or the context of the visit leads to Maintained Situational Interest (Phase 2). Triggered SI and Maintained SI contribute to meaningful learning.

4. The cognitive trigger impressive information leads to strong knowledge restructuring. The affective triggers of SI lead to affective learning and weak knowledge restructuring. When affective and cognitive triggers of SI occur together visitors are likely to reach a heightened emotional state that activates something in their minds that favours learning. Thus, both strong and weak knowledge restructuring occurs.

This model is open for further consideration and investigation to deeper our current knowledge of interest and learning.

A framework for biodiversity teaching and learning

I also propose that biodiversity education be addressed through three lenses 'ecological literacy', 'biodiversity and society' and 'nature and self' which have been very useful in investigating *what* students learnt about biodiversity, a broad, multi-dimensional and complex concept. It is suggested that biodiversity education be built on a similar framework that gives due consideration to the ecological, personal and socio-economic perspectives. An adequate understanding of biodiversity and its loss within the realms of education for and about sustainability cannot be achieved under a restricted ecologically focused perspective (Menzel & Bogeholz, 2009). School curricular and other educational programmes may incorporate all three aspects of their programmes to teach and learn about biodiversity.

8.6.2 Contribution for practice

The findings of this research also have different implications for practice by nature reserves and science education practitioners.

Story-line of exhibitions

The findings justify the need for a careful planning of the story-line of exhibitions to ensure that visitors are continually exposed to new discrepant information to keep ongoing suspense and curiosity and to prevent museum fatigue. Visitors could remain engaged from the beginning towards the end of the visit. This is supported by the fact that the visitors' interest might be directed towards different exhibits, even those encountered late in the visit as shown in this study. As described in Chapter 4, the museum was the last stopping point yet students were interested in the extinct species found there.

Affective experiences

Guided tours of nature reserves could further explore affective experiences that promote the aesthetic aspect of science to create strong emotions and body experiences that enable learners to feel, touch and experience science with their whole body. The hands-on component accompanied by a minds-on experience might 'shake' the learner's prior conceptions by impressively presenting concepts or information. This is likely to lead to cognitive activation, challenge and fosters the thinking process.

The high occurrence of the affective knowledge construction categories such as 'wonder' and 'experience' highlights the importance of affect, especially during out-of-school experiences where students search for discovery, entertainment and emotions, a form of edutainment. The whole visit contributed to students developing conative learning expressing their desire to take further actions due to the visit. Therefore, the value of affective and conative learning outcomes are not to be overlooked while presenting impressive information that potentially favours interest and learning through strong forms of knowledge restructuring.

Guided tours and the role of the guide

Despite the lack of explanatory labels during this guided tour, students could recall detailed information provided by the guide about exhibits as detailed in Chapter 4. The guide was the key to providing the impressive information that contributed to the triggering of interest and learning. Thus, in a guided tour of a museum setting, the guide, docents or floor staff who form part of the socio-cultural context of a visit are instrumental in creating the visitor experience. They are able to target visitors' emotions including surprise, suspence and discrepant information that sustain the triggering of SI and lead to learning. It is also suggested that the guided tour on IAA provides more opportunities for body experiences for visitors to touch, feel, smell and have a hands-on experience that enhances SI. For example, Kleespies et al. (2020) found that students with initial low Inclusion with Nature Score who got involved in hands-on activities such as petting and feeding during a 1-hour zoo guided tour have the potential to increase their connection with nature. Therefore the nature reserve could propose tailor-made programmes enabling students to participate in bird or reptile surveys, vegetation surveys and animals feeding etc.

Educational programmes, especially guided tours, may consider adapting their content delivery by including brainstorming and questioning that permit visitors to revisit their prior knowledge. Content delivery might then be adapted accordingly, and scaffolding could be introduced by sequentially presenting information to enhance understanding and meaningful learning.

Opportunities for biodiversity and science education

The nature reserve is a natural laboratory for exploration by schools. Given the high instances of learning about biodiversity that has been observed during this guided tour among students, it is suggested that schools in Mauritius, work in close collaboration with the nature reserve and other informal learning institutions. Post-visit follow up sessions and programmes could be tailor-made on specific topics covered in schools such as ecosystem interaction, diversity and conservation to enhance the teaching and learning about biodiversity. Through photo-elicitation students were able to recall concepts and exhibits learnt during the visit. Thus, photo-elicitation or discussion of science topics around a photograph could also be introduced in the classrooms to stimulate scientific debates and initiate recall and critical thinking among students.

8.7 Challenges

While writing my PhD proposal, my initial intention was to study students during school field trips. However, as I described in my methodology section, the Ministry of Education, Mauritius did not permit me to access school children. This raises much concern for research in Mauritius, especially regarding students on field trips in informal learning settings. As I show through my results, students learn about biodiversity and experience conservation actions in an authentic setting that triggers their interest and fosters cognitive, affective, and conative learning. If students are not able to attend such field trips, they might miss important learning opportunities.

One important challenge that I faced is the attrition of the number of participants, from the pre-visit interview to the post-visit interview. I conducted pre-visit interviews with 28 participants but had complete data sets from only 13 students in three Scout groups. In this research, a case study of 13 students was adequate to produce my findings since I intended to produce an in-depth qualitative study. Sample attrition might be problematic for other kinds of research designs, especially quantitative studies. Being part of the leisure activities of students, attending Scout meetings is voluntary by nature. Some students were absent on the day of the field trip or post-visit interviews. The challenges I encountered are likely to be common in informal learning studies which do not involve school groups where school attendance is more structured. Therefore while sampling for participants in purely informal settings, researchers might consider starting with a larger sample due to the possibility of drop-outs, especially where data collection spans over weeks or months.

Demonstrating that learning in informal settings does occur has been claimed to be very challenging (Falk & Dierking, 2013). The framework that I used to analyse learning through Human Constructivist and affective learning knowledge construction categories and the three lenses of biodiversity education proved to be very useful in showing that both surface and deep learning occur. Collecting data through PMMs and interviews before and after the visit enabled me to assess whether knowledge construction and interest have been triggered due to the visit. When students chose their ten best photographs for the post-interviews. they might have been compelled to reflect on the visit before they met me. This could potentially interfere with my research aim of investigating what happens during the visit. However, all interviewed participants confirmed that they did not conduct further research after the visit, although they intended to learn more. My post-visit data collection as an intervention did not seemingly impact the results. Thus, it is reasonable to claim that I did an appropriate investigation of what happens during the visit.

8.8 Conclusion

The current case study has shed light on several aspects of SI and learning about biodiversity, especially within a nature reserve visit, devoid of school involvement. SI leads to learning and both affect and cognition are intricately linked. Moreover, it is the first time that a study of this kind involving informal science education has been conducted in Mauritius. My study remained limited to being exclusively about informal learning experiences where the degree of structure that would have been possible in a school organised trip is lacking. Nevertheless, this is advantageous to informal learning since I have shown that learning is a continuous process and occurs irrespective of school involvement. I showed that interest and learning about biodiversity do occur even when students are in Scout members' role as part of their life-wide learning activities. Supplementing school learning of science with field trips might be useful and have proved promising by researchers from other countries (Dohn, 2013; Nielsen, 2009). I suggest that the formal school education system in Mauritius and elsewhere are more open to taking students on field trips as a complement to their school programme rather than as an extra-curricular activity. I suggest the development of a structured plan or policy to accommodate research studies on teaching and learning both in and out of school.

8.9 Epilogue

As I was writing the thesis during 2020 and 2021, Mauritius, which was already bearing the aftermath of the COVID-19 pandemic on the tourist industry, was faced with an ecological disaster: MV Wakashio Shipwreck 2km away from Ile aux Aigrettes Nature Reserve. I summarise a press release from the Mauritian Wildlife Foundation on 14 August 2020 before commenting.

Extract from Press Release of Mauritian Wildlife Foundation (14 August 2020)

On 25 July, MV Wakashio, a Panama flagged tanker carrying over 4000 tons of heavy oil, lubricants and diesel ran aground off South East Mauritius, a mere 2 km away from Ile aux Aigrettes, an island nature reserve managed by the Mauritian Wildlife Foundation (BirdLife Partner and IUCN member) and home to subpopulations of pink pigeons, Mauritius Olive White-eyes, Mauritius Fodies, Telfair's Skinks, Guenther's Geckos and dozens of endemic plants, most of which are IUCN red-listed. The vessel was on its way to Brazil when it hit the coral reef at about 2 km off Pointe d'Esny and in the vicinity of two important Ramsar sites (Blue Bay Marine Park and Pointe d'Esny wetlands), nature reserves (e.g. Ile aux Aigrettes) and islets national park. The wreck was on the reef for 12 days *before oil started leaking out of the tanker on Thursday 6 August. About 800 T spilled into the ocean, threatening Ile aux Aigrettes, the fragile marine ecosystem and the turquoise blue pristine lagoon. Within days the oil patch moved further north and reached the four islets overlooking the Mahebourg bay, Ile de la Passe, Ilot Vacoas, Ile au Phare and Ile Marianne key habitats for endemic reptiles such as Bouton and Bojer skinks which have gone extinct on mainland Mauritius. The Indian Ocean island nation, home to over 1.2 million people, is heavily reliant on fishing and tourism, which has already been adversely affected by the COVID-19 pandemic. The oil spill has badly impacted the pristine lagoons, coral reefs, mangrove forests and biodiversity with images showing shorelines covered with black sludge, in what is turning out to be an environmental disaster and emergency.*

The main consequences of the ecological disaster are described in the photographs in Figure 8.3 below:

i. Mauritian Wildlife foundation had to urgently translocate birds, reptiles and plants to mainland Mauritius, requiring additional **volunteers** and staff. The Mauritian Wildlife Foundation had to temporary stop its eco-tours on IAA. Flora and fauna on IAA and neighbouring islets and in the lagoon became **threatened**.
ii. Volunteers from the **community** rallied forces to urgently manufacture booms fashioned from stretch nets, sugarcane straw and plastic bottles sewed together with nylon thread to channel oil on the water. The Scout groups, participants of my study, also volunteered.
iii. The **livelihoods** of fishermen, skippers and other people directly dependent on the lagoon were threatened since they could no longer derive economic benefit from the lagoon for a few more months. The government had to find a means to support these people.
iv. Eating seafood fished from the South Eastern region is prohibited due to potential **dangers to human health.**
v. There was vehement **criticism** from the community, politicians and international media regarding the management of the crisis in the press and on social media.
vi. On a positive note, IAA and Mauritian Wildlife Foundation's work have received public and media attention. As of December 2020, the MWF has benefited from several funding and sponsorship opportunities to continue its conservation work. In October 2020, there was a resumption of ecotours on IAA.

Figure 8.3: A Photo-collage of the Oil Spill and its consequences

This ecological disaster testifies the vulnerability of nature reserves and small island states like Mauritius. It also highlights the complexity of biodiversity and its conservation. It is an example of how biodiversity education should include the three lenses I describe in my thesis: Ecological Literacy, Nature and Self and Biodiversity and Society. The management of the crisis entailed politics, societal efforts, funding from philanthropists and community engagement. It also highlights the importance of biodiversity for societies and livelihoods and how biodiversity is a global issue: Mauritius has received support from other countries such as France and India, to manage the crisis. Given the societal implication of biodiversity-related issues and crises, the interest of the population for biodiversity must be triggered and nurtured. The potential contribution of nature reserves and informal learning settings towards this end, should not be overlooked.

Furthermore, the population needs to be aware of biodiversity's ecological role to make informed decisions and participate in public discussions. At the end of 2020, Mauritius, was still recovering ecologically, economically and socially from the oil spill on top of the COVID-19 situation. Eco-tours on IAA started in October 2020 and permission to fish in the lagoon was restored from March 2021. Even if economic and social recovery might be quicker, ecological recovery in terms of replenishment of fish populations, coral reef re-establishment and micro-processes might take years.

