Exploring Mauritian Upper Secondary Students' Conceptions of and Approaches to Learning Biology

by

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Submitted in fulfilment of the academic requirements for the degree of Doctor of Philosophy in the School of Education at the University of KwaZulu-Natal, South Africa

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April 2023

DEDICATION

First, I would like to dedicate this PhD Thesis to my parents without whom I would not have been here today, my wife who always stood by my side, who always encouraged me and who has been the inspiration for my progress and, my two sons who were patient throughout my many years of study. I cannot express how grateful I am for their unwavering support.

DECLARATION

I, Deenesh Patpur (218081480), declare that:

1. The research reported in this thesis, except where otherwise indicated, is my original research.
2. This thesis has not been submitted for any degree or examination at any other university.
3. This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.
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a. Where other written sources have been quoted, then their words have been re-written, but the general information attributed to them has been referenced.

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5. This thesis does not contain text, graphics or tables copied and pasted from the Internet, unless specifically acknowledged, and the source being detailed in the thesis and in the references section.

The work described in this thesis was carried out in the School of Education, University of KwaZulu-Natal, from January 2018 under the supervision of Dr T Chirikure, Prof A James, and Prof A B Rumjaun.

Ethical clearance No. HSSREC/00002810/2021 was granted prior to undertaking the fieldwork.

Signature of Candidate: [redacted] Date: 03 April 2023

As the candidate's supervisors we, agree to the submission of this thesis.

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ACKNOWLEDGEMENTS

I would like to extend my thanks to all those who have directly and indirectly helped me to complete this study. I owe a considerable debt to the unfailing help and encouragement of my supervisors, Dr Tamirirofa Chirikure, Prof Angela James and Prof Anwar Bhai Rumjaun, whose constructive criticisms have been of inestimable value.

I wish to acknowledge the professional guidance, continuous help and encouragement provided by Dr Chintamanee Sanmukhiya in critically reflecting on the topic.

I am especially grateful for the support of my wife, Kamla, and my sons, Yugesh and Neelesh, who have had to sacrifice time I would have spent with them.

ABSTRACT

The low enrolment in science subjects, particularly biology, beyond the compulsory level (Grade 9) is a matter of concern to the Mauritian education authorities, teachers and other stakeholders, as it is a prerequisite to a wide range of university degrees and professional careers. Many studies have tried to explain the low enrolment in biology at secondary and tertiary levels, however, little is known about how conceptions of learning (COL) and approaches to learning (AL) respond to the issue. Conceptions of learning refer to students' or learners' views on their educational experiences and preferred methods of carrying out the learning process. Approaches to learning are the ways that students or learners learn or accomplish their academic assignments. Arguably, the existence of positive COL and AL in learning biology increases learners' chances of achieving the intended learning outcomes and improved student performances. This invariably creates positive perceptions of the subject and possibly helps to attract more students to study biology at School Certificate level and consequently at Higher School Certificate level. Therefore, the aim of this study was to explore Mauritian upper secondary school students' COL and AL. The approaches to learning and conceptions of learning theoretical perspectives informed this study. This study adopted a pragmatic approach with the assumption that using a variety of research methods would result in an informed grasp of the problem. An explanatory mixed methods sequential research design was used to first collect quantitative data, and then gather qualitative data to explain the quantitative results. Convenience sampling was employed with respect to the schools where the participants were drawn from. Quantitative data were collected from 497 Grade 11 biology students through survey questionnaires before purposely selecting 16 of them to participate in the face-to-face individual semi-structured interviews. Descriptive statistics were used to analyse the quantitative data, whereas coding, categorisation, pattern recognition, and inference were used to analyse the qualitative data. Analysis of the quantitative and the qualitative data identified COL and AL, much of which resonate with the theoretical framework that guided this study. The study revealed that Mauritian students had mixed conceptions and thus, adopted mixed or hybrid approaches to learning biology. The study also revealed that the students' COL influenced their AL. The findings of this study have significance for curriculum designers, resource people, and secondary school educators who want to improve biology instruction.

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LIST OF ABBREVIATIONS

AL	Approaches to Learning
ALB	Approaches to Learning Biology
ALC	Approaches to Learning Chemistry
ALCS	Approaches to Learning Computer Science
ALES	Approaches to Learning Earth Science
ALS	Approaches to Learning Science
ASSIST	Approaches and Study Skills Inventory for Students
CFA	Confirmatory Factor Analysis
CHC	Confucian-Heritage Cultures
CIE	Cambridge International Examinations
COL	Conceptions of Learning
COLB	Conceptions of Learning Biology
COLC	Conceptions of Learning Chemistry
COLCS	Conceptions of Learning Computer Science
COLES	Conceptions of Learning Earth Science
COLS	Conceptions of Learning Science
CV	Coefficient of Variation
EFA	Exploratory Factor Analysis
FRCESS	Framework for Rights-based, Child-friendly Educational Systems and Schools
HSC	Higher School Certificate

KM	Kreol Morisien
LTC	Learning and teaching conceptions
M	Mean
PLS-SEM	Partial Least Square Structural Equation Modeling
PSEA	Private Secondary Education Authority
SC	School Certificate
SD	Standard Deviation
SEM	Structural Equation Modeling
SPSS	Statistical Package for Social Sciences
SRMR	Standardized Root Mean Square Residual
UNICEF	United Nations Children’s Fund
UK	United Kingdom

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CHAPTER 1

INTRODUCING THE STUDY

1.1 Introduction

Learning is a procedure that results in change, which follows from experience and raises the possibility of better performance and further learning (Ambrose et al., 2010). The learning process has been described by many including Plato, Confucius, Socrates, Einstein, Pavlov, Thorndike, Skinner, and others. Another theorist, Piaget (1896–1980), who was considered extremely influential, was well known for his attempt to define how humans learn. According to Piaget (1959), people organise knowledge and new experiences by using mental schemata. Our schemata become more complex, sophisticated and culturally context specific as we grow older. Piaget (1959) further postulates that learning is actively created by the student (learner/pupil), putting the student at the heart of the learning experience instead of being a passive recipient of knowledge through the telling of knowledge by others, such as the instructor.

Understanding how people learn has long interested psychologists and educators because it forms the basis for a variety of human endeavours (Borich, 2019; Harasim, 2017). According to Goodfriend (2014), learning is a systematic process that involves an individual going through long-lasting, irreversible changes in their knowledge, behaviours, or worldviews. He summarises learning as gaining knowledge and abilities through instruction or self-reflection. Learning is a very general notion that goes beyond simply gaining knowledge (Lloyd, 2017). Development of skills, perceptions, behaviours, and experiences are also included. Learning can also happen at any age; however, the rate at which it happens depends on the learner's motivation.

In contrast to simply being able to memorize or rote-learn specific pieces of information, Goodfriend (2014) contends that learning also involves the capacity to analyse, reflect upon, and draw conclusions from information. According to him, the conceptualisations of learning evolve across time because of changes in contexts, cultures, and beliefs. From the aforementioned angles, learning appears to be a complicated and active process that is influenced by the contexts of the learners and other factors.

Learning is central to our lives and interactions in the world. It has become so ingrained in our daily lives that its meaning is sometimes taken for granted and presumed to be the same for everyone. However, according to Steketee (1996), the phenomenon of learning has multiple meanings, depending on the interrelationships that occur between individuals, settings, and cultures. To put it another way, how a person perceives the term "learning" is influenced by the context and culture to which they are exposed. Given that individuals, contexts, and cultures differ, it is only natural that people's interpretations of learning will differ as well. Kember (2016) recognised that there are various ways in which people perceive learning.

These differences in perceptions of learning are referred to as "conceptions of learning" (COL) in education. COL can be described as people's fundamental views about their own learning. They are subjective assertions that include the assumptions, rules and traditions that shape people's perceptions of knowledge and how they approach learning tasks (van Rossum & Schenk, 1984). The connection between people's COL and how they handle learning tasks emphasises how important it is to comprehend people's learning conceptions and approaches. Section 1.4 elaborates on the relevance of this relationship.

Consequently, the objective of my research was to examine students' COL and their approaches to learning (AL). The theoretical lenses that guided my study were adopted from Lee et al.'s (2008) theoretical framework for COL and from the theoretical framework proposed by Kember et al. (2004) for AL. To find out the COL and AL of the students, this study adopted a pragmatic paradigm (Creswell, 2014). To provide answers to my research questions, a sequential explanatory mixed methods design (Howell Smith & Shanahan Bazis, 2021) was used. Furthermore, this study applied both quantitative and qualitative research techniques sequentially to collect data. For my study, a survey questionnaire was used to gather data, which was then followed by semi-structured interviews. A sample of 497 Grade 11 biology students at 20 schools participated in the quantitative survey, from which 16 students were selected for face-to-face individual interviews.

I introduce and methodically provide the study's synopsis in this chapter. Therefore, in this introductory chapter, I attend to the reasons behind choosing to explore students' conceptions of learning biology (COLB), and approaches to learning biology (ALB). I also situate the context of the study and provide a background to the present research. This chapter also outlines the research problem, and the associated critical research questions the study seeks to address. The rationale of the study and how the thesis contributes to the field of education are included as well. A summary of the structure of the thesis and a synthesis of the chapter follows.

1.2 Background to the Research

Many countries, such as the United States (Carlsson-Paige & Liantieri, 2005), the United Kingdom (Taylor & Ali, 2017), and Mauritius (Betchoo, 2017), place a chief priority on encouraging meaningful learning. In its framework for rights-based and child-friendly educational systems in schools, the United Nations Children's Fund (UNICEF, 2019) has also emphasized the significance of meaningful learning. This framework emphasises the necessity to help children understand how to deal with difficulties in the twenty-first century, while also recognising children's rights to a high-quality basic education. The Mauritian educational system, according to Atchia (2017), is not properly preparing our children to enter and operate in the society of the future. It is questionable whether students are being adequately equipped to fulfil the needs of the 2030s (Atchia, 2017). Thus, it is crucial to determine the direction for learning while considering the demands of the learner in the twenty-first century in order to lay the groundwork for the growth of our human capital in the direction of more sustainable economies. Kang et al. (2016) further suggested that the modern educational system would become obsolete if the disparity between students' daily lives and their learning is not bridged.

The pivotal role that schools play in children's lives in terms of learning is heavily emphasised in the Framework for Rights-based, Child-friendly Educational Systems and Schools (FRCESS) produced by the UNICEF in 2010. Two fundamental traits of a learner-friendly and rights-based school are outlined. The first, distinctly recognises excluded children so that can be included in learning, while the second represents what is beneficial to the child by focusing teaching methods and curriculum content on learning quality and the learner (Mandiudza, 2013). These two characteristics underline how crucial it is to concentrate on students' academic experiences.

A crucial method for enhancing teaching and learning is learner-centred and active teaching (UNESCO, 2005). The report places a strong emphasis on cooperative learning, the growth of critical thinking, and the acquisition of problem-solving abilities (UNESCO, 2005). It further emphasises that the process of teaching and learning ought to be centred on the needs of the students (UNESCO, 2005). Although learning is a multifaceted process involving many factors, this study focuses on students' COL and AL.

1.3 Statement of the Problem

The least popular science subject in upper secondary schools in Mauritius is biology (Maulloo & Naugah, 2017; Rumjaun et al., 2022). According to Maulloo and Naugah (2017), the performance in biology of Mauritian students in the Higher School Certificate (HSC) examinations has been unsatisfactory in recent years. They argue that the declining quality of the grades achieved in biology has been accompanied by a declining enrolment in the subject as students opt for subjects where they believe they will end up with good grades. According to statistics from 2016 to 2021, fewer HSC students are taking the Cambridge International 'A' level biology exams as compared to other subjects (see Table 1.1). Furthermore, Cambridge International Examinations (CIE) data suggest that Mauritian students have been doing well compared to other countries doing CIE. As such, it is of interest to explore Mauritian students' COLB and ALB to understand why they constantly perform well. Table 1.1 shows the enrolment in biology and other subjects at 'A' level from 2016 to 2021.