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10 Appendices

10.1 Appendix 1: Agreement with Mauritian Wildlife Foundation

MAURITIAN WILDLIFE FOUNDATION

Agreement

It is agreed between

Bhamini Kamudu Applasawmy, researcher, on the one part ('the Researcher')

and

The Mauritian Wildlife Foundation (MWF) of Grannum Road, Vacoas represented by the Executive Director, on the other part

Purpose of the Agreement

The researcher is conducting a doctoral study with the University of Witswatersrand, South Africa entitled 'Investigating Situational Interest and Learning about Biodiversity: A case study of how Students experience a field trip to a Nature Reserve in Mauritius'

and is requesting that MWF provides:

- Access to Ile aux Aigrettes for the researcher and one other person to follow 1 to 2 groups of students or adults guided by MWF to familiarize the researcher with the contents of the guided tour
- Free access to Ile aux Aigrettes for the researcher and her research participants, on about 4 -5 occasions to bring a group of students numbering 15 to 30 students at a time to follow a tour led by the rangers of MWF.
- Interview with a MWF staff involved in the design and implementation of the Learning with Nature tour

This Agreement sets out the conditions whereby both parties agree to collaborate.

Duration and Termination

The terms of this Agreement continue to be valid indefinitely.

Article 1 – MWF's Contribution

MWF shall provide boat transportation and free access to the researcher, her assistant and participants as specified above.
All arrangements for access to Ile aux Aigrettes must be agreed in advance with Mr Danny Thisbe.

Article 2 – The Researchers' undertaking

The Researcher agrees:

- To respect the rules and regulations of Ile aux Aigrettes and ensure all persons that she brings to the island respect them too. These include:
  - Keep to the paths
  - No littering
  - No smoking
  - No loud noises
  - No picking or gathering plant material
  - No touching or feeding of Tortoises or any animal or bird
- not to release the MWF information / data provided under this agreement to any other person, organisation or entity
- only to use this information / data for the specific purpose mentioned in this agreement.
- to acknowledge MWF in any paper, and any presentations or other external documents issued linked to or referring to the Information provided by MWF
- The following MWF staff will be offered co-authorships in papers that she publishes and the opportunity to comment on the draft of the paper, provided that the co-authors contribute to the writing of the paper and keep to publication deadlines with their contributions. These contributors would be one or more of: Mrs Deborah de Chazal, Mr Danny Thisbe and Dr Vikash Tatayah if the research leads to publications.
- to submit to MWF a copy of all papers and publications within one month of completion of the examination of the thesis or publication date.
- To acknowledge North of England Zoological Society in papers and publications in their role of creating content for the tour and supporting Learning with Nature.
- MWF retains all copyright and intellectual property rights to the information provided regarding the contents of the guided tour and 'Learning with Nature' Trail

Article 3 - Notices

All notices in terms of this Agreement shall be in writing (which can be email). The party sending the notice must ensure the other party has acknowledged receipt of the notice and it shall be addressed to:

1. **Bhamini Kamudu Applasawmy**
   PhD Student,
   Wits School of Education
   University of Witwatersrand
   South Africa
   Email:kamudu.rgsc@gmail.com
   Home Address: 107, Morc VRS2, L'Avenir, Saint Pierre, Mauritius

2. **Mauritian Wildlife Foundation**
   Grannum Road
   Vacoas
   Mauritius
   Attn: The Executive Director
   Email: executive@mauritian-wildlife.org

Article 9 - Disputes

All disputes arising out of and in connection with this agreement shall be decided by arbitration by two persons, one nominated by each person:

For the Student:

(i) Prof Marissa Rollnick, Professor Emeritus, Marang Centre for Mathematics and Science Education, Wits School of Education, University of Witwatersrand, Education Campus, 27 St Andrew's Road, Parktown, Johannesburg
Or

(ii) Dr Eunice Nyamupangedengu, Lecturer, , Marang Centre for Mathematics and Science Education, Wits School of Education, University of Witwatersrand, Education Campus, 27 St Andrew's Road, Parktown, Johannesburg

For MWF: The President, Mauritian Wildlife Foundation or his nominee

This agreement is made in two originals.

Signed this ..13th...day of September... 2018

....
Executive Director
Mauritian Wildlife Foundation

....
Bhamini Kamudu Applasawmy

10.2 Appendix 2: Students details and schools attended

	student Code	Fictitious name	Age (years)	Class	Type of school	School pass rate at HSc (%)	years in scouts	Name of Youth Group	Pre-Interview	Date of Field Trip	Post-Interview	Residence
1	GG002	Shreena	15	Grade 9	State aided private school	15.79	7	Eclaireurs du nord (2eme Compagnie)	22-Sep-18	6-Oct-18	13-Oct-18	Grand Gaube
2	GG008	Selvina	15	Grade 10	State secondary school	84.3	3	Eclaireurs du nord (2eme Compagnie)	22-Sep-18	6-Oct-18	13-Oct-18	Grand Gaube
3	P002	Joanna	14	Grade 9	State-aided private school	28.19	4	Eclaireurs du nord (1ere Compagnie)	7-Dec-18	7-Dec-18	15-Dec-18	Pamplemousses
4	P008	Owen	14	Grade 9	State-aided private school	68.68	2	Eclaireurs du nord (1ere Compagnie)	2-Dec-18	7-Dec-18	15-Dec-18	Pamplemousses
5	P010	Tom	14	Grade 9	State secondary school	99.34	9	Eclaireurs du nord (1ere Compagnie)	2-Dec-18	7-Dec-18	8-Dec-18	Pamplemousses
6	P011	Anna	14	Grade 9	State secondary school	100	2	Eclaireurs du nord (1ere Compagnie)	2-Dec-18	7-Dec-18	8-Dec-18	Calebasse
7	P012	Felix	14	Grade 9	State-aided private school	61.79	6	Eclaireurs du nord (1ere Compagnie)	7-Dec-18	7-Dec-18	8-Dec-18	Pamplemousses
8	P013	Pascal	14	Grade 9	State secondary school	41.56	5	Eclaireurs du nord (1ere Compagnie)	7-Dec-18	7-Dec-18	15-Dec-18	Pamplemousses
9	P014	Ryan	14	Grade 8	State-aided private school	50	1	Eclaireurs du nord (1ere Compagnie)	7-Dec-18	7-Dec-18	8-Dec-18	Pamplemousses
10	P015	Steffy	14	Grade 9	State-aided private school	15.79	3	Eclaireurs du nord (1ere Compagnie)	7-Dec-18	7-Dec-18	8-Dec-18	Pamplemousses
11	HL 01	Alex	15	Grade 10	State-aided private school	96.8	5	Port Louis Girls Guide	16-Feb-19	17-Feb-19	2-Mar-19	Rose Hill
12	HL03	Sonia	14	Grade 9	Private secondary school	82.61	2	Port Louis Girls Guide	16-Feb-19	17-Feb-19	2-Mar-19	Vacoas
13	HL04	Kelly	15	Grade 10	State secondary school	100	5	Port Louis Girls Guide	16-Feb-19	17-Feb-19	2-Mar-19	Terre Rouge

10.3 Appendix 3: field observation notes

What happens during the trip/Contents of the trip	Biodiversity concepts that I identified and my reflections
Pre-Visit Students meet at the Jetty. The teacher finalizes formalities at the reservation desks and meets the guides. Groups of 14-15 students embark on a speed boat with the help of the silent skipper They travel for 5-10 mins to reach the islet Students get down one after the other with the help of the skipper The guide gathers everyone and the guided tour starts now The guide welcomes the group to the nature reserve and explains that the island is of coral origin, unlike mainland Mauritius which is of volcanic origin. So visitors, need to remain careful while walking so as not to get hurt with sharp structures. The group started walking along a narrow sandy trail surrounded by thick vegetation (*en file indienne).*	Little info was provided by the guide, she gave a quick intro and starting walking and students followed Geology refers to volcanic origin covered in the syllabus at the primary level. Safety instructions
Stopping point 1: The baby tortoise and Bat cage The group reaches the first stopping point and students gather around the tortoises' cage, each student trying to get the best view possible. The guide explains that 2spp of tortoise are present in the cage – Radiata tortoise from Madagascar and Aldabra tortoise The baby tortoise in the cages is between 2 months to 2 years old. After 5-7years they are transferred to Round Island Questions from students: Why are there numbers on their shell? Guide: to identify them. Each individual has their own identity Adjacent cage: bat cage The bats are frugivorous flying mammal, endemic to Mauritius. This spp is active both during the day and night, it is false that all bats are active only at night In nature, this spp of bats (*Pteropus niger*) can live up to 15years but in captivity, its lifespan may reach 30years. Its main means of population	The narrowness of the path The idea of Speciation and Taxonomy (though not explained in detail), species originate from different countries Breeding In captivity, partly life cycle Translocation Students ask questions about what is visible (observation) Tagging for identification Endemism, feeding habits Animal behaviour, life history

control is cyclones. Highlight the importance of bats for the ecosystem, mention mass culling with no particular emphasis	Life history Natural population control
Stopping point 2. Restoration works Kiosk with about 7 posters highlighting the restoration work of the Mauritius wildlife foundation. Students sit on benches and listen The group then walks for 2-3 minutes one after the other along the narrow path amidst the vegetation	Conservation work of NGOs and scientists Students chatted about school and Scouts meetings
Stopping Point 3: Bronze Skink Model After a short walk, the guide stopped in the midst of the vegetation and signalled for everybody's attention towards an animal sitting on a big rock: A large skink (lizard-like) about 50cm long was sitting calmly on the rock. Some students approached it furtively for a closer view of this strange-looking lizard kind of animal, while others preferred to remain cautious. Some bold students once asked their guide if they could touch the tortoise. The guide prohibited. From the students: Is it alive? Is it real? The guide questioned the group: do you think this is a live animal? Well, you guessed it right: it is not a live animal. This is a bronze model of the Telfair Skink or Giant Telfair. It is a giant skink once widely present around Mauritius but it slowly became restricted to Round island only. Following restoration work, we (Mauritius Wildlife foundation) introduced it on IAA. The skink helps to control the population of the shrew which are pests on the islet. In the meantime, some students were already touching the bronze skink and taking photos. Some exclaimed: A big 'Lezard'! *(literally 'lezard' in creole means lizard in English but Mauritians know lizard as the brown geckos which roam on house roofs or green ones found on some trees).)* The guide then informs the students that skinks and geckos are different: geckos can climb up objects using the adhesive digits on their feet while skinks are not excellent climbers. On IAA there are 450 Skinks roaming around in the wild.	Encounter with a reptile not usually seen on the mainland Curiosity, awe, precaution from students? Readiness to touch? The students displayed doubts about whether this animal is real or not? Telfair Skink: new name introduced to students How this reptile has gradually disappeared from the mainland. Restoration work/conservation/saving spp from extinction Population control – food web - the concept of pests and pest control Curiosity, eager to touch 'embracing' the animal since it is not dangerous Language barrier to learn scientific terms for second language speakers/multilingual speakers

Stopping point 4: Ficus Tree and Bronze of extinct Mauritius Owl The guide gathers everyone under one tree and asked whether students have seen this tree before. Some answered Yes Yes it is the Banyan Tree. But the Guide explains this is a different species the Banyan tree has smaller leaves while this is a Ficus spp endemic to Mauritius (to verify this information). They quickly went over the Bronze model of the extinct Mauritius Owl and students did not ask much about it.	Skinks v/s geckos Brown geckos – with reference to what the students may already know Anatomy and life history characteristics Speciation, the relatedness of species and taxonomy. Banyan tree reference to what the students may already know Endemism How to differentiate between species – leaf morphology as a tool for classification Other extinct birds of Mauritius – less widely known
Stopping Point 5: Ebony Tree The guide asks: Have you heard of 'Bois D'Ebene' (Ebony Tree'). Students: Yes it was used to repair ships! The guide informs the students that what they read in their school textbooks is false because Ebony cannot be used to repair ships since it is heavy, but it was used to make masts of ships. The wood to make ships was called 'Bois de Fer' which is solid and lightweight. The ebony tree used to be called the 'black gold' of the Mascarene, is was very expensive and used to make keys of piano and furniture. We now have 11 species of Ebony trees in the Mascarenes and one species is already extinct. The wood of the tree grows by 1 mm per year, so it is very slow-growing. Its fruits look like the Sharon fruit. Meanwhile, geckos were seen on the branches. This is the *Phelsuma ornata* also known as the ornate Day gecko endemic to Mauritius	The ebony tree is a well known endemic species due to the exploitation by the Dutch and French – the island was well known for its ebony back in the 1700s A misconception in science and history Different species of wood have different characteristics Speciation in the Mascarenes – how Mauritius, Reunion and Rodrigues have closely related species –Extinction Growth – slow growth of woody species Reference to the knowns Endemic geckos of Mauritius
Stopping Point 6: Heterophylous Plant – Bois de Rats After walking a few metres along the trail once more 'en file indienne', the guides stopped at a special tree. She told students to touch and closely watch the young leaves and compare them with the adult leaves. The studentsdiscovered that adult leaves found higher up the tree are spoon-shaped while the young juvenile leaves found at near ground level are long and pointed. The guide explained that this phenomenon is called heterophylly where only one plant has 2 different leaf shapes. This is because the tree developed a mechanism to prevent its leaves from being eaten by tortoises which once thrived on IAA and in Mauritius. The endemic tortoises	Let students observe and deduce and compare Heterophylly

of Mauritius with their long neck extended could reach up to 1.2 m long. Pointed leaves with a red mid-vein act as a deterrent to predators (in this case tortoises) Some students listen attentively. Student Question: Why is it called 'Bois de rat'?? (Eng: Rat Wood). The guide then tries to find some white flowers from the tree and which students could smell taking care not to break them from the plant. Flowers have a very nice smell but when it is plucked from the tree and left overnight it develops a bad smell. This is why older people have names it is called 'Bois de Rats'	Protection against predation by tortoise Co-evolution??? Morphology of the extinct Mauritian Tortoise A long neck is an evolutionary adaptation to feed on plants Educated children do not destroy flowers Smelling of flowers compare the smell to Compounds responsible for smells, Mauritian Folklore
Stopping point 7: Tortoises roaming freely around. As the group trailed along the pathway, they came across a tortoise roaming around. The guide explains that there are 25 tortoises on IAA, 13 males and 12 females, including one dominant male. They can live between 150 to 200 years and reach up to 200kg and this one is still growing. The guide asks whether students have ever climbed on tortoise backs. Some answered yes. The guide explained that the carapace of the shell is a very sensitive part of the body since it is made up of keratine, the same substance as our nails. Its spinal cord and muscles are attached to the shell. So one should never climb on tortoises or scratch their carapace. The guide then sits on her legs and rubs the tortoise's neck, some students were eager to follow her. Questions from Students: - How to tell the difference between males and females. Females have a hollow under the carapace. - Why did you bring tortoises here? All endemic tortoise went extinct in the 1800s. They were exterminated by colonisers who cooked meat in their carapace and burnt their meat to produce oil. We need 500 tortoises to make 1 barrel of oil. The species you find here is the nearest cousins of the Mauritian extinct tortoise. It comes from Aldabra, an island found near Seychelles to act as an *Analogue* species. - Is it sleeping – Well not really. As students touch the tortoise's legs it started moving slowly. The guide explained that we can count the number of lines on the tortoises carapace to estimate its age. As one student timidly touches the tortoise, others gradually followed now more readily. The guide explainéd that before saving animals from extinction, we need to save their habitats and food resources. This is why tortoises have been introduced on IAA. They feed on seeds and leaves and later contribute to seed dispersal by passing out seeds in their faeces far from the mother tree.	1 Male dominant – Life history Caring for animals Anatomy and body composition Comparison/reference to what is known Educate to care for animals Readiness to touch Sex differentiation Extinction due to human colonization and overexploitation Historical aspects

Bueeerrrkkk!! Some students exclaimed! During that time some a weaver bird was seen flying among the branches and the guide asked whether they have seen this bird before. Some students confirmed that they have seen this bird in their yard. But the guide again told students that what they usually see on the mainland is the Madagascan Fody while the one found on IAA is the endemic Mauritius fody which remains smaller. The group then walks freely amidst the vegetation trying to locate some Mauritius pink pigeons, (A Passerine, endemic to Mauritius once critically endangered and successfully saved from extinction by intense conservation efforts). Unfortunately, the group could not see any pink pigeons near their feeding place. But the guide detailed that there are 38 pink pigeons on IAA and many more in the Black River Gorges. She talks about how in the 1990s there were only 9 pink pigeons left in Mauritius, but intense conservation management efforts have enabled the population to reach more than 800 now. The populations are still being closely monitored by scientists. The guide asked students about other endemic birds in Mauritius but I could not hear the conversation as the guide was talking and walking at the same time. And I was behind.. some students next to me may not have heard also. Nearby there was another ebony tree, with some unripe fruits. A Student questioned what will happen if we eat the fruits, but the guide cautioned us not to taste anything.	Overexploitation of endemic resources for human consumption Classification and taxonomy Analogues species – the ecological role played by analogue spp Scientific procedures Peer 'pressure' or 'peer following' Importance of saving ecosystems, food web, Introduction of spp to do fulfil ecological roles Dispersal of seeds by animals Students exclaiming disgust at something dirty Again reference to the known Related species and common cousins from neighbouring islands Success stories of conservation efforts Supplementary feeding to helping restored species in the wild Conservation work on other places in Mauritius Population growth following conservation Scientific monitoring The disadvantages of the field trip Eating unknown fruits

As the group continued along the track, 'Big Daddy' was seen crawling around. Big Daddy is the oldest male tortoise on the islet and at that time students were super excited and amazed by its Big Size. It started moving as students approached. Some exclaimed' Oh my God, it is getting up!!' With the guide's permission students started stroking its legs and more students approached to touch it and followed by the next. By that time some girls were already tired they wanted to rest but they were not ready to sit on the ground. So they reluctantly followed the guide. Along the trail, 2 more tortoises were seen crawling but this time some old tortoise excrements full of seedlings were seen on the ground. The guide raised the attention of the students and showed them a real-life example of how tortoises help plants to disseminate seeds and colonise new areas. One of the tortoises, Mr Georges, had a damaged carapace and students questioned why but I could not hear the answer.	Big Size amaze, impressive Exclamations from the students Students touching animals Tired by the long walk – heat and humidity Evidence of previously explained concepts – real-life example.. Dissemination of seeds Colonization of new areas by plants
Stopping Point 9: The Pandanus Tree. The guide stopped in front at an endemic Pandanus tree which is very peculiar with its leaves arranged in a spiral. This shape and overall structure with deep roots make the tree very strong to make it resistant to cyclones. Students wondered whether there are some animals inside and the guide asked them to go nearer and 2 Phelsuma geckos could be seen. The guide said the tree is also commonly called a blue latannier due to its leaves which appear blueish under the sun. On the other side, another endemic palm tree was found: the bottle Palm hose trunk resembles an Orangina bottle. At this point, students were busy taking photographs either of the plants or of themselves in front of the trees. A few metres away there are two cannons and remnants of old stone buildings. The guide explains how IAA was used as a military base by the British during the second world war due to its ideal location which gives a view over the southeastern coast of Mauritius. In those times deforestation started on the IAA causing the degradation of the ecosystem. Conservation work started in the 1980s and the trees. Some students noticed coloured tags on trees and questioned their importance. The guide said the colours help to identify nesting places for birds and bird pairs.	Particular morphology of endemic trees as an evolutionary adaptation to resist cyclones Food web Mauritian language and folklore to name trees by appearance – particular leaf characteristics help to identify the spp Morphology of the plant Taking photographs as signs of engagement

Other questions by students: What do tortoises eat? .. dried leaves, fruits of trees and many other plants. Nearby the guide stops at another tree and caught some leaves in her hands – she passed on the leaves to the students and asked them to smell. Many students could tell that the leaf has a familiar smell but could not tell what it was. The guide gave them some hints and finally they guessed it right the leaf of that tree smelled like a green apple: 'Pomme de rennette'.but it was not an apple tree but a tree called 'Bois de Renette'	Historical aspects and geography of Mauritius World war II protection of the state Ecosystem degradation followed by conservation work Long time taken for conservation work to show its effects, Tagging Birds on trees – habitats Feeding habits of animals Smelling Hands-on Reference to the known guessing
The last stopping point is the museum Students reached the museum, some were relieved that they have covered the majority of the trail and thought it was time to get some rest. As they entered they could see some big spiders with orange coloured legs in their webs connecting the museum veranda and trees. However, they looked nicely surprised by what they saw. The museum was about 80metre square, Some exhibits include: Old Paintings showing the landscape in Mauritius during the 1700s. A real ebony wood (Black and hard) which students can touch. Bronze of the dodo and the guide explained that the dodo was extinct not because people ate it. In fact the meat was not delicious. But they had small wings and could not fly, laid only one egg per year and they were hunted by the dutch. Other skeletons are that of the Blue pigeon now extinct in Mauritius. Students were scattered all around the place and I could not follow what each student was doing. The explanations of the guide ended as she let students explore the museum on their own and invited them to see the gift shops . Students then met the guide who accompanied them to the jetty to catch the boat back to mainland Mauritius.	Historical aspects Seeing a real ebony wood Misconception is historical reporting Life history and reproductive characteristics Human causing extinction Other extinct birds of Mauritius

10.4 Appendix 4: Permission from Scout group leader

LES ECLAIREURS DU NORD

To: Mrs Bhamini Kamudu Applasawmy Date: 09 April 2018

107, Morcellement VRS2,

L'avenir, Saint Pierre

Mauritius

Dear Madam,

PERMISSION TO CONDUCT RESEARCH

This is to inform you that the *'Association Les Eclaireurs du Nord'*, a registered national scout group bearing registration number 10177 is agreeable to support your research entitled *'investigating situational interest and learning about biodiversity: A case study of students' experience of a visit to a nature reserve' for your PhD studies with the University of Witwatersrand.*

We are willing to take our students for a visit to Ile aux aigrettes Nature Reserve as it forms part of our programme and we accept that you interview and observe them provided students and their parents give their consent. We will facilitate your communication with students of our group and their parents.

You may contact me for further information and arrangements.

Yours sincerely,

Ms Jessica Legallant

Chief Scout Leader

'Eclaireurs du Nord'

09/04/18

Eclaireurs du Nord, Independence Road, Pamplemousses Contact : 57906520/sicabristol@gmail.com

10.5 Appendix 5: Parents' Consent Form

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Wits School of Education

27 St Andrews Road, Parktown, Johannesburg, 2193 • Private Bag 3, Wits 2050, South Africa
Tel: +27 11 717-3007 • Fax: +27 11 717-3009 • E-mail: enquiries@educ.wits.ac.za • Website: www.wits.ac.za

Parent's Consent Form

Please fill in and return the reply slip below indicating your willingness to allow your child to participate in the research project called "*Investigating situational interest and learning about biodiversity: A case study of students' experience of a visit to a nature reserve*." conducted by Mrs B.Kamudu Applasawmy.

I, Haafrah Ollite the parent of Aisha Ollite.

Permission to review /collect and use documents/artefacts/photos	**Circle one**
I agree that my child's Personal Meaning Maps and photos that he/she will take can be used for this study only.	YES/NO
Permission to observe my child during his/her outing to Ile aux aigrettes	
I agree that my child may be observed during the outing to Ile aux Aigrettes	YES/NO
Permission to be audiotaped	
I agree that my child may be audiotaped during interview or observations.	YES/NO
I know that the audiotapes will be used for this project only	YES/NO
Permission to be interviewed	
I agree that my child may be interviewed for this study.	YES/NO
I know that he/she can stop the interview at any time and doesn't have to answer all the questions asked.	YES/NO
Permission to be photographed	
I agree that my child may be photographed during the study.	YES/NO
I know that I can stop this permission at any time.	YES/NO
I know that the photos will be used for this project only.	YES/NO

Informed Consent

I understand that:

- my child's name and information will be kept confidential and safe and that my child's name and the name of their school/group will not be revealed.
- he/she does not have to answer every question and can withdraw from the study at any time.
- he/she can ask not to be audiotaped, photographed and/or videotape
- all the data collected during this study will be destroyed within 3-5 years after completion of my project.