Table 1.1

Enrolment in Biology and Other Subjects at HSC Principal (A) Level (2016-2021) (Mauritius Examinations Syndicate)

Subject	2016 (Total examined: 9022)		2017 (Total examined: 9250)		2018 (Total examined: 9102)		2019 (Total examined: 8657)		2021 (Total examined: 7868)	
	Number examined	%	Number examined	%	Number examined	%	Number examined	%	Number examined	%
Biology	472	***5.2***	431	***4.7***	455	***5.0***	380	***4.4***	393	***5.0***
Chemistry	2238	***24.8***	2096	***22.7***	2008	***22.1***	1881	***21.7***	1703	***21.6***
Physics	2686	***29.8***	2688	***29.1***	2583	***28.4***	2534	***29.3***	2293	***29.1***
Mathematics	5532	***61.3***	5561	***60.1***	5416	***59.5***	5184	***59.9***	4697	***59.7***
Computer Science	973	***10.8***	966	***10.4***	1054	***11.6***	1095	***12.6***	1126	***14.3***
Design & Technology	893	***9.9***	934	***10.1***	888	***9.8***	799	***9.2***	675	***8.6***
Travel & Tourism	1136	***12.6***	1268	***13.7***	1378	***15.1***	1296	***15.0***	1061	***13.5***
Sociology	1192	***13.2***	1219	***13.2***	1265	***13.9***	1194	***13.8***	899	***11.4***
Art & Design	825	***9.1***	874	***9.4***	755	***8.3***	660	***7.6***	431	***5.5***
Accounting	2560	***28.4***	3583	***38.7***	3525	***38.7***	3261	***37.7***	2942	***37.4***
Business	2076	***23.0***	2238	***24.2***	2250	***24.7***	2150	***24.8***	2019	***25.7***
Economics	2097	***23.2***	2762	***29.9***	2607	***28.6***	2453	***28.3***	2463	***31.3***
French (Mauritius)	2558	***28.4***	2549	***27.6***	2552	***28.0***	2337	***27.0***	1695	***21.5***
Literature in English	1245	***13.8***	1335	***14.4***	1406	***15.4***	1299	***15.0***	657	***8.4***

Note. There was no exam in 2020 due to COVID-19 pandemic

The academic year 2020, which normally ends in October, was exceptionally extended up to April 2021 because of the COVID-19 pandemic. Therefore, School Certificate (SC) and Higher School Certificate (HSC) examinations were held in May/June 2021 instead of October/November 2020.

The low enrolment in science subjects, particularly biology, beyond the compulsory level (Grade 9) is a matter of concern to the authorities, teachers and other stakeholders given that it is a prerequisite to a wide range of university degrees and professional careers (Maulloo & Naugah, 2017; Rumjaun et al., 2022). Knowledge of biology is important in everyday life because it allows students to better understand their bodies and how it functions, their environment, and the need for conservation because of potential threats in the environment. It provides us with an insight into the prevention and cure of many diseases as well as promoting good health practices. However, studies carried out by researchers such as Jufrida et al. (2019), Saleh (2014) and Veloo et al. (2015) have shown that physics is seen as more challenging and not as popular as other science disciplines, including biology.

Science interest is a significant issue because it is associated with success and the desire to pursue scientific studies or careers. Globally, research (Chen et al., 2022; Potvin & Hasni, 2014) has indicated that students' interest in science subjects declines with school years. This declining trend of interest in science subjects is of much concern because of its implications for the supply of future scientists and its effect on the scientific literacy of its citizens. However, according to Potvin and Hasni (2014), there have been some deviations from the general trend in some contexts. A few conflicting studies (Baram-Tsabari et al., 2006; Baram-Tsabari et al., 2010; Baram-Tsabari et al., 2005) claimed that interest in biology had increased (for instance, between Grades 4 and 8), but these were roughly comparable increases (compared to other interests) instead of absolute increases, or slight increases over short periods of time. According to Iqbal et al. (2008), South African students were less willing to engage in science and technology careers than Pakistani students were. Sarwar et al. (2011) asserted that college students could occasionally display substantial differences in curiosity, motivation, attitude, and preferences due to their cultural differences in their analysis of international differences.

Researchers such as Baruch (2006), Binali et al. (2021), Ke et al. (2020) and Prichard (2009) have tried to ascertain effective strategies to enhance students' learning outcomes by enhancing their learning setting and teaching approaches. However, they have not paid much attention to the probability that students may have individual differences. It can be argued that, though the teaching approach is the same for a class of students, learning activities could be conceptualised and experienced by them in diverse ways and consequently adopt diverse learning approaches in the same classroom context (Trigwell & Prosper, 1991).

According to studies by Bliuc et al. (2011), Ferla et al. (2009), Richardson (2010) and Tsai (2010), learners' perceptions of learning have a substantial influence on the strategies they use and subsequent results. Additionally, a number of researchers have stressed the significance of studying the link between learners' COL science and what methods are used for learning science (Chiou et al., 2012; Hsieh & Tsai, 2018; Li et al., 2013; Tsai, 2004; Zheng et al., 2018). Since students' conceptions of learning biology, physics, or chemistry could not be generalised through the COL science questionnaire, which included questions about the science domain, Tsai (2004) argued that COL should be domain (subject) specific. Based on Tsai's (2004) findings, other researchers conducted studies on COL and AL in particular science domains such as biology (Sadi & Evik, 2016; Sadi & Dayar, 2015), chemistry (Li et al., 2013), and physics (Chiou et al., 2013; Mahinay, 2014), assuming they would discover a difference in students' COLB from their COL for other science subjects.

According to Biggs et al. (2001) and Dart et al. (2000), COL and AL are two significant determinants of students’ academic performance in any subject. While a myriad of studies has centred on students’ COL and AL (Chiu et al., 2016; Hsieh & Tsai, 2018; Tsai & Kuo, 2008), only a few (Chiou et al. 2012; Sadi, 2015; Sadi & Lee, 2018) have addressed the relationship between these two factors, particularly in the specific areas of learning biology, chemistry or physics. Given the fact that COL are domain-specific as biology is a distinct and significant learning subject among the sciences (Tsai, 2006), studies on conceptions of learning science, and in particular COLB, have excluded the connection with learning approaches. While Chiou et al. (2012) looked into the COLB and ALB at the tertiary level, one could argue that these characteristics are formed at lower educational levels.

Comparative studies conducted by researchers in different countries have led them to conclude that students’ COL may be culturally sensitive (Li, 2003; Tsai, 2004). According to Sadi and Lee (2015), relationships between COL and AL may differ from country to country, given that different countries have different cultures, particularly learning cultures. In an earlier study, Lee et al. (2008) stressed the necessity of investigating students’ COL and AL across different cultures and countries. In this context, geographically cut off from the continental mainland, the small island of Mauritius is characterised by a unique learning culture which is largely uncorrupted by intrusions from other African countries and beyond. Consequently, the unique educational context and cultural background of Mauritian high school students offer a distinct opportunity to explore students’ COL and AL.

Duff and McKinstry (2007) state that students' COL and AL are malleable and dynamic. As a result, they vary based on the students' learning motives and the learning environment. According to Duff and McKinstry (2007), teachers and administrators have the capacity to change the environment to promote a more desirable (deep) approaches among learners to achieve higher quality learning outcomes leading to higher academic performance. According to Kember et al. (2004), students may exhibit varied learning behaviours depending on the subject matter. For example, they might employ the deep approaches they think they need for learning science, but not for other subjects. Arguably, the existence of positive COL and AL in learning biology increases learners' chances of achieving the intended learning outcomes and better student performances. This invariably creates positive perceptions of the subject and possibly helps to attract more students to study biology at SC level and consequently at HSC level.

The methods that students use to complete their academic assignments are referred to as approaches to learning (Kember et al., 2004). Deep learning and surface learning are the two primary AL that researchers have identified (Biggs, 1978 & 1987b). Students that use deep learning strategies strive to comprehend the purpose of the course material. In contrast, students that use surface learning strategies typically pick up information through rote memory. When compared to surface AL, which comprise surface motivations (such as fear of performing poorly) and surface approaches (such as narrowing the scope of learning and rote learning), deep learning approaches include deep motivation (such as the intrinsic appeal of the subject) and deep approaches (such as meaningful learning) (Kember et al., 2004). As a result, it is crucial for teachers and other stakeholders of education to promote deep learning strategies among learners.

1.4 Aims and Objectives of the Study

This study's aim was to explore Mauritian upper secondary school pupils' COLB and ALB. The study's explicit research objectives, derived from the aim, were:

1. To critically examine:

   (a) Mauritian upper secondary school students' conceptions of learning biology.

   (b) Mauritian upper secondary school students' approaches to learning biology.

2. To explore the influence of students’ conception of and their approaches to learning biology

3. To critically examine:

   (a) Why students have specific conceptions of learning.

   (b) Why students have specific approaches to learning.

4. To critically examine why students’ conceptions of learning influence their approaches to learning biology, in the way/s that they do.

1.5 The Research Questions

The objectives of the study in the previous section served as the foundation for the research questions. The four research questions below were the focus of this study's purpose:

1. (a) What are Mauritian upper secondary school students’ conceptions of learning biology?

   (b) What are Mauritian upper secondary school students’ approaches to learning biology?

2. How do students’ conceptions of learning influence their approaches to learning biology?

3. (a) Why do students have specific conceptions of learning biology?

   (b) Why do students have specific approaches to learning biology?

4. Why do students’ conceptions of learning influence their approaches to learning biology, in the way/s that they do?

1.6 Rationale of the Study

I have taught biology in Mauritian secondary schools for twenty-two years and held the position of Head of Department during the time. I have been employed by the Private Secondary Education Authority (PSEA) for the past fifteen years as a supervisor of private secondary schools. The Ministry of Education and Human Resources, Tertiary Education, and Scientific Research provides oversight for the PSEA's operations. The PSEA serves as a governing body for the private secondary schools in the Republic of Mauritius, both grant-aided and non-grant-aided (fee-paying).

My interest in biology education lies in the fact that I have a background as a biology teacher, and as Supervisor, I have been responsible for the teaching of biology in the private secondary schools. In performing these roles, I have witnessed a declining enrolment in biology at SC level (Grades 10 and 11) and at HSC level (Grades 12 and 13) in Mauritian secondary schools. Furthermore, during my visits to schools as a supervisor, biology teachers have often expressed their concern about students' lack of interest, low performance, and the declining enrolment in biology. This led me to probe the literature on students' interest in biology, while deciding on a topic for my research.

My interest in conducting this research was sparked by an article by Lee et al. (2008) concerning conceptions of learning and approaches to learning science. As I read other articles in this domain of literature, I came across an article by Chiou et al. (2012) concerning conceptions of learning biology (COLB) and approaches to learning biology (ALB) of undergraduate students in Taiwan. This article prompted my decision to explore Mauritian students' COLB and ALB in a bid to understand how they learn biology.

1.7 The Context of the Study

I conducted the current study in Mauritius where I currently reside. The major island of the Republic of Mauritius, Mauritius, is located in the Indian Ocean some 2,000 kilometres from the continent of Africa's southeast coast. Figure 1.1 illustrates the geographical location of Mauritius.