Sign ________________ Date 14/09/18

10.6 Appendix 6: Learner Assent Form

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Wits School of Education

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Learner Assent Form

Please fill in the reply slip below if you agree to participate in the research on "**Investigating situational interest and learning about biodiversity: A case study of students' experience of a visit to a nature reserve"** conducted by Mrs B.Kamudu Applasawmy.

My name is: StPiene Jean mathieu

Permission to review/collect documents/artifacts	**Circle one**
I agree that Personal Meaning Maps and photographs I will produce can be used for this study only.	YES/NO
Permission to observe you during the outing on Ile Au Aigrettes	
I agree to be observed during my visit to Ile Aux Aigrettes.	YES/NO
Permission to be audiotaped	
I agree to be audiotaped during the interview	YES/NO
I know that the audiotapes will be used for this project only	YES/NO
Permission to be interviewed	
I would like to be interviewed for this study.	YES/NO
I know that I can stop the interview at any time and don't have to answer all the questions asked.	YES/NO
Permission to be photographed	
I agree to be photographed during the study.	YES/NO
I know that I can stop this permission at any time.	YES/NO
I know that the photos will be used for this project only.	YES/NO

Informed Consent

I understand that:

- my name and information will be kept confidential and safe and that my name and the name of my school/youth club will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- I can ask not to be audiotaped, photographed and/or videotape
- all the data collected during this study will be destroyed within 3-5 years after completion of my project.

Sign ______________ Date 15.09.18

10.7 Appendix 7: Interview Schedule

Questions during the semi-structured interview (not all questions asked to all students)

PRE-VISIT QUESTIONS

Section A: Proposed Field trip

1. Where are you going for the forthcoming school outing?
2. What subject area is the visit related to?
3. What do you think is the purpose of the visit?
4. What preparation have you been doing for the visit? Probe for organizational preparation; tasks/worksheets, learning preparation, preparation for the nature of the venue; etc.
5. How do you think your forthcoming trip to Ile aux Aigrettes will be?
6. Are you looking forward to your visit? Why or why not?

Section B: Assessing Prior interest for Biodiversity about Biodiversity and ecology

1. Tell me what do you usually enjoy doing in your free time? Probe for engagement in Scouting activities, leisure activities, watching TV documentaries, or nothing related to the environment.
2. What kind of programme do you enjoy watching the most on TV? Do you watch any programme thing related to the environment or science?
3. Do you surf the internet or use social media? What kind of pages or activities do you do on social media?
4. Are you a member of any club at school? Or in your village/town? Probe for membership in any environment club.
5. Tell me something about the sea in Mauritius or elsewhere?
6. What can you tell me about the forest in Mauritius or elsewhere?
7. What are your two most favourite subjects and school? Least favourite? Why?

Section C: Assessing Prior Knowledge

1. When you hear the word biodiversity or diversity of living things, what is the first thing that comes to your mind? And what else? Can you explain
2. Can you tell me something about the environment in Mauritius?
3. Do you think all life on eartneeds to be protected? Why?
4. Do you know what is a food chain and a food web? Can you explain?
5. Do you know what is an ecosystem?
6. Do you think we should enable people to cut down forests? Why? Why not?
7. Tell me something about the dodo?
8. What are endemic species?
9. Can you name some native plants and animals in Mauritius?
10. Do you know about species that have been saved from extinction?
11. Do you think we should kill the Mauritian Fruit Bats?
12. What are the dangers that endemic species face in Mauritius?
13. Do know of any famous animal or plant in the world that is important for the environment?

POST VISIT QUESTIONS

Section A. The Recent Visit.

1. Can you tell me the name of the place you went to for the outing? When did you go?
2. What subject is your visit related to? Can you tell me what subject area or topic you could relate your visit to?
3. What do you think was the purpose of the visit?
4. Did you do any work on the topic of the visit? Before or after the visit? Did you do it on your own or at school?

Section B: Assessing interest

1. In one word or a few short words, how would you describe your outing and Ile aux Aigrettes?
2. What do you remember of the outing?
3. Name 2-3 aspects of the visit that you enjoyed the most? The least? Why?
4. Did you have fun during the visit?
5. Can you tell me anything or occurrences that happened during your visit, that you are not ready to forget?
6. Did you talk to your friends or family about your outing? What did you tell them?
7. Since you returned from the field trip, what programmes did you watch on TV? Did you surf the internet or read any magazine and newspaper article? Tell me about it? What do you think?
8. Are you involved in any club? Or would you like to be involved?
9. What is your most favourite place to visit or leisure activity? If you have to choose to go to that place or Ile Aux Aigrettes, what will be your choice?
10. Will you go to Ile aux Aigrettes again if you have the opportunity? Why?

Section C: Assessing Knowledge gained

1. Tell me, what do you remember of Ile aux Aigrettes Nature Reserve?
2. What is special about Ile aux aigrettes?
3. When you hear the word biodiversity or diversity of living things, what is the first thing that comes to your mind? And what else?
4. Tell me what animals or birds you remember on the islet? What do you remember about them?
5. Do you remember anything about the plants on the islet? What can you tell me about them?
6. What are endemic species?
7. Why do you think we need to protect the plants and animals which are native to Mauritius?
8. Do you think we need to kill the Mauritian Fruit Bat?
9. What is an ecosystem? What does it consist of?
10. Do you think we should protect all life on earth?

10.8 Appendix 8: Grouping of inductively derived codes into categories and the description of the categories

S.N	Examples of Codes	Categories	Description of categories
1	bats, bats not killed,bats killed, bats no opinion, value life	Bats	when student mention the bats and give their opinion about whether bats should be killed or not
2	animals, plants, medicinal, corals, different types, etc..	Biodiversity	when students mention about animlas, plants,corals, medicinal plants, sea as part of biodiversity or describe biodiversity as different types of plants and animals, or make reference to the food chain/food web.
3	smell, body, touch, walk	Body Experience	when students mention about walking on something, touching or smelling things/plants
4	nursery, translocation, dispersal, pollination	Conservation	when students showed evidence of knowledge related to conservation e.g translocation, MWF, nursery activities, save endangered species; when students talked about the importance of habitat and nursery
5	camouflage, red veins, reproduction, oxygen, etc	Ecology Terms	show knowledge or recall of ecology related concepts such as camouflage, dispersal of seeds, ecosystem function, endangered species, exotic species, heterophylly, food chain, invasive species, predation, sex differentiation, reproduction, pollution and importance of oxygen
6	geckos, skink, endemic birds	Endemic Species	when students mentioned about endemic plants such as ebony and endemic animals such as geckos, skink, Pink pigeons, Mauritian fody
7	blue pigeon, hen, long-necked tortoise, owl, etc	Extinct Species	when students refer to animals such as bleu pigeon, dodo, giant gecko, giant skink, red rail, museum exhibits, owl, parakeet and long-necked tortoises
8	canon, Dutch	History	mention about historical aspects of IAA or Mauritius such as the Dutch and the canon, past exploitation of flora and fauna
9	reading, sports	Interest Indicators	Reference to interview questions about students favourite leisure activities such as reading, sports, social media, watch documentaries etc
10	new discovery, new learning, reality, first time	Novelty	reference to seeing or experiencing for the first time, making new discoveries, new learning or seeing things in reality for the first time
11	boat, new place	Overall Experience	refrence to overall experience of the visit such as the boat trip, the new experience of discovering a new place,
12	like biology, french, learnt at school	School	When students talked about their favourite subjects at school or having learnt something at school
13	big, small, number of years, lifespan	Size/Numbers	when students make reference to the idea of size and numbers such as big, small, number of years, lifespan
14	guide, friends	Social Aspect	social aspects of the visit when students make reference to the guide or to their friends as part of their visit experience
15	surprise, strange, impressive, incredible	Strong Emotions	describe use of words that illustrate emotions by participants such as impressive, incredible, strange, surprise,
16	carapace, small tortoise, female tortoise, male tortoise, tortoise	Tortoise	When students mention something about the tortoises or related such as carapace or tortoise
17	beautiful, nice	Beauty	When students describe exhibits and landscapes as beautiful

10.9 Appendix 9: Analysis of photos and photo-elicitation for 'extinct animals'

The categorisation of photographs submitted by students under 'extinct' animals

Category of photos	Felix P012	Orwin P008	Pascal P013	Alexia HL01	Anna P011	Joana P002	Selvina GG008	Shreena GG002	Stefy P015	Tom P010	Total number of Photos per category
Giant Skink	1	0	1	0	0	1	0	1	0	1	5
Blue Pigeon	0	0	0	1	1	0	0	0	0	0	2
Dodo	0	0	1	0	0	0	0	1	0	1	3
Parakeet	1	0	0	0	0	0	1	0	0	0	2
Museum (bats)	0	0	0	0	0	1	0	0	0	0	1
Owl	1	0	0	0	0	0	1	1	1	0	4
Total number of photos per student	3	0	2	1	1	2	2	3	1	2	17

Codes that co-occur with the category 'Extinct animals' during photo-elicitation

Codes grouped in category 'Extinct animals'	Selected extracts from the interviews	Co-occurring codes with the code 'extinct animals'
Big Parakeet	**(i) Felix:** I liked to see a parakeet of this **size**! **(ii) Selvina:** this is the **big** parakeet**. I have never heard of it**. I know parakeets are smaller and there it was larger! Me: **The one in the picture, do we still have them in Mauritius?** **Selvina: no** Me: Do you know how was it called? Selvina: The Big Parakeet!	**Size** **Size/ New discovery/knowledge** **Extinction**
Bronze of extinct owl	**(i) Felix:** I saw its face and I **didn't know it existed**" **(ii) Selvina:** Long ago there were owls in Mauritius, now it is **extinct** because **monkeys** and **rats broke their nests** and it could not reproduce, so it went extinct. **(iii) Shreena:** yes this owl because **I never thought of seeing an ow**l. I would like to see an owl in Mauritius but unfortunately, people have **destroyed the forests and its habitats** also, now it's no longer here it makes me **sad**, I would like to see one in reality	**New discovery/knowledge** **Extinction, Predation by invasive species.** **Habitat destruction** **New discovery** **Habitat destruction** **Empathy**
Big lizard (Giant Skink)	**(i) Felix:** This one is the big lizard statue. This is the **first time I saw this**. **(ii) Joana:….There is no more**, it was the **biggest** lizard that I knew, that's all and **predators** ate it etc	**First time** **Extinction, size predation**

Codes grouped in category 'Extinct animals'	Selected extracts from the interviews	Co-occurring codes with the code 'extinct animals'
	etc"	
dodo	**(i) Tom:** this was explained in details how they lived and what were its characteristics Interviewer: Do you remember? **(i) Tom:** a bit, it ran quickly to run away but **unfortunately,** they were trapped **and could not survive** **(ii) Shreena:** this is our dodo that **unfortunately** we **no longer have** on Mauritius, that has **disappeared**. When **people** saw it, the only thing they thought of was that it is a chicken very fat and greasy but they ate it, they found that it does not taste good and that its meat smells bad.	**Empathy, Extinction** **Empathy, Extinction** **Impact of humans**
Blue Pigeon	**(i) Alex:** this is the blue pigeon that we have not been able to see. I found the pink pigeon beautiful and I was very **sad** that we have not been able to see the blue pigeon. **(ii) Anna**: I liked that there was the blue pigeon, it is **bigger** than the pink pigeon. Interviewer: is it still there? Anna: **unfortunately** no"	**Empathy** **Big** **Empathy, Extinction**
Bats in Museum	(i) **Joana**: this is the bats in the museum. It's the story of a bat that **is no longer in Mauritius**	**Extinction**
Codes that co-occur more frequently: Big, empathy, extinction, habitats, new knowledge/ discovery, Size/numbers		

10.10 Appendix 10: Description of how photos were coded and categorised

	Total number of participants in the study	**13**		
	Number of students who participated in photo-elicitation	**9**	**Number of photographs analysed from the participants' perspective (stage 1)**	**93**
	Number of students who submitted photos	**11**	**Number of photos analysed from the researcher's perspective (stage 2)**	**113**
	Coding and categorisation of photos from the researcher's perspective (stage 2)			
	Main Categories and initial codes	**Number of photogra-phs**	**Description of categories and codes and logic of categorisation**	
Category	**Conservation effort**	**24**	**Conservation practices to present any intervention by MWF to restore populations and ecosystems**	
Code	Nursery	8	Planting and propagation of rare endemic plant species to restore ecosystems	
	Tortoise/tortoise related	16	Tortoises is used as analogous species to perform the ecological role of the endemic extinct tortoise	
Category	**Endemic Birds/animals**	**21**	**All endemic birds and animals introduced and closely monitored on IAA**	
Code	Mauritian Fody (Bird)	2	the endemic bird was introduced and its population closely monitored on IAA	
	Mauritius Fruit bat (Mammal)	7	the endemic bats are not rare but showcased to represent endemic mammals of Mauritius	
	Pink Pigeon (Bird)	5	the endemic bird was introduced and its population closely monitored on IAA	
	Telfair Skink (Reptile)	7	re-introduced species of skink on IAA and population monitored	
Category	**Endemic Plants**	**21**	**All endemic/native plants that are presented to students during the nature walk**	
Code	Banyan Tree/Ficus spp	1	*Ficus spp- not endemic but present at several places on Ile aux Aigrettes*	
	Bois de Catafaille	5	*Zanthoxylum heterophyllum* - endemic to mauritius and Reunion island - sappling displaying about 50cm tall with small leaves and red veins- the sappling was fenced by the side of the main tract	
	Bois de Chandelle	2	*Dracaena reflexa- endemic to the mascarenes present on IAA*	
	Bois de Renette	2	*Dodonaea spp* - native to mauritius found in sevaral places on IAA	
	Ebony Bark	3	The transection of the bark of the ebony (*Diospyros egrettarum)* in the museum	
	Fruit	1	Furit of an endemic tree	
	orchids	1	Scented endemic orchid found on the tract	
	Pandanus (Vacoas)	2	*Pandanus spp* - endemic to Mauritius - encountered along the main tract	
	Plants with heterophyllous leaves	2	Unidentified seedlings of endemic plants with leaves having red veins (heterophylly)	
	Vegetation	1	a landscape with different trees and plants	
	Veloutier vert	1	*Scaevola taccada* - coastal plant found on IAA - the guide refered to it as important for the tortoise food.	
Category	**Extinct animals**	**24**	**all extinct animals presented as bronze models either anchored in the vegetation or in the museum**	
Code	Bats	1	*Pteropus subniger* (lesser mascarene fruit bat)Extinct bats of the mascarenes in the museum	
	Blue Pigeon	3	*Alectoenas nitidissima*- Extinct Mauritius Bleu pigeon in the museum	
	Dodo	4	*Raphus cucullatus* - Bronze of the extinct dodo amidst the	

			vegetation
	Extinct Parakeet	2	*Lophopsittacus mauritianus* - Extinct Broad Billed Parrot in the museum
	Gecko (extinct)	1	*Phelsuma gigas* - Extinct Rodrigues Giant Gueko found in the museum
	Giant Skink	5	*Leiolopisma mauritiana* - extinct Giant Skink of Mauritius on a large rock amidsts the vegetation
	Hen	1	*Aphanapteryx bonasia* . Extinct red rail from Mauritius in the museum
	Long-Necked Tortoise	3	*Cylindrapsis triserrata* -Extinct Saddle back tortoise amidst the vegetation
	Owl	4	*Mascarenotus sauzieri* - Extinct Commerson Owl of Mauritius amidst the vegetation under a Banyan Tree
Category	**Friends**	**1**	**Any photos that show students with other students or in groups** 2 girls taking a selfie while on the boat
Category	**History**	**1**	**Represents historical aspects of IAA- its use as a military base during World War II**
Code	Cannon	1	the cannon seated along the main path
Category	**IAA**	**13**	**Photos of IAA to represent its specificity as an attraction in terms of vegetation or non-volcanic formation**
Code	IAA	10	Photos of IAA captured either from mainland, from the boat or from the jetty
	Rocks	3	rocks on IAA which are porous and of coral origin - passed on by the ranger during the tour
Category	**Seductive details**	**8**	**Photos that students provide but not directly related to the guided tour**
Code	Water/Landscape/sea/boat	8	water, landscape with mountains captured from IAA, from mainland or from the boat
	Total Number of photographs analysed (stage 2)	**113**	

10.11 Appendix 11: coding of interview questions for interest

<table>
<tr><th>Interview questions</th><th>Example of an interview extract</th><th>Most frequently occurring categories and codes during the semi-structured interviews for the questions</th><th>Themes emerging from the grouping of categories</th></tr>
<tr><td rowspan="10">-Tell me 2-3 aspects of the visit that you liked the most</td><td rowspan="10">Anna: it's the ambience, how the guide explains to us. She explains well for us to understand, I liked how she explains how a tortoise reacts when we touch its carapace because its vertebral column is attached to it. Heterophylly of plants how their leaves change as they grow for them to be protected against the predators. (Post int: Anna, line 27)</td><td>Tortoises (tortoise)</td><td rowspan="14">1. Novelty (all aspects that students find new)

2. Social aspects (interaction of participants with other people- friends, guide)

3. Strong Emotions (emotions, the overall experience of the visit, what they find interesting)

4. Size/numbers (when participants are impressed by size and number)

5. Body experience (When the body is engaged in doing things e.g. touching, stepping, smelling)
6. Impressive Information (when students recall key words or information related to biodiversity, ecology and conservation practices)

7. Seductive details (aspects not related to the content of the guided tour that students find interesting)

8. Content of the guided tour or attractions/exhibits (tortoise, endemic species, plants, animals, extinct species, island formation – refers to the attraction offerings of the guided tour)</td></tr>
<tr><td>Endemic animals (Skink, pink pigeon)</td></tr>
<tr><td>Body experience (Touch, Body experience)</td></tr>
<tr><td>Biodiversity (Plants)</td></tr>
<tr><td>Novelty (New learning/discovery)</td></tr>
<tr><td>Social aspect (Guide)</td></tr>
<tr><td>Overall experience (Events/occurrences)</td></tr>
<tr><td>seductive details (Boat)</td></tr>
<tr><td>Size/number (big)</td></tr>
<tr><td></td></tr>
<tr><td rowspan="4">How would you describe your visit to IAA? Can you to describe your visit in one word or few short words?</td><td rowspan="4">Pascal: Interesting, yes a lot of discoveries and there are rare things (Post Int: Pascal, line 4)</td><td>Novelty (New discoveries, new learning,)</td></tr>
<tr><td>Biodiversity (Rare, Plants, Animals)</td></tr>
<tr><td>Strong emotions (Emotions, surprise)</td></tr>
<tr><td>Interesting</td></tr>
</table>

<table>
<tr><th>Interview questions</th><th>Example of an interview extract</th><th>Most frequently occurring categories and codes during the semi-structured interviews for the questions</th><th>Themes emerging from the grouping of categories</th></tr>
<tr><td rowspan="10">Did you enjoy your visit? Why?</td><td rowspan="10">Selvina: There were many things I did not know about IAA for example tortoise comes from Seychelles. The Mauritius Tortoise has been extinct for a long time, that IAA was used during the war, second world war. And for a tortoise to lay their eggs they made an artificial pond, and that IAA was formed from corals (Post int: Selvina, line 11)</td><td>Body Experience (foot, Body experience)</td><td rowspan="20">1. Novelty (all aspects that students find new)

2. Social aspects (interaction of participants with other people- friends, guide)

3. Strong Emotions (emotions, the overall experience of the visit, what they find interesting)

4. Size/numbers (when participants are impressed by size and number)

5. Body experience (When the body is engaged doing things e.g. touching, stepping, smelling)
6. Impressive Information (when students recall key words or information related to biodiversity, ecology and conservation practices)

7. Seductive details (aspects not related to the content of the guided tour that students find interesting)

8. Content of the guided tour or attractions/exhibits (tortoise, endemic species, plants, animals, extinct species, island formation – refers to the attraction offerings of the guided tour)</td></tr>
<tr><td>Social aspect (Friends, guide)</td></tr>
<tr><td>Novelty (New experience, New learning)</td></tr>
<tr><td>Strong emotions (surprise)</td></tr>
<tr><td>Endemic Plants (Ebony)</td></tr>
<tr><td>Interesting</td></tr>
<tr><td>Island formation</td></tr>
<tr><td>Extinct species (Museum, Owl)</td></tr>
<tr><td>Endemic Species (pink pigeon)</td></tr>
<tr><td>Ecology terms (Predators, camouflage)</td></tr>
<tr><td rowspan="10">Did you talk to someone about your visit?</td><td rowspan="10">Shreena: …..I also told them that I saw bats that can see both at night and during the day, I thought that Bats could see only during the night. This is why we see them … and then when they eat a fruit, it is not their usual food, they eat only a piece then they leave it.(Post int:Shreena, line 22)</td><td>Size/number (big)</td></tr>
<tr><td>Biodiversity (Animals, corals)</td></tr>
<tr><td>Strong emotions (Emotions, incredible)</td></tr>
<tr><td>Endemic plants (Heterophylly)</td></tr>
<tr><td>Overall experience (IAA),</td></tr>
<tr><td>Novelty (New discoveries, new learning, First time)</td></tr>
<tr><td>Endemic animals (pink pigeon, skink, bats)</td></tr>
<tr><td>Extinct species (Long-neck tortoise)</td></tr>
<tr><td>Tortoise (tortoise, Translocation of tortoise)</td></tr>
</table>

<table>
<tr><th>Interview questions</th><th>Example of interview extract</th><th>Most frequently occurring categories and codes during the semi-structured interviews for the questions</th><th>Themes emerging from grouping of categories</th></tr>
<tr><td rowspan="9">What do you remember of your visit?</td><td rowspan="9">Tom: I liked the Bats, the baby tortoise, the big tortoise of Ile aux Aigrettes(Big Daddy), I liked to learn how they function and help nature, even their dungs, it helps the seeds to grow. I find this wonderful because it makes plants grow like there will be more, more and more. It’s them that make all trees grow again….. There were some plants and when they passed out faeces and all, then the seeds grew. Its thanks to them that there are all these…I liked the Cardinal, the beautiful orange colour and the girlfriend of the cardinal as well, I saw the skinks in reality how it was. I liked to see the Ebony Tree in Reality how it was (Post int: Tom, line 19)</td><td>Endemic plants (ebony, Heterophylly)</td><td rowspan="9">1. Novelty (all aspects that students find new)

2. Social aspects (interaction of participants with other people- friends, guide)

3. Strong Emotions (emotions, the overall experience of the visit, what they find interesting)

4. Size/numbers (when participants are impressed by size and number)

5. Body experience (When the body is engaged in doing things e.g. touching, stepping, smelling)
6. Impressive Information (when students recall key words or information related to biodiversity, ecology and conservation practices)

7. Seductive details (aspects not related to the content of the guided tour that students find interesting)

8. Content of the guided tour or attractions/exhibits (tortoise, endemic species, plants, animals, extinct species, island formation – refers to the attraction offerings of the guided tour)</td></tr>
<tr><td>Biodiversity (plants, animals, rare)</td></tr>
<tr><td>conservation</td></tr>
<tr><td>Endemic Species (gecko, bats, Mauritius fody , pink pigeon, skink)</td></tr>
<tr><td>Island formation,</td></tr>
<tr><td>Ecology terms (Sex differentiation, dissemination dispersal)</td></tr>
<tr><td>Extinct Species (Giant skink, parakeet)</td></tr>
<tr><td>Size/Number (size/numbers, big)</td></tr>
<tr><td>Seductive details (boat)</td></tr>
<tr><td>Emerging themes and the frequency of their occurrences in the interviews</td><td colspan="3">Content of the guided tour (14), Strong Emotions (7), Impressive information (6), Novelty (4), Size/numbers (3), Body Experiences (3), Social aspects (2), Seductive details (2).</td></tr>
</table>