Figure 1.1

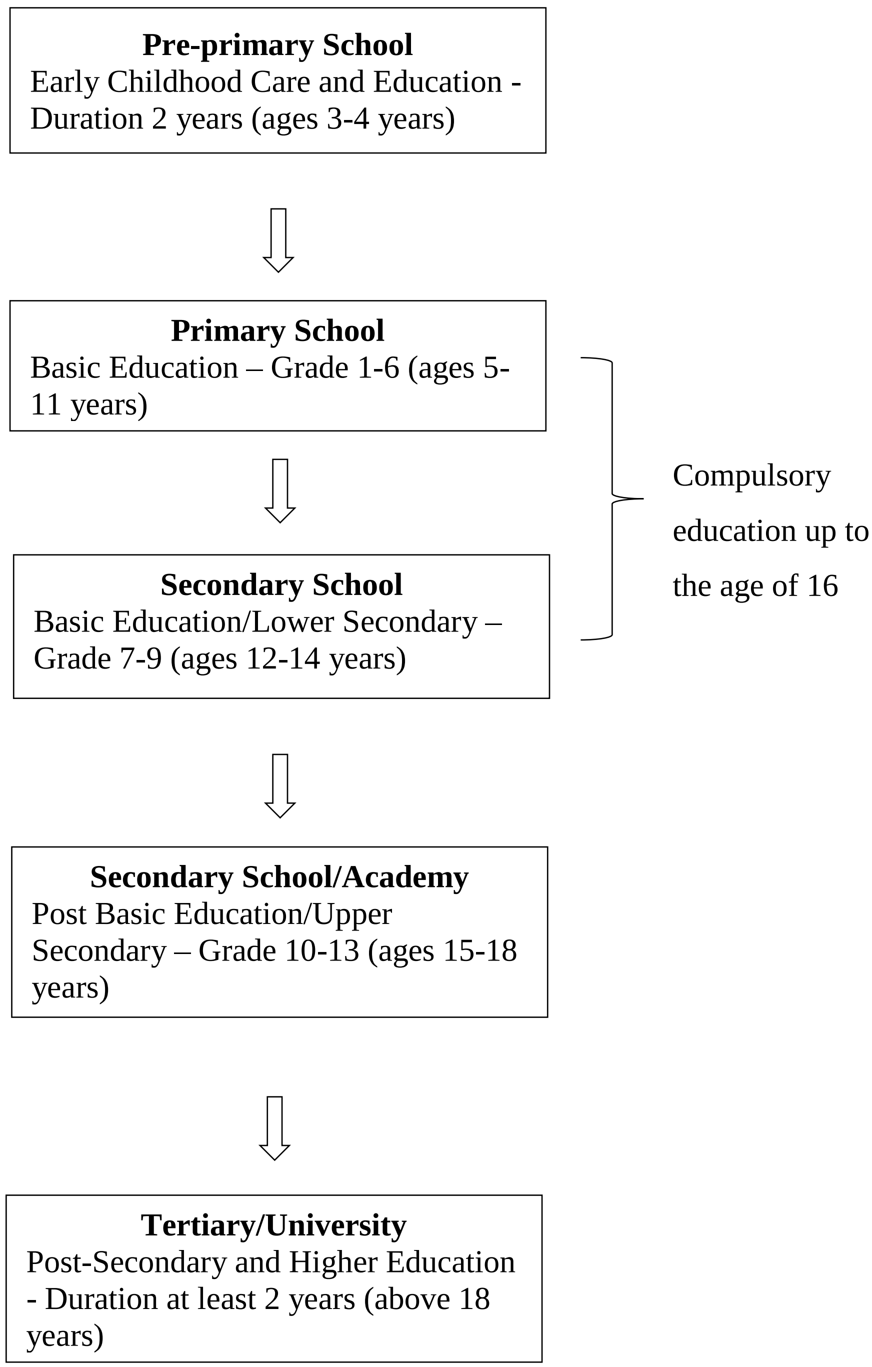
Map of the Location of Mauritius (Google)

The people of Mauritius (Mauritians) are multi-ethnic, multireligious, multicultural and multilingual due to their Indian, African, European and Chinese ancestry. Despite English being the official language, which makes it the primary language of teaching in most schools, Kreol Morisien (Mauritian Creole) is widely spoken and understood.

Since Mauritius was once a British colony, the country's educational system is heavily influenced by that of the United Kingdom. It is based on a formal education structure of 2+6+5+2. Pre-primary, primary, secondary and tertiary education are the four main fields of the Mauritian educational system. Figure 1.2 depicts the schooling system in Mauritius.

Figure 1.2

The Schooling System in Mauritius (Ministry of Education, Tertiary Education, Science & Technology)



The Ministry of Education, Tertiary Education, Science and Technology's curriculum is used in all public and private grant-aided primary and secondary schools. In these schools, mathematics, English, and French are compulsory subjects. At the lower secondary level (Grades 7 to 9), students are exposed to all the subjects available in the school. It is only when they reach Grade 9 that they are allowed to choose some of their subjects, English language, French and Mathematics being compulsory core subjects, to be taken in Grades 10 and 11.

Science is taught to pupils from primary school, where basic concepts are introduced. At the secondary level, pupils study science as biology, chemistry and physics. Several pupils opt for biology at Grades 10 and 11 and expect to obtain quite a good grade in the subject at the SC examinations. Fewer students opt for biology in Grades 12 and 13 and thus a small number (as compared to other subjects) take part in the HSC examinations.

1.8 Significance of the Study

This study aimed to investigate Mauritian upper secondary school learners' COLB and ALB and if there exists a relationship between the two. The potential value of the findings will be in informing educators on learners' COLB and ALB in the Mauritian education context. A knowledge of students' COLB and ALB might help biology teachers to align their current teaching methods with the learners' characteristics of learning, which might lead to achievement of the subject's specific learning outcomes and better performance. Consequently, positive perceptions might attract more students to study the subject beyond the compulsory level (Grade 9).

Teacher Educators, tasked with teacher professional development could use the findings in their development of programs aimed at improving classroom practice. At the national level, my research can contribute to better performance in biology by informing teachers that students hold a variety of learning conceptions and that the use of constructive conceptions could motivate them to use deep learning approaches more frequently. Guiding the students towards more meaningful learning may contribute to improve their performance in biology. The findings might also help researchers to understand COL and AL in other similar small island nations throughout the world. This study will also build on the existing literature on COL and AL.

1.9 Outline of the Chapters of this Thesis

This thesis was structured into eight chapters as follows:

Chapter 1: Introducing the Study

All the subsequent chapters' backgrounds were established in this initial chapter. The goal, focus, and justification of the study were all outlined. It introduced the reader to the study by talking about a number of subtopics that describe the context of the study and the research questions.

Chapter 2: Review of Related Literature

Although most issues discussed in each chapter are backed by literature, Chapter 2 drew purely on relevant literature. This chapter discussed the review of literature related to students' COL and AL. The relationships between COL, AL and academic performance were highlighted. The COL and AL of students across different cultures were also elaborated on. Several players from domain specific COL and AL fields were highlighted in the debate. Additionally, the gaps in the literature reviewed were identified.

Chapter 3: Theoretical Framework

I covered the theoretical foundation of my study and a review of the relevant literature in this chapter. The study was grounded in two bodies of theory, namely, COL and AL. This chapter provided the historical background and the emergence of these theories in science and their application to this study. Each theory was discussed broadly in their individual sections. Lee et al.'s (2008) six COL and the key tenets of each conception were discussed in one section. This was followed by Kember et al.'s (2004) four subscales of the approaches to learning developed by. The theoretical lens informed the data gathering instruments' design and the interpretation of the findings this study.

Chapter 4: Research Methodology

Chapter 4 described the study's design and methodology, which was a mixed methods approach based on the pragmatic paradigm. Purposive sampling was utilised to choose participants for the study. This study used a sequential explanatory design that involved the sequential collection of quantitative then qualitative data. Semi-structured interviews were used to supplement the survey questionnaire that was used to collect the data for this investigation. A sample of 497 Grade 11 biology students at 20 schools participated in the quantitative survey, from which 16 students were selected for face-to-face individual interviews. Ethical considerations were maintained at all times during the data collection stage.

Chapter 5: Students' Conceptions of and Approaches to Learning Biology: Quantitative Findings

The results of the survey questionnaires for COLB and ALB, the first stage of the investigation, were presented and described in Chapter 5. The results were presented in accordance with the methodology; the quantitative findings were presented first, followed by the qualitative findings in chapter 6. The COLB and ALB questionnaire responses from the students were presented and discussed. The use of exploratory factor analysis (EFA) to identify COL and AL was highlighted. The strength of the theoretical model's support from the sample data was assessed using the structural equation modeling (SEM) technique.

Chapter 6: Students' Conceptions of and Approaches to Learning Biology: Qualitative Findings

This chapter reported the findings of the face-to-face individual interviews. The quantitative findings were explained using the qualitative information gathered during the interviews. Relevant quotes supported the reported interpretation of the students' interview responses.

Chapter 7: Discussion of Findings

This chapter further condensed the analysis process by contrasting the analyses from Chapters 5 and 6 with Chapter 2's literature review and Chapter 3's theoretical framework. This chapter covered how I interacted with the findings of previous research and carried the investigation to its conclusion.

Chapter 8: Summary and Conclusion

In the final chapter, I addressed the important queries and outlined the significant concepts that had evolved as theoretical and contextual advancements of earlier study. These constructions were seen as an unbroken flow of time and space. The study's emergent elaborations, limitations, suggestions for more research, and conclusion were covered in the chapter.

1.10 Synthesis

This first chapter introduced the background to the study and provided a detailed overview of this research study. It set the scene or foundation for other chapters to follow. It also included the statement of the issue, the justification, the goals, the research questions, and the importance of the study. The structure of the thesis and chapter summaries were also provided. The next chapter looks at what other scholars have written about COL and AL.

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Introduction

In the preceding chapter, I described the key features of this study. In this chapter, I review national and international literature relevant to the study. The review of literature presented is based on the works of authors who have researched and presented studies, journal papers and reports on COL and AL. A critical review of previous research provided the foundation of my study. The literature review also provided me crucial knowledge about what has been explored, the gaps, and the areas that have been previously ignored. Setting the research problem in the context of relevant research was helpful to me. It decided whether the research issue called for more research and offered an explanation or justification for the study. This investigation is subject-specific and is in the discipline of biology. Nevertheless, studies carried out on COL and AL in other subjects have been used as towlines for my study.

An overview of the COL and AL literature is provided in this chapter, thus establishing a reason for the thesis's path. The focus next shifts to research on COL and AL, and their relationship with a special emphasis on academic accomplishment across a range of disciplines. A variety of cross-cultural research and research on domain specific COL and AL are also discussed. The chapter concludes with literature-based inferences that lead to the thesis's goals and research questions.

2.2 Understanding Learning from the Perspective of Students

Since the 1970s, it has been acknowledged that it is essential to comprehend learning from the viewpoint of students (Kember, 2016; Säljö, 1979). According to Phillips and Soltis (2015), these investigations predominantly concerned tertiary level students and high school pupils since it was believed that they needed to be able to clearly describe their learning experiences and provide accurate information. Numerous quantitative and qualitative studies have studied students' viewpoints on learning (Kember et al., 1999; Kember, 2016). According to earlier research on student learning, even while students may study the same subjects in the same class, they often have differing views of learning (Kember, 2016).

The sections that follow give a synopsis of the research on how the students' COL affect their AL. One of the main conclusions of the aforementioned studies was the connection between students' COL and AL, which impacted their achievement. Students' COL from various cultures were also looked at in reference to the current study. My research was based on studies conducted in Australia, Nepal, Hong Kong, Sweden, Portugal, the Netherlands, and the United Kingdom. This study also drew on deliberations from cross-cultural research involving Flemish, German, Uruguayan, and Chinese students. In small countries like Mauritius, little is known about how students think about learning. In addition to multi-ethnic society, the education system in Mauritius is centralised which make the current study's context distinctive and, as a result, provided new insights into how students experience and approach learning.