10.12 Appendix 12: Codes for interest co-relating with exhibits

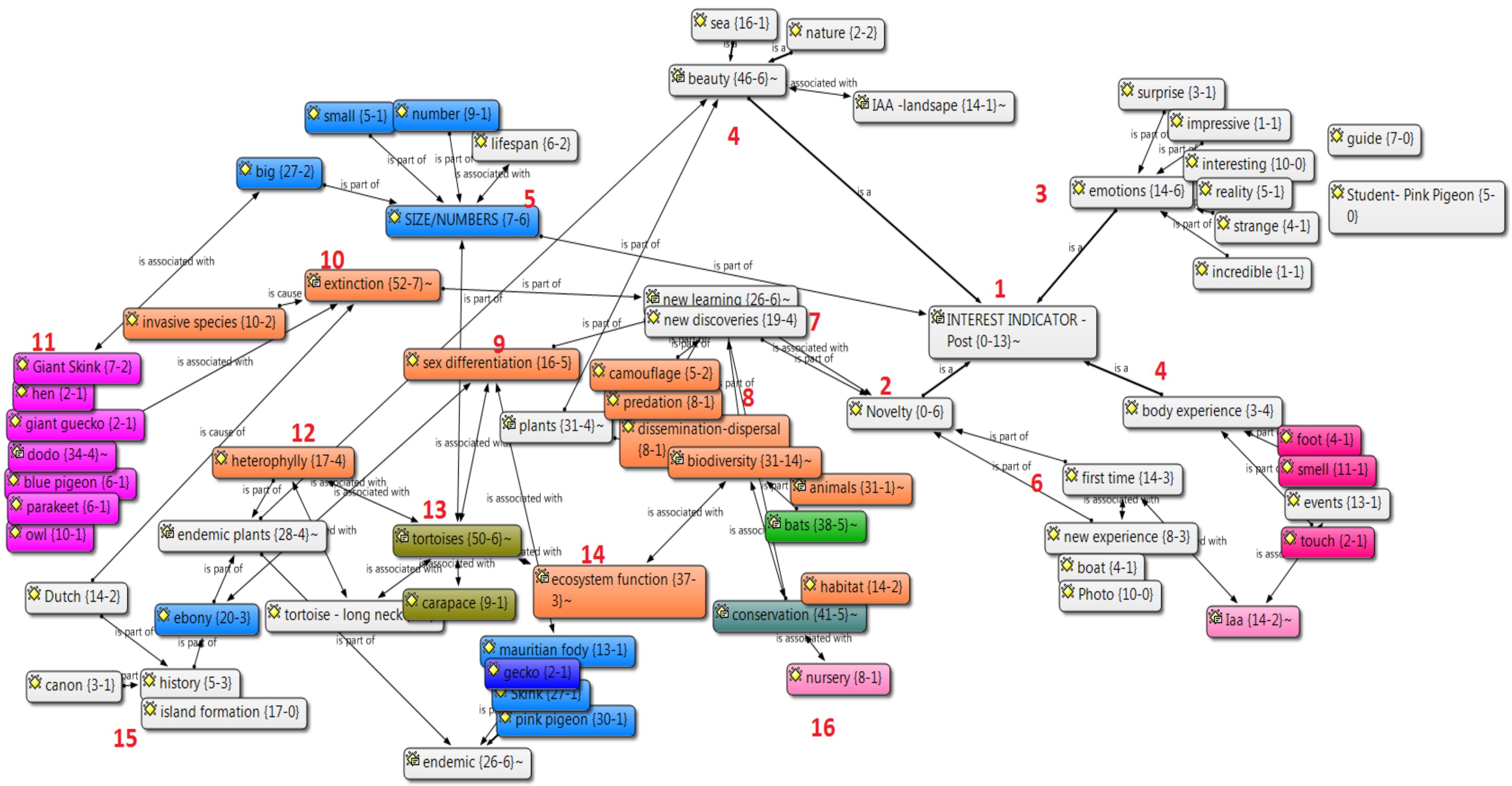
Exhibits	co-occuring codes	codes regrouped into Themes
Blue Pigeon	Beauty	Beauty
	Big	Size/numbers
	Emotions	emotions
	First time, new Learning	Novelty
Dodo	Beauty	Beauty
	Big, Big Bird	Size/numbers
	Dutch	History
	Emotions	emotions
	Extinction	Extinction
	Flightless Humans	Ecology terms
Giant Gecko	First time	Novelty
Giant Skink	Big	Size/numbers
	New Discover	Novelty
	Extinction Predation	Ecology terms
Red Rail (hen)	Beauty	Beauty
	Extinction	Extinction
	New Discover	Novelty
Owl	Beauty	Beauty
	Emotions	emotions
	Extinction	Extinction
	First time New discover	Novelty
Extinct Blue Parakeet	Big	Size/numbers
	Extinction	Extinction
	New Discover	Novelty
	Size	Size/numbers

Exhibits	co-occuring codes	Codes regrouped into Themes
Mauritian Fod	sex differentiation	Ecology term
	Interesting	emotions
	new learning	Novelty
Pink Pigeon	endemic bird	Biodiversity
	first time ,	Novelty
	new learning new discovery	Novelty
	rare	rare
	reality	Reality
	Part of Biodiversity	Biodiversity
Telfair Skink	Beauty	beauty
	Big	Size/number
	camouflage	ecology term
	emotions	emotions
	first time	Novelty
	interesting	emotions
	new learning/discovery	Novelty
	surprise	emotions
	events	body experience

Exhibits	co-occuring codes	Codes regrouped into Themes
Endemic plants	Ebony	Biodiversity
	Heterophylly	ecology terms
	Rare	rare
	first time new discovery/ new learning	Novelty
	Tortoise	tortoise
	beauty	beauty
	smell	body experience

Exhibit	co-occuring codes	codes regrouped into Themes
Tortoises	Beauty	Beauty
	conservation translocation	conservation
	carapace dispersal/ dissemination ecosystem function lifespan predation sex differentiation	ecology terms
	emotions (impressive, incredible)	emotions
	endemic plants red veins/heterophylly	Endemic Plants
	first time new discovery, new experience	Novelty
	Big number size	Size/numbers

10.13 Appendix 13: Main triggers of interest and their relationship with co-occurring codes (generated from Atlas TI)



10.14 Appendix 14: knowledge scores of each student for the learning areas falling under the three lenses of biodiversity learning

		Ryan	Stefy	Felix	Pascal	Owen	Sonia	Kelly	Joana	Selvina	Shreena	Tom	Alexia	Anna
Ecological literacy lens	Understanding the concept of biodiversity	1	2	1	1	1	3	3	3	2	3	3	3	3
	Understanding the importance of biodiversity	1	2	2	2	2	2	3	2	3	2	3	3	3
	Knowledge of the terms endemic and extinct	1	2	3	3	3	3	3	3	3	3	3	3	3
	knowledge of conservation practices	1	1	2	2	2	2	2	3	2	3	2	2	2
Nature and Self lens	appreciation,experience and learning about nature	3	2	2	3	3	2	3	3	3	3	3	3	3
	view on the morailty of conserving species	1	1	1	2	2	2	2	2	3	3	3	2	2
Biodiversity and society lens	understanding of the negative impact of man on the ecosystem	1	1	1	3	1	2	3	2	3	3	3	2	3
	awareness of the bats' debate	1	1	1	1	1	3	3	2	3	3	3	3	3
	knowledge of the causes of the extinction of the dodo	2	1	2	1	2	2	1	3	2	3	2	2	3
	Mean Pre-visit score	**1.1**	**1.1**	**1.3**	**1.8**	**1.4**	**1.7**	**2.3**	**1.9**	**2.2**	**2.2**	**2.4**	**2.0**	**2.3**
	Mean Post-visit score	1.3	1.4	1.7	2.0	1.9	2.3	2.6	2.6	2.7	2.9	2.8	2.6	2.8

Key:

1	Pre and Post visit score 1
2	Pre and Post visit score 2
3	Pre and Post visit score 3
2	Pre visit score 1, post visit score 2
3	Pre visit score 2, post visit score 3
3	Pre visit score 1, post visit score 3

10.15 Appendix 15: Co-occurrence Co-efficient from Atlas TI.

Co-occurrence coefficient of the interest codes and the knowledge construction codes

	Human Constructivist and Affective Learning Knowledge Construction Categories										
Interest codes	Addition	Emergence	Differentiation/ Dissatisfaction	Discrimination	Recontextu-alisation	Superordinate	Experiences	Germane	Salient	Wonder	Conative
Aesthetic experience (beauty)	0.04	0.05	0	0.02	0.01	0	0.07	0.02	0.05	0.1	0
Body experience (smell, touch, walk)	0.17	0.15	0.05	0	0.06	0.07	0.56	0	0.16	0.14	0.07
Novelty (new experience)	0.13	0.16	0.09	0.14	0.1	0.14	0.43	0.12	0.11	0.42	0
New learning	0.1	0.01	0.03	0.06	0.04	0.13	0.06	0.07	0.03	0.16	0
Emotions (e.g. strange, happy, impressed)	0.12	0.1	0.05	0	0.03	0.13	0.2	0	0.06	0.23	0
Impressive information	0.9	0.91	0.6	0.21	0.98	0.95	0.6	0.14	0.34	0.66	0.22
Size	0.19	0.1	0.08	0.14	0.1	0.16	0.16	0	0.08	0.35	0

The frequency of co-occurrence determines the strength of the relationship between various codes. The number represents the c-coefficient which is similar to a correlation coefficient in statistics, without obtaining a p-value.

$c := n12/(n1 + n2) – n12$

n12 = co-occurrence frequency of two codes c1 and c2, whereby n1 and n2 are their occurrence frequency

C-coefficient is a method of performing quantitative analysis on qualitative data. The value of the c-coefficient is between zero and one. The closer the number is to one, the stronger the relationship between the codes (Lewis, 2015). Atlas TI user guide suggests that c-coefficient is useful for interview sizes above 10 and in my case I have 26 interview transcripts including 13 pre and 13 post interview transcripts. I considered c-oefficients ‹ 0.1 as weak, c-oefficient ≥ 0.1 as quite strong and c-oefficient ≥ 0.2 as strong.

10.16 Appendix 16: Results from the co-occurrence analysis of knowledge construction categories and exhibits

Knowledge construction category	**Concepts/information that students described**	**Exhibits/Stopping points identified which related to the information and knowledge construction categories**
Addition (cognitive learning)	-Tortoise is an example of an animals/reptile -Males and females tortoises look different -Examples of endemic birds (pink pigeon and Mauritius fody) -Examples of endemic plants (Ebony, Palms, Plants with red veins Examples of extinct animals	Tortoise Endemic Birds Endemic Plants Extinct animals
Emergence (cognitive learning)	Students described concepts previously stored in their memory which they associated with the exhibits, For examples camouflage of the Telfair Skink, predation by rats, carapace, nests and eggs of **tortoise,** corals in the sea and forests as habitats of animals	Tortoises Endemic reptile (Skink) Whole visit
Differentiation/ dissatisfaction (cognitive learning)	Students revisited or disagreed with their previously held conceptions: for example Bats in Mauritius can see both at night and during the day. Bats should not be killed as they have an important ecological role	Mauritius Fruit bats (endemic animals)
Discrimination (cognitive learning)	Students made comparisons among concepts integrating sub-concepts into higher-order concepts: - pink pigeon is alive, the blue pigeon was similar, it is now extinct -similarities between Mauritius fody and pink pigeon as endemic bird -Owl and giant skink are extinct just like the dodo -Similarities between ebony, Palms, plants with red veins, as endemic plants	Endemic Birds Extinct animals Endemic Plants
Recontextualisation (cognitive learning)	Students provide more details around the extinction of the dodo and its anatomy as a result of what they learnt during the visit A better understanding of the concept of 'endemic' and 'ecological roles' of tortoise and bats as a result of the visit	Extinct animals (dodo) Tortoise Bats
Superordinate learning (cognitive learning)	Students describe in details, making connections between newly learnt concepts to concepts already present in their knowledge structures: Sex differentiation in Tortoises and Mauritius fody , Hardening of seedlings before transplantation from the Nursery Heterophylly in plants and its association with the long-necked tortoises which 'grew' a long neck to reach out for leaves higher up in trees ecological roles of bats, tortoises, skink and geckos as dispersers and pollinators	Tortoises, Mauritius fody (endemic birds) endemic plants, bats (endemic animals) endemic reptiles

Knowledge construction category	**Concepts/information that students described**	**Exhibits/Stopping points identified which related to the information and knowledge construction categories**
Wonder (affective learning)	Students mention finding plants and animals beautiful, remembering or liking to see these animals, finding them interesting. They learnt about the existence of the species previously unknown to them	Tortoise endemic birds Endemic Reptiles (Telfair skink) Extinct animals (Saddle-Back tortoise, Owl) endemic plants
Salience (affective learning)	Students found exhibits particularly striking or conspicuous and they remembered about them: Heterophylly in Plants (Red veins) SaddleBack Tortoise with a long neck to reach out to leaves high up in trees Leaves of plant smelling like apple Change of plumage colour in Male Mauritius fody during mating seasons The Telfair Skink looks like a Big Lizard Sex Differentiation in Tortoises and its lifespan	Endemic plants and nursery Extinct Animals Endemic Birds, Endemic Reptiles
Experiences (affective learning)	Students had body experiences such as Touching and seeing the Tortoise Carapace to learn to differentiate sex Smelling leaves and flowers to learn about endemic plants Walking on and touching rocks to learn about the formation of IAA Seeing extinct, and endemic plants and animals	Tortoise Endemic Plants Extinct Animals Island Formation
Germane (affective learning)	Information during the guided tour was personally meaningful to students due to their interest/liking. Students examine the cross section of the ebony bark and learnt about its historical exploitation and use The plants with red veins are associated with endemic plants Students wanted to learn more about the 'Cousin' of the dodo	Endemic Plants dodo
Conative Learning	Students explained being interested in conducting more research on the dodo and some animals Students showed a willingness to change their behaviour while walking in forests	Whole visit

10.17 Appendix 17- Pre and Post interview transcripts, Personal Meaning Map, auto-photography and photo-elicitation transcript for one student, Anna

Student Anna (P011), Eclaireurs du nord (1ere compagnie, Pamplemousses)

Pre- Interview: 05 December 2018, Visit: 07 December 2018, Post interview: 08 December 2018

Pre-Visit Interview, Section A of interview schedule – The forthcoming trip

Interviewer: Good morning Anna
Anna: Good morning
Interviewer: Do you know where you are going for the outing?
Anna: Ile aux Aigrettes
Interviewer: Do you know why we are going there?
Anna: I have never been there. To learn about plants and animals
Interviewer: Do you have an idea of what will be there?
Anna: I think a place where there are many endemic things
Interviewer: Ok what you think your visit will be like?
Anna: I will learn a lot of things and maybe discover plants that I did not know about

Pre-Interview, Section B: Assessing Prior interest for Biodiversity

Interviewer: Tell me, what do you like to do during your free time?
Anna: I like to play games with my brothers. Board games, UNO, Monopoly, watch TV.
Interviewer: What do you watch on TV?
Anna: films, serials and documentaries
Interviewer: What do you usually watch in documentaries, films and serials?
Anna: On Research and Enigmas that are things like humans try to understand etc..
Interviewer: ok... Are you a member of any group apart from Scouts?
Anna: In the choir at church
Interviewer: Why did you join Scouts?
Anna: euhh, in the beginning I didn't use to like to come then I found that it is a means to express myself and discover myself
Interviewer: So someone brought you here?
Anna: Yes My Mum
Interviewer: and what part of Scouts do you like the most?
Anna: the adventures that we do and the fact that we go to discover places in Mauritius. We usually go for adventures in the forests, I like it a lot to go and discover what there are because previously I did not use to do this?
Interviewer: if you could repeat some activities in Scouts, what would you like to do?
Anna: Camping
Interviewer: why?
Anna: because we live in a community, we are disconnected from the world and we don't have technology around us and we are like…we live together
Interviewer: Ok. Do you surf the internet?
Anna: yes
Interviewer: What do you surf about on the internet?
Anna: I look at tutorials, DIY, I like life hacks
Interviewer: What is your favourite subject at school?

Anna: chemistry
Interviewer: why?
Anna: I find it quite intriguing the reactions in nature, how they are, and why this is so and why that is like this?
Interviewer: Ok, so you like science?
Anna: yes
Interviewer: So you like Chemistry...Do you like Biology?
Anna: yes I like
Interviewer: what do you like about Biology?
Anna: It explains how human beings are
Interviewer: Any favourite Chapter or topic?
Anna: I like reproduction. It explains many things that I think I know but in fact there are many more things
Interviewer: You talking about human reproduction or reproduction in plants?
Anna: Human
Interviewer: What does the sea represent for you?
Anna: It's a fun, an entertainment (amusement)
Interviewer: why entertainment?
Anna: because we gather together with our families and we share some time and enjoy it together
Interviewer: So you mean a time at the seaside?
Anna: yes
Interviewer: and inside the sea? What does it mean to you?
Anna: there are living things and aquatic animals?
Interviewer: can you tell me about them?
Anna: not really, I don't know

Section C: Assessing Prior interest for Biodiversity

Interviewer: Can you tell me something about the environment in Mauritius?
Anna: These days I think they are constructing a lot and we need to protect our nature more and make more place because this is the beauty of our island
Interviewer: we need to protect nature. Why?
Anna: because we have the chance that on our island there are many endemic plants that we do not have in other countries and we need to protect this
Interviewer: What are endemic plants?
Anna: Plants that are not found elsewhere, are found only in Mauritius
Interviewer: Ok. The forest in Mauritius? What can you tell me about it?
Anna: its very… there are different types of plants, different diversity….
Interviewer: Yes
Anna (thinking): and the natural habitats of animals
Interviewer (checking the PMM): ok. When you hear of the diversity of living things, what do you think?
Anna: it's especially the differences that there are among living things and each living thing is unique.
Interviewer: Unique? What do you mean?
Anna: meaning there is not one which is the same as the other. Each one is different from the other
Interviewer: difference in terms of what?

Anna: or human beings, the cultures… This is what makes the world more… how to say this… marvellous

Interviewer (referring to the PMM): this is for human beings, what else? You wrote about plants, colours habitats, yes you wrote cold regions and hot regions, what do you mean by this?

Anna: some plants live in regions where it's cold and some plants can survive in hot regions

Interviewer: and how this is important?

Anna: this shows that everywhere there are plants, there is not a region where there are no plants

Interviewer: Why there are plants there?

Anna: firstly it's there so that we can breathe because plants give us oxygen

Interviewer: yes

Anna: Also sometimes plants are for nutrition for us to eat and to make medicines

Interviewer (referring to PMM): Ok, you wrote plants different sizes, different growth and some grow more rapidly than other

Anna: Some plants take many years to reach their final growth stages and grow completely and other plants grow rapidly

Interviewer: Do you mean that this forms part of the diversity of living things?

Anna: yes

Interviewer: Now you wrote insects, reptiles?

Anna: reptiles are animals like crocodiles and snakes and insects are small animals

Yes: can you give me an example of a reptile?

Anna: crocodile

Interviewer: insect?

Anna: ants

Interviewer: mammal ?

Anna: whales!

Interviewer: What can you tell me about the dodo?

Anna: It was an animal that we had in Mauritius but unfortunately, it went extinct

Interviewer: what type of animal?

Anna: it was a bird and due to its appearance it could not fly, it could not run away from the Dutch who were killing them for eating

Interviewer: ok, what can you tell me about plants, trees and forests in Mauritius?

Anna: There are many diversity, many types and in an ecosystem, we need to have many types to be able to survive

Interviewer: what do you mean by ecosystem?

Anna: meaning everything is connected with one another.

Interviewer: how connected?

Anna: each one needs one another to survive

Interviewer: Should we cut down trees in the forest in Mauritius?

Anna: No because they are essential for animals that live in the forests, especially for wild animals which naturally live in the forests and they cannot get used to humans and so if we cut down the forests they may go extinct

Interviewer: Do you know about plants and animals that live only in Mauritius?

Anna: Endemic!

Interviewer: do you know some examples?

Anna: pink pigeon, euuuhhh Ebony Tree

Interviewer: Can you tell me something about Ebony
Anna: It's a plant that is found long ago in Mauritius
Interviewer: Do you know about species of plants or animals that have been saved from extinction
Anna: euhhhh, there is a bird I read about, Cateau Verte I Think, It was nearly extinct but luckily there are some people who succeeded to protect them and put them in a place only for them
Interviewer: Very good, do you think we need to kill the bats in Mauritius
Anna: Maybe not kill but put them in a place where they can live without disturbing the humans
Interviewer: ok, do you what is currently happening with the bats in Mauritius?
Anna: they are eating all the fruits that are being produced these days
Interviewer: Do you think humans need to protect all living things on earth?
Anna: yes. Humans must protect them, they have a life and specific roles in nature
Interviewer: ok on 1 to 10 are you looking forward to your visit to IAA?
Anna: 10 on 10

End of Pre-visit interview

Post-Visit Interview, Section A of interview schedule – The trip

Interviewer: Good Morning Anna
Anna: Good Morning
Interview: Can you tell me the name of the place we went to the outing?
Anna: Ile aux Aigrettes
Interviewer: When did we go there?
Anna: yesterday
Interviewer: Do you know to which subject and topic is the visit related to?
Anna: Biology, Plants and animals

Section B: Investigating interest

Interviewer: How would you describe your visit in one word or few short words?
Anna: Discovery, I could better understand the plants and learn things I did not know about plants
Interviewer: Did you have fun or enjoy your visit?
Anna: yes
Interviewer: how? Tell me
Anna: I liked the way the guide explained to us, she explained well, and the moments I spent with my friends and learn more about Mauritius and its endemic plants. I understood the functioning of plants for example the way the 'Pied la fourche' (Ficus spp) when its roots grow from top to downwards, another tree grows. I liked the Ebony Tree, the outside is brownish and the heart inside is black. I understood how to differentiate a male from a female tortoise
Interviewer: Did you talk to someone about your visit?
Anna: yes my parents
Interviewer: What did you tell your parents?
Anna: the things we saw there, it was a lot of fun and I really enjoyed it.
Interviewer: Ok, what do you remember of your visit?

Anna: The islet has a part below the sea and a part on top. it's a fossilized island, with sand and another thing I have forgotten the name

Interviewer: ok tell me about what you remember?

Anna: I liked to see the pink pigeon, I never knew why we called it pink pigeon, I didn't know how it was, now I understood, it is not entirely pink, the tail is 'rousse' (redhead coloured) and its body is a bit pink. I liked when we were told about the 'Cardinal' how to differentiate a male from a female. A male's head is reddish during the mating period

Interviewer: Tell me 2-3 aspects of the visit that you liked the most. You talked about your friends…

Anna: It's the ambience, how the guide explains to us. She explains well, I liked how she explains how a tortoise reacts when we touch its carapace because its vertebral column is attached to it. Heterophyly of plants how their leaves change as they grow for them to be protected against the predators.

Interviewer: Did you do any research or watched TV since you came back from Ile Aux Aigrettes?

Anna: no. I did not have time

Interviewer: Would you like to do some research if you had time?

Anna: I would like to learn about the cousin of the dodo, its good for me to know that the dodo has not completely completely disappeared, it has its cousin somewhere.

Interviewer: Very good. Following your visit would you like to join some club?

Anna: I would like to join a club where we can discover more plants because we discovered many things that we did not know

Interviewer: What is your favourite place for you leisure activities?

Anna: I like to cycle on the road, I also like to play with my brothers

Interviewer: if you had to go to Ile aux Aigrettes again, would you go?