2.3 Conceptions of Learning

COL research was undertaken in order to better understand how people learn (Pillay & Boulton-Lewis, 2000). Many educational researchers (Yang & Tsai, 2010; Bliuc et al., 2011) carried out studies to understand how students conceptualise learning. Conceptions of learning, as defined by Marton (1981), are students' inherent knowledge or interpretation of the learning phenomena. Benson and Lor (1999) defined COL as being the personal opinions of individuals which they build on authentic learning experiences. Additionally, they described COL as students' opinions about the subjects they have learned, the teaching process, or what they have learned.

Byrne and Flood (2004) described COL as the manner in which a person perceives learning, or what the meaning of learning is to them. They claim that each notion has a "what" and a "how" component, both of which have dialectically entwined referential and structural elements. The "what" component identifies the subject of learning, while the "how" component identifies the method of learning. They added that most students do not fully express both dimensions of learning, but rather express fragments of the conception, and that a comprehensive conceptualization of a notion includes both the "what" and "how" components of learning. Liang and Tsai (2010) defined COL as learners' beliefs about their experiences of learning and the learning methods they prefer.

Lin et al. (2012) described COL as the interpretation and reflection of individuals upon their learning experiences. According to them, learning conceptions could be explained in terms of both students and teachers. For instance, according to the concept is described as including both students' and teachers' perspectives on learning encounters and which teaching and learning approaches they prefer (Liang & Tsai, 2010). Therefore, COL is interested in how people view and consider their encounters with education (Lin et al., 2012). Additionally, the meaning of COL was modified to investigate learners' conceptions regarding learning science (Bahcivan & Kapucu, 2014).

There is no single generally accepted definition of COL. However, there are certain common elements as to how learning has been defined by researchers and they all agree that experience is a significant element of learning. Hence, COL can be understood as having importance on experiences of learning. They assert that each conception consists of a "what" and a "how." COL was therefore defined in this study as students' perceptions of, interpretations of, and reflections on their learning techniques and experiences.

To comprehend the nature of COL, it was necessary to look at the classifications of COL that researchers have created. Säljö (1979) first classified COL using the so-called phenomenographic method. In classifying the information gathered about college students' COL, he identified five distinct COL: memorisation, increase in knowledge, abstraction of meaning, acquiring methods and facts that can be recalled and/or used practically, and an interpretive process that facilitates comprehension reliability. To identify the students' conceptions of learning science (COLS), Tsai (2004) also performed a phenomenographic investigation with 120 university students divided into seven subcategories. The researcher's objectives included identifying their conceptions of memorisation, increase in knowledge, problem calculation and application, exam preparation, understanding, application and development of a new way. Prior investigations had discovered almost equivalent COL groups (Li et al., 2013; Chiou, et al., 2013).

According to Tsai (2004), the first group generally identified students' tendency for memorising strategies when learning science. Learning objectives stated that passing exams and achieving top grades were the second group's main objectives. The third group revealed students' ideas of learning, which is defined as performing calculations and resolving problems. The fourth group concentrated on students' enthusiasm for more studying. The fifth one focused on students' definition COL as the integration of science into everyday life. The sixth group represented a thorough comprehension of accumulated information. Finally, the last category was the creation of a fresh viewpoint on natural occurrences.

Pratt (1992) describes conceptions as people's perception of the world, how they make sense of it, and react to what they have learned about it. Schmeck (2013) defined COL as differences in how students explain their educational experiences. Studies on COL have verified that students experience learning from qualitatively diverse perspectives. According to Kember (2016), a COL consists of two parts: perceiving what is learnt and a method of understanding how it is learnt. Both components are included in a complete learning conceptualisation.

Teaching and learning conceptions, according to Alt (2018), are predetermined ideas that form the basis for approaches, or collections of techniques and tactics that will be used in diverse learning and teaching contexts. Students' COL, according to these theories, shape their understanding of learning tasks and aims, influencing their learning.

2.4 Conceptions of Learning as Domain Specific

According to Liang and Tsai (2010) and Lin et al. (2012), as COL are experience-dependent, learning experiences in various domains may lead to various COL and, as a result, various AL.

Tsai (2004) agreed that learning conceptions vary depending on the circumstance. In addition to the five COLs that Säljö (1979) proposed, he identified two additional COLs while examining Taiwanese high school students' conceptions of learning science (COLS), namely "testing" and "calculating and practicing." Those who identified the conception of learning science as test preparation did so in a conceptual way. He discovered that they learned science so that they could do well on scientific tests and pass their exams. They placed a great deal of significance on exam success. Students who described their understanding of science as "practicing tutorial questions and calculating" believed that science was a subject that required formula and number operations, as well as calculations and solving tutorial issues. The manner in which school science is taught may have influenced the calculating view of learning science. Formulas, equations, and computations are frequently used to convey scientific knowledge in science textbooks and educational activities (Tsai, 2004).

Tsai (2004) was also of the opinion that students may have good computing skills to solve a science problem and obtain the right answer without even knowing the nature of the issue and the meaning of the answer. He listed the following seven COL: memorising, test preparation, working out and practicing science problems, increasing knowledge, utilising it, comprehension and gaining new perspectives. He found that, in contrast to domain-general learning, at least one sort of COL, "calculating and practicing," was specialized to science. The first three COL, which represented the lower-level group, and the last four conceptions, which represented the higher-level group, were classified into two major categories, according to his suggestion. He asserted that the majority of COL categories come from students' experiences learning in schools. He suggested that COL should be described as "domain-specific epistemological beliefs" based on his assertion that COL should be domain-specific. Additionally, he discovered that questions on science were unable to uncover students' ideas about what it means to learn biology, physics or chemistry. Because of this, students' conceptions about learning biology may differ from their conceptions about learning physics or chemistry. Other scholars have conducted studies that highlight this subject-specific aspect of COL in disciplines like engineering (Lin & Tsai, 2009) and mathematics (Reid et al., 2005). According to Darlington (2019), AL can vary between subjects and is also subject-specific. Therefore, a student's COLS and ALS could be distinct from those for learning history.

To study Taiwanese high school learners' COLS, Lee et al. (2008) designed the COLS questionnaire grounded on the results of Tsai's (2004) earlier related research. Through the factor analysis process, only six factors were kept in the final COLS questionnaire. Tsai (2004) discovered that very few students had the idea that learning involves "viewing in a new way" (p. 1742). Therefore, "understanding" and "seeing in a new way" were merged into a one factor called "understanding and seeing in a new way" by Lee et al. (2008). To evaluate students' COLS, they presented a framework that included six factors: memorisation, testing, calculation and practice, knowledge gain, application, and new understanding and perspective. Another assessment framework for students' approaches to studying science was proposed by Lee et al. (2008). It comprised two components (surface approaches and deep approaches), composed of two subscales (motive and strategy): a surface motive, a surface strategy, a deep motive, and a deep strategy.

2.5 Influence of Culture on Conceptions of Learning

Australian and Japanese pupils had different conceptions about what learning was, according to Guo et al. (2017). In Li's (2003) study, Chinese and American college students had significantly different COL. Tsai's (2004) study which examined the COL of Taiwanese high school learners in the science subject revealed that students' COL, such as studying for exams, were shaped by culture, creating a unique educational environment in Taiwan. Therefore, he claims that culture may have a significant impact on parental expectations and education, which may then have an effect on children' opinions about learning.

The majority of research findings exploring how students experience learning, however, have been produced in Western nations with Western cultures. While non-Westerners can adapt Western teaching methods to enhance their learning objectives, a customised, culturally relevant method is necessary (Watkins, 2000). A few inquiries were conducted to examine how learners in various cultures perceive learning. In the vast majority of these research, Chinese students were compared to counterparts from students from Western nations including Australia, Belgium, and Germany. Researchers have examined Asian learners' perspectives of learning. The outcomes of some of these comparative researches are summarised in Table 2.1.

Table 2. 1

Summary of cross-cultural COL and AL (adapted from Jaidin, 2018)

Critera	Chinese and Uruguayan students' views of learning (Marton et al., 1996)	Chinese and Flemish students' conceptions of learning (Zhu et al., 2008)	Chinese and German students' approaches to learning (Dahlin & Watkins, 2000)	Nepalese students' conceptions of learning and approaches to learning (Dahlin & Regmi, 1997; Watkins & Regmi, 1990)	Portuguese students' conceptions of learning (Duarte, 2007)
Meaning of Learning	Students from China and Uruguay agree that learning is the method of collecting information. Chinese students focus heavily on continuous learning activities. Uruguayan students are interested with the eventual result of their studies. Memorization is seen as a natural means of learning by Uruguayan students. Chinese students believed that memorization improved understanding of information and that repeated practice was required to improve memorization. Chinese students described two types of memorization: mechanical and meaningful.	Learning was seen as crucial for personal growth and social competence by Chinese students. Learning was viewed as understanding by Chinese students. Flemish students tended to adopt a surface-level approach to learning.	German and Chinese children held opposing views on the use of memorization in primary school and the importance of repetition in understanding. German students regard repetition as a technique to double-check their learning, whereas Chinese students see repetition as crucial in the building of understanding, especially when working hard (Dahlin & Watkins, 2000).	Learning is viewed by Nepalese students in three ways: (1) as an increase in knowledge; (2) as a process of viewing things in new ways; and (3) as a part of personal development. The learning strategies used by Nepalese pupils were found to be similar to those used by students in Australia (Biggs, 1987b) and the Philippines (Watkins et al., 1991). Nepalese students believed that in order to get good scores, they needed to know what the learning task expected of them. As students in Nepal go through the educational system from elementary school to university, they tend to choose a more surface-oriented approach rather than a more in-depth and achieving one.	The six learning conceptions identified by Säljö (1979) and Marton et al. (1993) were all described by Portuguese students.

The spectrum of students' learning conceptions has been proven to be broadly similar across cultures. Learning as memorization and learning as comprehension or understanding, for example, were recognized in nearly every study, as shown in Table 2.1. They are particularly comparable to the learning conceptions discovered by Säljö (1979). Distinctions in their AL were identified. On the one hand, memorisation was regarded by Chinese students as a means of better understanding what they had learned, and they believed that repetition was essential in the development of remembering (Marton et al., 1996; Zhu et al., 2008). Memorisation, on the other hand, was seen by Uruguayan students as a by-product of learning and not as a process that developed learners' ability to grasp things (Marton et al., 1996). An additional significant distinction was the way Chinese and German pupils approached learning through memorisation (Dahlin & Watkins, 2000). Memorisation was seen as a technique for Chinese pupils to improve their knowledge of a material they had learned. On the other hand, German pupils employed memorisation to double-check their understanding.

According to a child-centred approach to learning, it is better to see learning through a child's perspective because doing so gives one a greater comprehension of children's learning experiences. As a result, children's perspectives offer important details regarding their ideas about learning and learning strategies (Schuh, 2004). An examination of children's perspectives from a small, non-Western country like Mauritius also contributes to the scant corpus of research that looks at students' COL across cultural boundaries.

2.6 Approaches to Learning

Approaches to learning (AL) explain what you do during learning and why you should. Many studies (Abedin et al., 2013; Gilakjani, 2012) have indicated that students adopt different ways of learning. According to Biggs (1994), students' academic learning outcomes are influenced by how they approach their academic tasks. Gilakjani (2012) defined AL as the ways in which individuals see and process information under learning conditions. According to Abedin et al. (2013), AL refers to a person's interactions with newly acquired information.

The preference for one set of learning conditions over another is referred to as learning approach preference, which is one of AL's components. According to Gilakjani (2012), it refers to how a student perceives, communicates with, and reacts to his or her learning environment. Gilakjani (2012) defined a learning approach as a group of social, intellectual, emotional and physiological behaviour which indicates how students view, experience and respond to their learning setting. When new knowledge is acquired, learners view or interact with it in their own style or method (Abedin et al., 2013). Since each person has a unique way of learning and each student has a unique way of receiving and reacting to new experiences, each student evaluates knowledge in a different way.

AL are generally divided into two groups in the literature: surface and deep approaches (Liang and Tsai, 2010; Lin et al., 2012). A surface approach describes students who memorize or repeat knowledge through rote learning to satisfy work requirements that have been imposed externally. However, a deep approach describes students who actively seek comprehension while reading literature by concentrating on the author's context, combining lived experience and knowledge, while connecting facts to conclusions. A straightforward way of distinguishing between surface and deep learning strategies is illustrated in the following table.

Table 2.2

Distinction between deep and surface AL

Approach	**Deep**	**Surface**
Intention	Understanding	Memorization
Strategy	Seeking comprehension	Rote learning

Learning strategies that are meaning-focused and aimed toward understanding by critically connecting new concepts to existing knowledge and experience are known as deep approaches (Ramsden, 1983). Surface approaches, on the other hand, are concerned with memorising information without analysing its meaning in light of other information (Trigwell & Prosser, 1991). Such a strategy may put success at risk if what is memorised is forgotten or cannot be applied to fresh, non-standard problems since the concept loses its meaning (Novak, 1978). Although a deep AL could be preferred, not all learners benefit from it (Lonka et al., 2004). Furthermore, the memorisation techniques used in a surface approach can be used as strategies in a deep AL (Entwistle, 1997a).

Students who engage in "surface-level processing" focus on information content and prioritize memorization and rote learning techniques (Biggs et al., 2022). Instead of understanding essential concepts and understanding how they link to other knowledge and how the information works in diverse settings, students who use surface AL intend to avoid failing (Beaten et al., 2013). Abedin et al. (2013) added to this by stating that students prefer to concentrate on and memorise only basic details rather than comprehending all aspects of knowledge. Their only objective is to finish the assignment or master the material. In essence, students who opt for this strategy rely largely on verbatim notes from lectures out of fear of failing. They seek to recreate these notes in essays, tests, and exams through memorization rather than by attempting to connect the individual bits of information. On the other hand, pupils who engage in "deep-level processing" focus on both the information's content and underlying significance. Deep learning, according to Biggs et al. (2022), is characterised by a personal commitment to comprehending the content, as evidenced by using multiple techniques such as extensive reading, integrating a range of tools, discussing viewpoints with other people, focusing on how the broader structures or patterns are influenced by singular parts of information, and be able to use what they have learned in real life. Deep learning requires investigating novel phenomena, making an effort to understand things from several perspectives, and integrating and synthesizing previously acquired knowledge in ways that become ingrained in one's consciousness (Duarte, 2013).

According to Abedin et al. (2013), students who utilize a deep AL have a more structured organization of their thoughts and are better able to retain and apply the information and skills they have learned. Abedin et al. (2013) went on to say that they read wisely, relate ideas to other subjects, carefully and objectively analyse reasoning and claims, and then review facts and relate them to the conclusion. According to Vermunt and Vermetten (2004), deep learning is characterised by the capability to apply newly learned concepts in diverse contexts and circumstances, while surface learning is characterised by the ability to apply new information to specific tasks and problems without transferability. Chan (2007) maintains that deep AL is motivated by the idea that knowledge is learned by self-inquiry rather than being passed down by authority.

While using a surface approach, which is more conducive to a reproductive orientation, pupils who employ a deep AL technique focus on the task's underlying context (Kember & Kwan, 2000). While individuals who utilise a surface approach are passive recipients of knowledge and see of it as something that happened to them, those who apply a deep AL are actively involved in learning and perceive it to be something they do (Marton & Säljö, 1976). Students who process information deeply strive to examine the meaning of the text, as opposed to students who process information superficially and focus on the text itself. No one is a surface or deep learner by nature, but students may choose one of these AL depending on the situation, claims Skinner (2022).

Other researchers, such as Biggs (1991); Winstone and Boud (2019), also found similar AL in the United Kingdom and Australia. According to these researchers, students adopt an achieving or strategic approach to maximise their study effort. Research on learners' AL have been conducted in the wake of these investigations. The findings of those studies have greatly influenced education in terms of teaching approaches.

2.7 Relationship between Conceptions of Learning and Approaches to Learning

An increasing number of educational researchers have explored the relationships between COL and AL. Duarte (2007) and Edmunds and Richardson (2009), have proposed that learners' COL could affect their AL and that the relationship between COL and AL could be a causal one. Numerous scholars have considered the connections between students' AL and their COL since the 1980s.

Before giving 60 psychology students the assignment of reading an article and reporting on their reading strategy, van Rossum and Schenk (1984) utilised an open-ended questionnaire to assess their COL and AL. These categories were comparable to the categories Marton and Säljö (1976) and Säljö (1979) discovered. Van Rossum and Schenk (1984) also discovered a strong affiliation between their surface AL and their lower-level COL. In contrast, the students' deep AL were closely related to their higher-level learning conceptions. Similar findings were made by Edmunds and Richardson (2009), Lee et al. (2008), and Minasian-Batmanian et al. (2006).

2.8 The Relationship between Students' COL, AL and their Academic Performance

Other studies have frequently looked into the connection between the COL, AL, and pupils' academic achievement. Globally, the literature seems to substantiate the idea that students' COL affects their AL and subsequently their academic success. A few examples include Bovill (2020), Dart et al. (2000), Lee et al. (2008), Lonka et al. (2021), and Sinatra (2001). In other words, a person's approach to learning depends on how well they grasp the task at hand. According to the research done by Lee et al. (2008), a correlation exists between COL, AL and student performance.

According to research on AL, using a deep AL is often related with high academic performance and grades, whereas a surface approach yields poorer marks and lower academic results (Bovill, 2020; Lonka et al., 2021; Ramburuth & Mladenovic, 2004). According to Prosser and Trigwell (1999), all aspects being equal, deep active learning and ways of knowing that encompass fully conceptualizing something are more inclined to provide high-quality educational results, while surface approaches are more likely to produce poor results.

However, not all data revealed a substantial link between a deep AL and learning outcome quantitative scores (Byrne et al., 2004; Darling-Hammond et al., 2020). According to certain studies (Minbashian et al., 2004; Trigwell & Prosser, 1991), a deep AL did not translate into higher marks. The relationship between 122 first-year nursing students' perceived learning styles and academic accomplishment was examined by Trigwell and Prosser in 1991. They discovered a link between a deep AL and high academic accomplishment quality levels. However, no such link could be established between quantitative differences in the outcomes. Struyven et al. (2005) remarked that, in this sense, the evaluation system rarely rewarded a deep AL. The explanation could be that evaluation focuses on knowledge for which a surface approach is sufficient for success (Scouller, 1998). Nevertheless, several researchers have investigated how students learn in the classroom. As a result, understanding students' learning styles can help to improve learning in educational environments. In order to provide students the confidence to take charge of creating a sustainable future, they should also be at the centre of a forward-thinking academic learning environment.

Richardson et al. (2012) found that deep and strategic learning approaches were positively linked with successful learning outcomes, but with weak correlations. Surface learning was found to have a weak and negative relationship with academic success. Poor academic performance is commonly linked, according to Mystakidis (2021), to a superficial AL and a non-strategic lack of regulation. The highest correlation between a strategic approach and academic success occurs when the evaluation necessitates a high level of comprehension. When the evaluation necessitates a high level of comprehension, a deep approach is linked to higher academic results (Mystakidis, 2021). Cassidy and Eachus (2000) found that a strategic AL was positively correlated with academic achievement, a surface AL was adversely correlated, and a deep AL was unrelated. Performance impacts of learning style rely on the specifics of the assignment and cannot be generalized, claims Cassidy (2004).

Experiments to induce deep learning were prompted by these findings (Duarte, 2007; Entwistle, 1997a). However, most of these studies revealed inconsistencies in United Kingdom (UK) university policy and practice. While educational practices usually promote "deep understanding," evaluation methods frequently focus on "superficial learning," with memorising and copying of content being commended (Norton & Crowley, 1995). According to Richardson (2000), this may provide an explanation for the increase in a surface approach that has been noted in various research among the first-year students.

Contrary to popular opinion, students' COL are positively correlated to their performance. However, the relationship between the two has not as much received attention in studies as expected. Students who view education as an interpretive process aimed at understanding reality will grow as individuals and do better than those who view education as a means of acquiring more knowledge. Purdie et al. (1996), van Rossum and Schenk (1984), as well as Alamdarloo et al. (2013), claimed that a connection between students' COL and academic performance exists. However, there is not enough support for this claim. These studies typically involve interventions intended to improve students' application of learning strategies without data regarding the association between COL and academic performance (Norton & Crowley, 1995). However, other papers including that of Norton and Crowley (1995) suggested such evidence. Purdie and Hattie (2002) found that students who adopted all six of their COL had higher self-rated academic accomplishment than those who only used the first few COLs in their cross-cultural study on COL. However, it was not specified at which point in the course these participants evaluated their own academic progress. The research provided strong evidence for the link between the importance of self-controlled learning and academic success. (Ste-Marie et al., 2019). Instead of focusing on a student's ability or knowledge, self-regulated learning is concerned with how and why they control their own learning. According to Waheed et al. (2020), learning environments have a bigger influence on students' academic success than learning conceptions. Additionally, they asserted that since learning concepts are such complicated concepts that grouping students under one conception is essentially incorrect.

Rienties et al. (2012) looked into the variation of academic performance when domestic and international students were compared, concentrating on these students' degrees of social and academic assimilation. They found that a student's academic performance is an extremely complicated phenomenon. Academic modification turned out to be the most significant predictor of study performance among Dutch, Mixed-Western and Western participants. However, because social and academic assimilation processes are nonlinear, this did not predict long-term success. In a study of 108 post-graduates from around the world at a British university, Young et al. (2013) found significant correlations between academic performance, language proficiency, mental health, intercultural competence, contentment with life in the new environment, and the amount, value and patterns of social interaction.

As success and/or performance are not consistently measured in the literature, examining the elements that affect pupils' academic achievement is challenging. Self-report measures are used in a number of studies, but seldom are their methods disclosed. The link between COL, the learning context, and AL has yet to be established. Thus, while it is conceivable that the COL and experiences of learning influence students’ performance, the evidence is insufficient.

2.9 Influence of Culture on Approaches to Learning

The AL of a pupil can change depending on the task and the teacher. There are several variables that could affect a student's AL, and it is thought that these variables are interconnected. Research has emphasised how culture affects AL. The impact of learners' cultural backgrounds on their learning processes has been the subject of numerous research. The manner in which a student approaches learning could also be affected by additional elements like gender, locus of control and self-esteem.

Why Asian children perform better in mathematics and science than Western pupils has been the subject of investigation. Tweed and Lehman (2002) discovered that Asian parents had higher expectations for their children's learning and were more involved in it. They also discovered that Asian learners were more motivated to accomplish than their Western counterparts.

Contrary to Western perceptions, cross-cultural analyses of Asian students' learning styles indicated that the students did not primarily use surface learning strategies, which accounts for their seeming high accomplishment. In investigations performed by Kember (2000) and Biggs (2001), memorisation was a general AL for Asian students. Nevertheless, this AL could be seen as an element of a profound AL. It was found that good academic achievement in students in Eastern nations including Hong Kong, China, Singapore, Taiwan, Japan, and Korea were associated with surface approaches (Wong & Wen, 2001). There appeared to be significant cultural differences in how students experience learning, according to Säljö (1979). Systematic cultural differences may have been one of the causes of inequalities in academic achievement, according to Wong and Wen (2001). Researching students' COL in Mauritius will help us better understand learning approaches and outcomes.