Anna: yes

Interviewer: If you had to choose between cycling or playing with your brothers and going to Ile aux Aigrettes which one would you prefer?

Anna: go to IAA

Interviewer: What career would you like to do?

Anna: lawyer

Post Interview, Section C Investigating knowledge gained

Interviewer: Can you tell me what is special about Ile Aux Aigrettes?

Anna: it's the diversity of plants, different plants that there are and how they live together. yes and there are many different kinds of plants

Interviewer: When you hear the word Biodiversity, what comes to your mind?

Anna: different types of plants that we have in the forest

Interviewer: only plants?

Anna: animals also. How animals feed on other plants in the food chain

Interviewer: What do you remember about the animals on Ile Aux Aigrettes?

Anna: what animals?

Interviewer: the animals that you saw there, what do you remember about them?

Anna: the Lizard, skink, that we saw. I liked the way it hides in nature, It's camouflaged and it's not easy to spot it

Interviewer: Can you tell me something about the dodo?

Anna: What I learnt there is that it's not the Dutch who are the main cause for the dodo's extinction, its predators… and dodo had small wings because in the beginning it did not have any predators on Mauritius and it did not need to fly. dodo was not good at flying but could run very quickly

Interviewer: Do you remember something about the plants over there?

Anna: There was a plant that the leaves had the smell of an apple

Interviewer: Do you know what is an endemic species?

Anna: it's the plants and animals that are found only in Mauritius, it's not found elsewhere

Interviewer: Do you think we need to kill the bats?

Anna: No, because bats form part of our ecosystem, if there are no bats, they will not be there to transport the fruits, there will be no new plants that will grow in Mauritius

Interviewer: ok, why?

Anna: because when they eat fruits, often seeds fall and this gives new plants

Interviewer: Ok, very good, do you think we need to protect all life on earth?

Anna: yes. Each living thing has its function on earth, it has its reason to live

Interviewer: What kind of reasons for example?

Anna: like the insects, some people don't like the insects but how are we going to … like the toads, if they are not here, they will not be there to kill mosquitoes

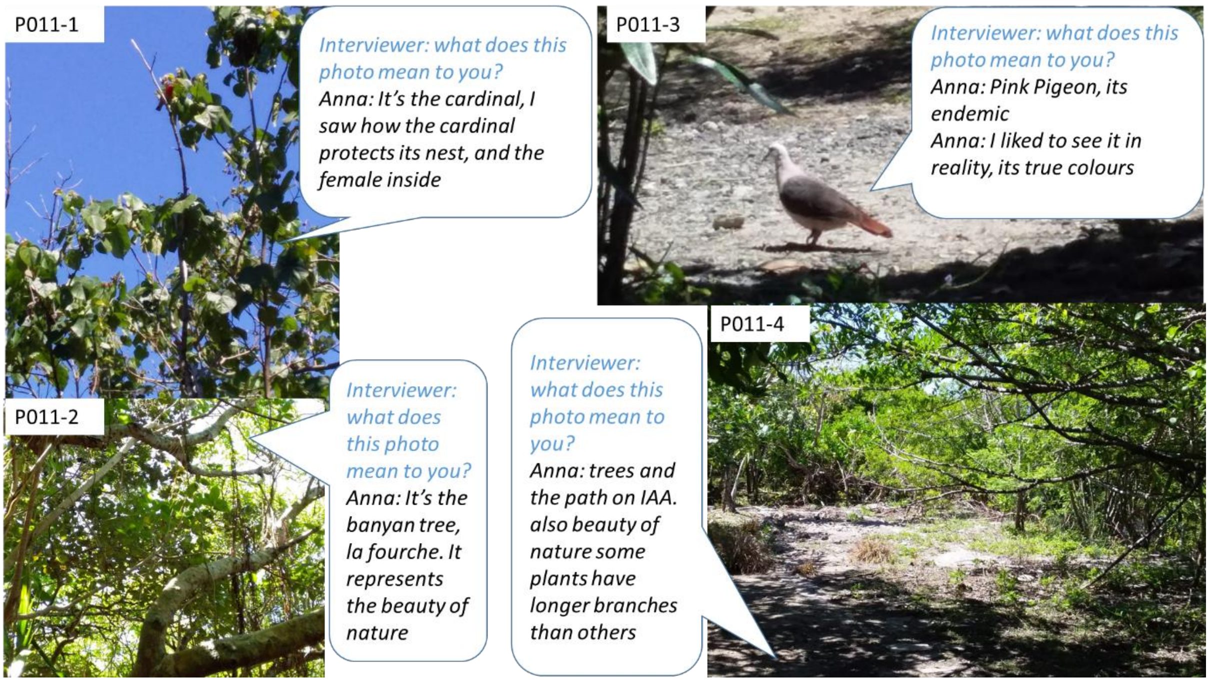
Interviewer: Ok good. What are the values of Scouts that you identify yourself with?

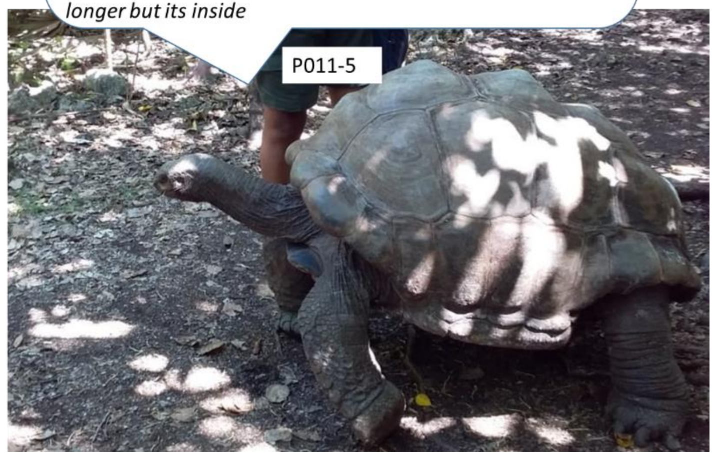
Anna: Life is not easy, we need to work to get what we want

Interviewer: Ok! Great. Thank you very much, Anna.

End of Post-visit Interview

Anna's auto-photographs and Photoelicitation transcripts





P011-5

Interviewer: what does this photo mean to you?
Anna: I think it's the biggest male tortoise. It's the dominant male
Interviewer: Can you tell me more about the tortoise?
Anna: the differences between males and females. Female's carapace is smoother while that of the males is more curved. Their belly is curved inside while for the females is flatter. The females' tails are smaller while for the males it's longer but its inside

P011-6

Interviewer: what does this photo mean to you?
Anna: Skink I liked the aspect that it's very well camouflaged and can adapt to its environment
Interviewer: What is special about the skink?
Anna: that's all

P011-7

Interviewer: what does this photo mean to you?
Anna: Nursery. it's how they adapt the plants to our environment in Mauritius. Gradually they give more sunlight and less water for the plants to adapt to the environment

P011-8

Interviewer: what does this photo mean to you?
Anna: Blue pigeon. I liked that there were the blue pigeon, its bigger then the Pink Pigeon
Interviewer: is it still there?
Anna: unfortunately no, its extinct

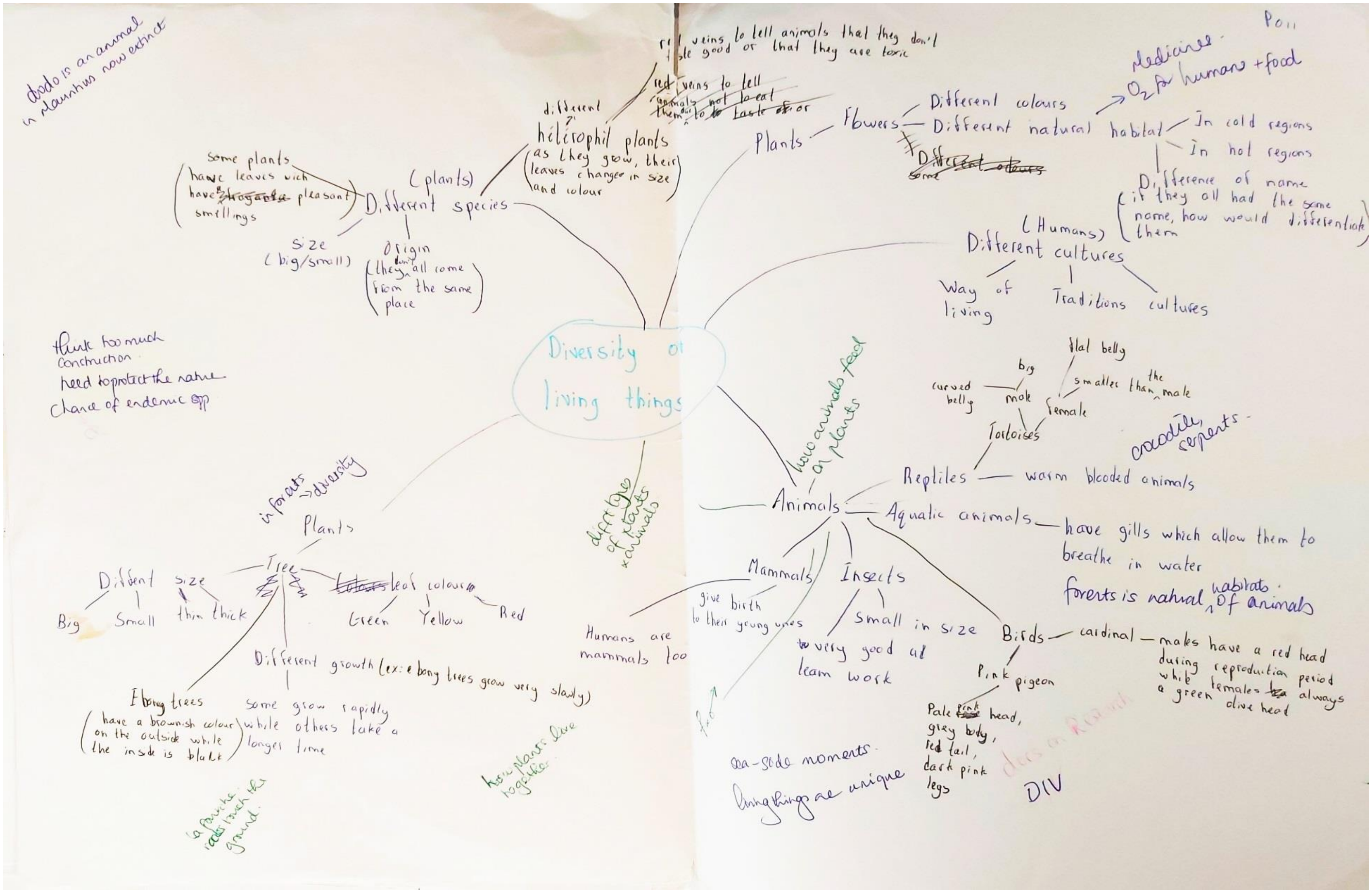
P011-9

Interviewer: what does this photo mean to you?
Anna: It's a photo of the sea and view, they go well together, I liked the photo, nature, its beauty.

P011-10

Interviewer: what does this photo mean to you?
Anna: It's the contour of the islet. I liked that it's not the entire island that is laid on the water, it's laid down and the top part visible.
Interviewer: what is it made up of?
Anna: its fossilized.

Anna's Personal Meaning Map



10.18 Appendix 18- Clearance from Human Research Ethics Committee of Wits University

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Kamudu Applasawmy

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H18/05/07**
PROJECT TITLE	Investigating interest and learning about biodiversity: A study of how students experience a visit to a nature reserve
INVESTIGATOR(S)	Mrs B Kamudu Applasawmy
SCHOOL/DEPARTMENT	Education/
DATE CONSIDERED	18 May 2018
DECISION OF THE COMMITTEE	Approved
EXPIRY DATE	19 September 2021

DATE 20 September 2018 **CHAIRPERSON** (Professor J Knight)

cc: Supervisor : Professor M Rollnick and Dr E Nyamupangedengu

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

Signature

24 / 09 / 2018
Date

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

-END-