Chinese students have been the focus of most of these studies. In a sequence of cross-cultural studies, Wong and Wen (2001) compared the link between COL and educational accomplishments between students from China, Singapore, Hong Kong, Taiwan, Japan, and Korea. Expository teaching techniques are frequently used to instruct Confucian-Heritage Cultures (CHC) students in large courses which Western standards do not consider an effective learning environment (Chen et al., 2014). In mathematics and science, however, CHC students frequently surpass pupils from

Western countries. The phrase "paradox of the Chinese learner" has been used to characterize these discrepancies. (Cheng & Wan, 2016; Kember, 2016).

2.9.1 Paradox of the Chinese Learner

Competitive examinations and textbook learning are common among Chinese students (Biggs, 1991; Kember & Gow, 1991; Chen et al., 2014). Furthermore, academics including Samuelowicz (1987) and Ho (2020) argued that Chinese students use rote memorisation extensively which is considered to be less participatory and more passive in class compared to most of the students. As a result of their dependence on surface AL, Chinese students are assumed to perform poorly in academic contexts (Watkins, 2000). Their academic achievement, however, is quite strong, with deep and strategic inventory scores that exceed that of pupils in Western countries (Kim, 2020; Li & Liu, 2022; Liu et al., 2020). If memorisation as a form of learning is so closely associated with surface AL, and if surface AL results in poorer learning, then why do Chinese students, who spend a lot of time in activities that seem to be solely aimed at memorizing, perform so well compared to their Western counterparts in mathematics and the sciences? (Gao, 2020; Guo & Leung, 2021).

This paradox prompted a number of investigations into Chinese students' COL and AL (Kember, 2016). Qualitative and quantitative research investigated how Chinese pupils mix memorising and understanding attempted to describe this combination as "deep memorising," in which memorisation is utilised as a deep method that becomes part of a deeper approach (Au & Entwistle, 1999; Dart et al., 2000). According to Marton et al. (1997), the argument for this is that knowing anything includes remembering, just like (meaningful) memory requires comprehension. Chinese pupils see the combining of profound memorising and understanding as natural. As a result, memorisation is considered as a supplement rather than a replacement for comprehension (Heng, 2018).

Several researchers have identified various types of memorisations (Biggs, 1993; Entwistle & Entwistle, 2003). Au and Entwistle (1999) established the relationships between rote memorization, memorization with comprehension, and understanding without memorization, as well as surface approaches. First, students memorized as much knowledge as they could through rote memorization without considering its meaning (Au & Entwistle. 1999). This is associated with quantitative COL and surface AL since it denotes the learners' replication of material even though they do not understand its meaning. Second, they practiced memorisation with understanding which is similar to deep memorising (Dart et al., 2000). Memorising and comprehending were considered mutually fortifying. Here, memorising helped them to better grasp the learning content, and understanding helped them to memorise more effectively (Au & Entwistle, 1999). Students in the third AL stated that they could grasp learning materials without first memorising it verbatim, that is, understanding without memorising.

2.10 Conceptions of Learning and Approaches to Learning in Specific Domains

Tsai (2004) proposed that COL are domain-specific and that examining these concepts in a given science domain helps improve knowledge of students' COLS, and that COL is related to AL. Based on this, Chiou et al. (2012) performed research in Taiwan on undergraduate students' COLB and ALB. They designed a survey for COLB which was a slightly modified version of the Lee et al.'s (2008) and Liang and Tsai (2010) COLS questionnaires. The final COLB questionnaire comprised six subscales namely, (1) memorising, (2) testing, (3) calculating and practicing, (4) increasing one's knowledge, (5) applying, and (6) understanding and seeing in a new way. The ALB questionnaire was based on Kember et al.'s (2004) framework for AL and Lee et al.'s (2008) ALS questionnaire, comprising two factors: deep and surface ALS, each containing the two subscales of motive and strategy. The final ALB questionnaire had four components: surface motive, surface strategy, deep motive, and deep strategy.

Their study's structural equation model supported their theory that students' ALB can predict their COLB and that there are relevant correlations between surface/deep ALB and lower-level/higher-level COLB and. In other words, their research found that lower-level COLB impacted surface ALB, whereas higher-level COLB encouraged deep COLB. They discovered that pupils with the two lower-level COLB, "testing" and "calculating and practicing," had a surface motive and used a surface strategy to study biology. Pupils that perceived biology as memorising had a tendency to learn biology via the surface approach. Those who possessed the two higher-level COLB, applying, "understanding, and seeing in a new way", tended to apply a deep motive and learned biology in a deep way. Their findings support prior research that found links between COL and AL (Edmunds & Richardson, 2009; Ferla et al., 2008; Lee et al., 2008). As a result, these data may be utilised to corroborate the links between students' higher-level and lower-level COLB, and deep and surface ALB.

Chiou et al. (2012) discovered, however, that some linkages contradicted the lower-level concepts compared to surface approach and higher-level conceptions compared to deep approach associations. For instance, lower-level COLB "calculating and practicing" had a substantial impact on deep motive, and students who held this conception tended to learn biology with a surface-level motivation and strategy. They argued that, despite the preference of students who see biology learning as practicing and calculation to involve in biology learning via surface approaches, this conception could influence both the surface and deep motivation to learning biology. Second, in the first higher-level COLB, increasing one's knowledge influenced just the surface motive and not the deep motive or the deep strategy.

Tsai (2004) and Lee et al. (2008) also came to the conclusion that having a dual perspective when learning science suggested a dual worldview. This conception may allude to knowledge acquisition and accumulation and may represent a reproductive and lower-level COLS. However, it might be understood as the finding of the unknown, therefore sharing the crux of constructive higher-level learning scientific notions. This dual perspective suggests that either the lower-level or higher-level conceptions of studying science do not entirely correlate to expanding one's knowledge (Lee et al., 2008). Lin and Tsai (2009) discovered comparable results in a study with college engineering students. Furthermore, Chiou et al. (2012) found that "applying" and "understanding and seeing in a new way" were the last two higher-level COLBs that had an impact on surface motivation. They concluded that these two COLB activate a twofold motive. They also believed that future study should focus on learning conceptions in more explicit domains such as chemistry, biology and physics in order to acquire a better insight into how pupils learn in different scientific fields.

Similarly, other researchers have also concluded that COL and AL may be domain specific and have extended their studies on COL and AL to other domains including statistics, science, accounting and management. Much attention has been given by researchers to studies concerning COL and AL in the science education field. Hence, research on COL and AL was carried out in subjects such as science (Bahcivan & Kapucu, 2014; Lee et al., 2013; Liang & Tsai, 2010; Lin et al., 2012; Park & Jeon, 2015), biology (Chiou et al., 2012; Sadi & Çevik, 2016; Sadi & Dağyar, 2015), chemistry (Li et al., 2013), physics (Chiou et al., 2013; Mahinay, 2014), computer science (Liang et al., 2015) and earth science (Shen et al., 2016).

Park and Jeon (2015) conducted a quantitative survey of 353 South Korean middle school students to determine the relationship between their COLS and ALS. For their investigation, they employed the COLS and ALS questionnaires produced by Lee et al. (2008). They linked the COLS constructs of calculating, memorising, testing and increasing one's knowledge to the quantitative conception. Their study revealed a positive correlation between the deep ALS and the qualitative COLS. They came to the conclusion that students who view science education as the process of using information to solve new challenges and comprehending the relationship between various scientific ideas are intrinsically motivated and employ positive methods to acquire scientific knowledge. They also discovered a favourable association between "deep approaches" and the qualitative COL of "memorizing" and "increasing knowledge." As a result, they came to the following that even quantitative notions can result in the adoption of positive techniques, depending on the study's goal and aim. Calculating, memorization, testing, and increasing knowledge are associated with the quantitative COL because they place emphasis on how much has been learned, whereas applying, comprehending, and developing new perspectives are connected to the qualitative COL because they place emphasis on how well students have learned. (Tsai, 2004).

Park and Jeon (2015) discovered that applying, comprehending, and perceiving in a new manner, all of which are qualitative concepts, have a relationship that is statistically significant with the deep motive and deep approaches, that is consistent with research previously done. Memorising and testing, which are considered as quantitative conceptions, displayed a positive correlation with surface approaches, as expected. Calculating, which was also considered as a quantitative COL, showed a positive correlation with the deep AL as well as the surface AL, that seemed to suggest that despite calculating being a quantitative activity, it entails deep thinking and logic. Interestingly, memorising, which is a quantitative COL showed a substantial positive association with the deep AL. Therefore, it suggests that increasing one’s knowledge, which is perceived as a quantitative COL, shows more of a positive relationship with the deep AL than with the surface AL. This implies that, unlike surface AL which is considered as an accumulation of knowledge through memorising and remembering, the AL of increasing one’s knowledge through remembering learned information can considered as a deep approach. This tendency was observed by Dart et al. (2001) who stated that remembering learned information could be connected to deep AL among Southeast Asian students. The positive correlation of the memorising, and increasing one's knowledge conceptions with the deep AL among Korean students observed by Park and Jeon (2015) was also surveyed by Dart et al. (2001) among Southeast Asian students. This may be due to the fact that, in general, Asian students are under a lot of pressure during examinations.

Liang et al. (2015) conducted a quantitative survey of 421 Taiwanese college students' conceptions of learning computer science (COLCS) and approaches to learning computer science (ALCS), as well as their relationships. By adding the factor "learning computer science as programming" and placing the items in the COLCS context, they modified Lee et al.'s (2008) COLS survey form to produce a COLCS survey. To investigate the students' learning approaches, they created the ALCS survey questionnaire, which was adapted from the ALS survey questionnaire established by Kember et al. (2008), by placing the items in the context of COLCS. They discovered that pupils with the memorising, calculating and practicing conceptions are inclined to utilise surface AL, which included both the "surface motive" and the "surface strategy." However, learners with the testing conception had a surface strategy but no surface motivation for COLCS. Students who agreed with programming, application, increasing one's knowledge, understanding and seeing concepts in a new way expressed surface motives, deep motives and deep strategies for COLCS. In summary, the study's findings divulged that students with lower-level COLS, such as memorising, testing, calculating, and practicing, indicated surface motives and surface AL for COLCS. Higher-level COLCS, such as increasing one's knowledge, application, and understanding, seeing things in a new way, and the new factor "programming," were associated with the surface motivation, deep motive, and deep AL. Their findings complemented Lee et al.'s (2008) that students with higher-level (constructive) COLCS opted for deep AL, as opposed to those with lower-level COLCS who were inclined to use surface AL.

Shen et al. (2016) conducted a quantitative survey of 268 Taiwanese undergraduate students to investigate their COL, AL, and capability to learn earth science (COLES). They updated Lee et al.'s (2008) COLS and ALS questionnaires to focus on earth science-related material for their study. The Structural Equation Modeling (SEM) technique was used to investigate structural links between these concepts. They found that while students' deep strategies had a favourable link with the idea of knowing and seeing in a new way for COLES, the concept of "testing" had a negative relationship. Lower-level COLES (calculating, testing, memorising and practicing) were also found to have good structural correlations with surface strategies. The surface ALES was a strong predictor of COLS of “testing.” Additionally, the COLES of “calculating”, “practicing” and “applying” were discovered to be strong positive predictors of the ALES mixed motivations pattern. These results also confirm prior findings in broad domain learning (Dart et al., 2000; Ferla et al., 2008), specific domain science learning (Lee et al., 2008), and physics, chemistry and biology specialised science courses (Chiou et al., 2013, 2012; Lee et al., 2008; Li et al., 2013). Furthermore, testing provided a negative association with deep strategy and deep motive, but a positive relationship with surface strategy. This appears to be common in science teaching and some empirical investigations back this up (Chiou et al., 2013, 2012; Li et al., 2013). When compared to various studies on COL and AL when studying disciplines of science, students favour a mixed learning motive. Students who perceive learning COLB as "calculating and practicing," "applying," and "understanding and seeing in a different way” are more likely to have mixed motives, while students who perceive learning chemistry as memorization and transformation also have mixed motives, according to Chiou et al. (2012). The transformational conception in their research refers to higher-level concepts like gaining more knowledge, applying it, and comprehending, as well as having new perspectives. Likewise, Chiou et al. (2013) found that students who view studying physics as applying, comprehending, and seeing in new ways have conflicting motivations. According to prior research and the findings of Shen et al. (2016), students may have mixed motivations for studying the subject, even if they have mature COL such as applying.

Li et al. (2013) carried out a quantitative survey of 369 Taiwanese college chemistry majors to explore the relationship between conceptions of learning chemistry (COLC) and approaches to learning chemistry (ALC). The researchers in this study constructed two questionnaires to evaluate students' COLC and ALC, which were modified from the questionnaires employed by Lee et al. (2008) and Liang and Tsai (2010) for COLS and ALS, respectively. The COLC and ALC questionnaire components, which were broken down into four categories: memorization, testing, calculation, and practice, as well as one mixed factor for higher-level COL, were evaluated using exploratory component analysis by Li et al. (2013). Because the higher-level COLC were interconnected, "transforming" emerged as a single element.

2.11 Gaps in the Literature

Researchers have studied students' COL and AL in a variety of subject domains, including science (Lee et al., 2013; Liang & Tsai, 2010; Lin et al., 2012; Park & Jeon, 2015; Tsai, 2004;), biology (Chiou et al., 2012), chemistry (Li et al., 2013), physics (Chiou et al., 2013), computer science (Liang et al., 2015), earth science (Shen et al., 2016). They have also studied students' COL and AL in many educational contexts including Western countries such as Australia, Belgium, Germany, Portugal, Sweden, United Kingdom, Uruguay, United States, and Eastern or Asian countries including Taiwan, Hong Kong, China, Singapore, Japan, Korea and Nepal. According to earlier research, pupils with lower levels of COL tended to use surface AL while those with higher levels of COL tended to use deep AL. According to Chiou et al. (2013), lower-level COL, like "testing," are more likely to be associated with students' surface AL whereas higher-level COL, such "seeing things in a new way," have a better probability of positively correlating with students' deep AL to physics. However, it would negatively correlate with their deep AL.

Despite this, previous research, has highlighted significant inconsistencies. Li et al. (2013) discovered that learning chemistry by memorising, a component of students' lower-level COL, could predict a deep motive in learning, whereas learning chemistry by transforming, a component of higher-level COL, could predict surface motives in learning chemistry. Inconsistencies like these, according to researchers, are generated by differing contexts and subject areas (Shen et al., 2016). Therefore, because students exhibit different behaviour in different learning domains and educational contexts (Kember et al., 2004), the link between students' COL and AL may likewise alter across subject domains.

Furthermore, according to Sadi and Lee (2015), relationships between COL and AL may differ from country to country given that different countries have different learning cultures. Earlier, Lee et al. (2008) had also emphasised the need to study students' COL and AL across various countries and cultures. As the small island of Mauritius is geographically cut off from the continental mainland, it is characterised by a unique learning culture which is largely uncorrupted by intrusions from other African countries and beyond. Consequently, the unique educational context and cultural background of Mauritian secondary school students offer a distinct opportunity to explore students' COLB and ALB. To date, there has been no empirical study in Mauritius that has focused on students' COLB and ALB and their relationships.

Most of the research that has been conducted on COL and AL is quantitative. Given that it is possible to use quantitative research to examine the relationships in large representative populations and samples, investigating qualitatively the relationships between students' COLB and ALB could further our understanding of students' COLB, thus, inform us on how to enhance current instructional strategies.

2.12 Synthesis

In this chapter, I reviewed the literature on COL and AL. The literature reviewed revealed that COL and AL are domain-specific and are influenced by culture. The literature reviewed also revealed that students' COL may influence their AL. The theoretical framework is discussed in the next chapter with the goal of highlighting recurrent theoretical ideas connected to the phenomenon of the study, namely students' COL and AL. Also provided is a temporary theoretical lens to direct the methodological procedure.

CHAPTER 3

THEORETICAL FRAMEWORK

3.1 Introduction

In the previous chapter, I reviewed empirical literature on conceptions of learning (COL) and approaches to learning (AL). The literature reviewed provided me with information on the theories that are crucial to the research and helped to establish what theories are important to understanding the research problem. This chapter was the philosophical framework that influenced the study. The theoretical frameworks underpinning this study were based on COL and AL which were in line with the context of this study. Numerous investigations on COL and AL have been conducted worldwide. Therefore, it is expected that several theoretical frameworks have been developed to understand and explain students' COL and AL in different educational contexts and cultures. It is also logical to assume that some of these theoretical frameworks have evolved over several repeated uses. However, the theoretical perspectives and lens that informed my study were the theoretical frameworks developed with the help of Lee et al. (2008) in COL and Kember et al. (2004) in AL.

In this chapter, I give an account of the development of the COL framework followed by the selection of the theoretical lens for COL that guided this study. I then describe how the AL framework developed followed by the theoretical lens selected to guide this study. Next, I discuss the hypotheses that were proposed for this study, based on previous studies and the conceptual framework that informed this study.

3.2 Development of the Conceptions of Learning Framework

A person's perception or belief about learning is referred to as their conception of learning. (Chiou et al., 2012). It is a construct of the individual based on their lived learning experiences (Entwistle & Peterson, 2004).

The literature divulged that Säljö (1979) led the first known study concerning COL in Sweden. Dahlgren and Marton (1978) originally distinguished between two types of COL. The first one views learning as a passive process that entails the transmission of unrelated pieces of knowledge, whereas the second embraces an active perspective of learning that entails a person changing how they perceive the world (personal transformation). Säljö (1979) classified five qualitatively distinct COL after interviewing 90 people from 15 to 73 on their experiences of learning and COL. He asserted that a gain in knowledge, memorization, the acquisition of facts, procedures that can be remembered and/or utilized in practice, the abstracting meaning, and an interpretative process designed to grasp reality were all part of the common understanding of learning. The first conception refers to learning whereby students concentrate on accumulating what they had learned, the second conception refers to rote learning, the third one refers to the facts and procedures acquired by students during learning, the fourth conception refers to students' understanding of what something means, and the fifth conception describes students' ability to apply this knowledge in real life. The first two conceptions are reproductive, repeating knowledge by utilising memorisation, while the last two conceptions are reconstructive, a thematic type of study that places knowledge in context, which is a deeper approach to acquiring knowledge. The next conception represents a shift from "reproductive to reconstructive" COL. The first three conceptions show a superficial understanding of learning, whereas the latter two show a thorough comprehension. Tsai (2017) claimed that although the categories of conceptualization of learning are hierarchical, they are never stable. It implies that students' COL would gradually advance from simpler to more complex levels as they progressed from elementary schools to colleges. Therefore, it can be concluded that COL is developmental.

Other researchers have confirmed Säljö's (1979) findings on COL (Chiou et al., 2012; van Rossum & Schenk, 1984) since the original article. Thus, Säljö's (1979) five qualitatively distinct COL can be seen as providing a strong foundation (see Table 3.1). The first three COL offer a cursory grasp of learning, whereas the last two conceptions offer a thorough comprehension of it.

Following Säljö's study, research has been carried out to explore the COL of students in diverse educational contexts. Subsequent studies have used these five COL as a foundation to devise new sets of COL, after certain modifications. Other researchers, such as Eklund-Myrskog (1998), Dahlin and Regmi (1997) and Marton et al. (1993) have found parallel groups of five categories of Säljö's COL. Van Rossum and Schenk (1984), who introduced a sixth COL characterized as an intentional process, driven by human interests and focused on achieving harmony and happiness or changing society, supported Säljö's five COL. In their longitudinal phenomenographic inquiry, they provided more information about Säljö's (1979) five conceptions, accurately differentiating and thoroughly integrating the five conceptions already in place, as well as creating a new category.

In contrast to other studies, Marton and his colleagues describe the various theories of learning in greater detail and show connections between them. They showed that what is learned and how it is learned are inseparable aspects of learning. According to them, students' experiences of COL varied. They characterised the COL in a more precise way than in past studies, and recognised associations between them. They claimed that "changing as a person," which is related to "learning as understanding" and "learning as perceiving something in a different manner," is the sixth COL and is, "hierarchically," the most advanced conception. They were able to recognize the hierarchical relationships that exist between each conception of learning. In a hierarchical structure, the subsequent conception includes the earlier ones (Duarte, 2007).

As a result, Marton et al. (1993) categorised learning conceptions into six levels: (1) increasing one's knowledge, (2) memorisation and reproduction, (3) applying, (4) understanding, (5) viewing something from a new perspective, and (6) developing as a person. All subsequent COL are derived from the first COL, "increasing one's knowledge," which is to acquiring and storing knowledge. Remembering is the reproduction of memorised information, and it is also the ability to reproduce something that has been learned. Applying is closely related to an increase in knowledge. It is the ability of the student to apply knowledge in practice, where necessary (Duarte, 2007). In understanding, the learners play a major role in giving meaning to and in forming personal views on the material to be learnt (Duarte, 2007).

In the opinion of Smith et al. (2021), comprehending something requires memory. Seeing something in a different way depends on whether something has previously been considered in a certain way and there is a change to perceive it another way. The last COL, personal transformation, shows that learning has a more personal character and that it is an integral part of the person's life, that is, a learner changes as a person when he or she develops a different way of the world (Duarte, 2007).

These six categories, according to Marton et al. (1993), could capture how the majority of individuals view learning. They believed that there was a developmental and hierarchical pattern in the six kinds of COL. Furthermore, they maintained that a student's COL may start out in the first category before shifting to the sixth category. They discovered that any prior category may fall under the latter subsequent category. They contended that the six concepts of learning categories can be grouped into two categories. Learning is viewed as a passive accumulation of external fragmentary information in the first three categories (knowledge expansion, memorisation and reproduction and application). Learning is viewed as actively converting outside information into relevant, comprehensive and practical knowledge in the last three categories (comprehension, seeing something differently, and personal transformation).

Likewise, the first three COL were categorised as quantitative conceptions, whereas the latter three were categorised as qualitative conceptions. While qualitative conceptions place focus on comprehending and seeking meaning in what is taught, quantitative conceptions pertain to the act of gathering information or content. These two types of COL were categorised as low-level and high-level perspectives, respectively, by Dart et al. (2000) and Tsai (2004), and as reproducing and transforming by Brownlee et al. (2003).

Marton et al. (1993) classified the last three conceptions as cohesive conceptions whereby there is an enhanced understanding of dependency and connectedness of the student learning and learning environment and the first three as disjointed conceptions with no or little understanding of the association between the learning environment and student learning (Yang & Tsai, 2017). Marton et al. (1993) maintain that the first three COL correspond with the surface AL and 4 to 6 with the deep learning approach. They believed that the deep learning approach-compatible learning conceptions help students achieve higher learning results. Cohesive COL may result in superior learning outcomes, according to empirical data that links COL to how learning activities develop (Ellis et al., 2006; Tsai & Tsai, 2014).

Purdie et al. (1996) established nine categories of COL based on their study of secondary school learners in Japan and Australia. Their research aimed to recognise, define and evaluate participants' self-controlled learning processes and learning beliefs. They discovered that Japanese pupils had a significantly broader perspective on learning than Australian students. Learning is a lifetime process for them that provides individual fulfilment, as opposed to Australian schoolchildren who associate learning with something that occurs at school.

Despite their conceptual variances, similar techniques were employed by both groups, where the conception of “learning as understanding” was associated with a higher overall number of approaches used. The first six conceptions of Purdie et al. (1996) can be related to former investigations such as Marton et al. (1993) (see Table 2.1). Purdie et al.'s (1996) findings for their first conception, “learning as increasing one's knowledge,” agrees with Marton et al.’s (1993) metaphor of consumption. Because their participants frequently associated studying with memorising and reproducing, Purdie et al. (1996) included “studying” in their second conception. Their third conception, in line with earlier studies, referred to applying knowledge. Learning as understanding by Marton et al. (1993) referred to obtaining meaning. Purdie et al.'s (1996) learners hardly mentioned “having a fuller view”, therefore Marton et al.’s visual metaphor is not as applicable here. Perhaps the emphasis for comprehension was tied to the classroom experience because their participants were in school.

Although much research emphasises the distinction between memorisation and comprehension, Purdie et al. (1996) discovered that participants in their study considered learning to be a combination of both these processes. The concept of expansion overwhelmed descriptions, led to the fifth COL as "seeing something in a new way." Personal fulfilment corresponds to the concept of Marton et al.'s (1993) “changing as a person” which leads to “personal growth, maturity and improvement.” Purdie & Hattie (2002) was the first who documented learning as a duty. It was only mentioned by one Australian learner and 14 Japanese youngsters (7.22%), however it was thought to be culturally significant to be included in their classifications. Learning as a process that is not constrained by time or circumstance alludes to learning throughout one’s life, which is a progressive and ongoing activity. Even though this concept is similar to Tynjala's (1997) “learning as a developmental process,” it has been generally overlooked in earlier learning studies. It is remarkable, in view of the Australian OECD, in 1996 Education Ministers proclaimed the policy of “Lifelong Learning for All” as a priority (OECD, 2008), and Adult Learning Australia has been promoting learning throughout your life for almost 50 years. “Developing social competence” was a Japanese-only category that had similarities with Tynjala's sixth category, “learning as an interactive process.” Relationships, social responsibility and interpersonal skills are the focus of this category.

Purdie and Hattie (2002) established a COL registry based on these nine categories. One of the main goals of their research was to go beyond identifying the many kinds of learning ideas to empirically assess their dimensionality. They found no significant differences across students' COL, contrary to earlier studies. They discovered that using structural equation modeling (SEM), the model that best suited the data from their sample was one with six universal ideas (see Table 3.1). It combines conceptions three, four and five from prior studies to form a single category. “Remembering” and “using information” have been identified as overall surface conceptions in a number of studies, whilst “understanding” has been recognised as a deep COL. Purdie and Hattie (2002) contend that it verifies Confucian heritage culture research (Marton et al., 1993; Watkins & Dahlin, 1997), which focus on the importance of memorisation to develop meaning and subsequent comprehension, as opposed Western COL that separate memorisation and comprehension. Purdie and Hattie (2002) discovered that it also holds true in Australian classrooms.

Tynjala (1997) classified seven types of COL using a phenomenographic methodology. “A certain kind of hierarchy may be seen in the categories... but the hierarchical nature of the categories should not be taken strictly," stated Tynjala (1997, p. 284), who did not accept the generally recognised hierarchical structure of the classifications. This means that is not possible to tell if approaching learning from a processing or information perspective is on a lower or higher level than expressing learning in terms of approaches or styles (Tynjala, 1997). Her study, however, differed from those previously addressed in this section in that the categories were connected to the students' descriptions of the learning process rather than definitions of learning, making it impossible to map categories directly (see Table 3.1).

Students' learning and teaching conceptions (LTC) was more recently presented in a six-stage model by van Rossum and Hamer (2010). In previous articles, Dutch students were requested to write brief compositions about their COL using a traditional phenomenography methodology. They added another learning concept to the five identified by Säljö (1979), named “self-realisation”, based on their findings (van Rossum et al., 1984; Van Rossum and Schenk (1984). No gender disparities were found in their experiments, but that COL changed with age, and self-realisation was not common between the ages 18 to 25 years old, which was the prevalent age group of students in higher education (van Rossum & Hamer, 2010).

Van Rossum and Hamer (2010) aimed to employ Saljo’s (1979) model to create a curriculum that increased student-centredness. The researchers investigated students' perceptions of successful learning, culminating in a six-stage model of students' LTC. They discovered some epistemological progress as a consequence of the new curriculum used in the study. This model gathered the accounts of students studying for a hotel administration degree in a traditional teacher-centred program compared with the innovative student-centred one. Most students, however, have recently switched from one reproductive conception to another.

Table 3.1 depicts that there is a lot of overlap among the important research looking at students' COL.

Table 3.1

Conceptions of learning (adapted from Thomson, 2017)

Säljö (1979)	Marton et al. (1993)	Purdie et al. (1996)	Tynjala (1997)	Purdie & Hattie (2002)	van Rossum & Hamer (2010)
An increase in knowledge	Increasing one's knowledge	Increasing knowledge	Learning as an externally determined event/process	Gaining information	Increasing knowledge
Memorizing	Memorizing and reproducing	Memorizing, reproducing and studying	Learning as a developmental process		Memorizing
Acquisition of facts, procedures etc. which could be retained and/or utilized in practice	Applying	A means to an end	Learning as student activity	Remembering, using and understanding information	Reproduction understanding/ application or Application foreseen
Abstraction of meaning	Understanding	Understanding	Learning as strategies/ styles/approaches		Understanding subject matter
An interpretative process aimed at	Seeing something in a different way	Seeing something in a different way	Learning as an externally determined event/process	Personal change	Widening horizons

According to Tsai (2004), COL are arranged in a hierarchy, with the three lower-level COL first which include (1) memorisation, (2) test/exam preparation and (3) calculating and practicing. This is followed by higher-level COL of (4) knowledge expansion, (5) application, (6) comprehending and (7) seeing things in new ways. He gave recommendations derived from these categories for how to help pupils to acquire "higher-level learning conceptions."

Based on Säljö's (1979) pioneering work, more than three decades of research have produced the generally accepted notion that there is a hierarchy of COL that evolve as students progress throughout the education system. The prevalent COL point to an interpretative/constructivist understanding of learning compared to an emphasises on the acquisition and replication of knowledge. Researchers and educators often believe that pupils with higher-level COL are better learners and experience better academic performance than those with lower-level COL. It is worth noting, however, that Sadi et al. (2018) argued that the meaning of the concept of learning was highly ambiguous and not susceptible to any analytically satisfactory definition.

Despite this conclusion, the primary research looking at students' learning conceptions have a lot in common. Although it is widely known that COL are hierarchical, inconsistent levels of support are provided by the literature. Few studies have looked at the development of COL across time, and less have looked at the COL of experienced learners. It is evident that the manner in which students perceive and experience learning affects how they approach learning even though the debate over the relationship between students' AL and COL has not yet been resolved. This study filled this gap by investigating the COL of Mauritian students and the relationship between those beliefs and students' learning practices. This helps to advance our understanding of COL and AL.

3.3 The Theoretical Lens for Conceptions of Learning Biology

To investigate students' conceptions of learning biology (COLB), the theoretical framework proposed by Tsai (2004) and developed by Lee et al. (2008) was adopted for this study because it was specifically designed to examine COL in the domain of science. Also, it is a well-established theoretical framework in the science domain and has been used by many researchers to determine participants' conceptions of learning science (Li et al., 2018; Park & Jeon, 2015; Sadi & Lee, 2015**).** Furthermore, other researchers have adapted Lee et al.'s (2008) framework to specific science domains such as chemistry (Li et al., 2013), physics (Chiou et al., 2013; Mahinay, 2014), and biology (Sadi & Çevik, 2016; Chiou et al., 2012; Sadi & Dağyar, 2015). It has been consistently confirmed that students' perceptions of learning follow this theoretical framework.

Various studies (Chiou et al., 2012; Liang & Tsai, 2010; Liang & Tsai, 2013; Tsai, 2004; Tsai et al., 2011) have revealed that COL could be classified hierarchically from lower order to higher order. These investigations also extend the notion that the first three COL, namely memorising, testing, calculating and practicing, are lower-level COL, whereas the last three, namely knowledge expansion, applying, comprehending and seeing in a new light, are higher-level COL. The lower-level conceptions represent the passive rote way of learning which aim to replicate the content, while the higher-level conceptions represent meaningful, active learning that includes actual comprehension. Even though various researchers favour different terms for these dichotomised groups of COL, such as higher-level/lower-level, passive/active, quantitative/qualitative, fragmented/cohesive (Marton et al., 1993), and transforming/reproducing (Brownlee et al., 2003), their core seem similar.

However, a recent study by Bonsaksen and Thorrisen (2017) concluded that the six items might preferably be used as a unidimensional scale with all the six items reflecting different aspects of one higher-order concept of learning, instead of considering them to be two different as considered originally. This study will refer to the two categories of COL using the words low-level and high-level views to prevent confusion with the terms used in AL.

3.4 Development of The Approaches to Learning Framework

An "approach to learning" (AL) describes how academic material is learned (Zakariya et al., 2021). The surface and deep approaches are two approaches that classify experiencing and managing learning circumstances, according to educational researchers such as Duarte (2007), Trigwell et al. (1999), Chin and Brown (2000) and Cano (2005). Chin and Brown (2000) claimed that deep approaches are related to inherent motivation and content interest and focus on comprehending the significance of the learning content and connecting conceptions to real-world experiences. As opposed to deep approaches, surface approaches apply to learning based on instrumental or external motivation, perceiving the task as a requirement, whereby students use rote learning to memorise content, replicate terms and reproduce it.

Marton and Säljö (1976) introduced the idea that students could adopt two different approaches to learning either the learning approach emphasising understanding (deep approach) or the learning approach which emphasises reproducing (surface approach). Four groups of academics and researchers have significantly contributed to developing the original model devised by Marton and Säljö (1976) for surface and deep AL; a Richmond group headed by Pask, a Lancaster group led by Entwistle, a Swedish group directed by Marton, an Australian group headed by Biggs (Beattie et al., 1997). This field of study has been studied for more than thirty years. Its ideas and definitions have been proposed and developed over time. In addition, as the AL framework evolved, a "strategic or achieving" approach emerged.

Deep approaches are defined by learning procedures that are centred on meaning and geared toward understanding by critically linking new concepts to prior knowledge and experience (Ramsden, 1983). While a student pursuing deep approach may recall an idea as a result of their efforts, "this is viewed as an almost unintentional by-product" (Kember, 1996, p. 343). Furthermore, if the content is too tough, a student who learns with the aim of comprehending may not necessarily attain profound knowledge (Entwistle et al., 1979). For example, in order to prove or understand any mathematical theorem, one may need to memorise mathematical definitions. As a result, memorisation will serve as "a necessary precursor to understanding, and for other purposes, it is a way of reinforcing understanding" (Entwistle, 1997b, p. 216).

Surface approaches, however, emphasise on memorising without reflecting on the task or considering its consequences relative to other understanding (Trigwell & Prosser, 1991). For example, such approaches compromise mathematical achievement when what is learned by rote cannot be recalled or converted to be employed in problem-solving activities (Novak, 1978) due to its lack of mathematical meaning. If a student uses the surface AL mathematics and merely remembers bits of information in the short term, they can "memory dump" (Anderson et al., 1998) what they have learned, preventing the formation of solid foundations on which to build an understanding of new concepts. It is not always true, however, that a student who uses a surface AL may not get the same good grades as one who opts for a deep AL. As argued by Cuthbert (2005), a student with the deep approach but who is not very skilful may do worse than a student with a well-polished surface approach.

Additionally, Biggs (1978) and Ramsden (1979) developed a third strategy for learning, the achieving approach. “Students with an achieving approach to learning are driven by the need for achievement as a form of ego-enhancement” (Bowden et al., 2015, p. 275). These students usually work towards achieving high grades for practical individual gain (Biggs, 1979; Tickle, 2001). As students’ learning became guided by assessment and assessment criteria, an additional approach was introduced, the “strategic approach” (Galloway & Bretz, 2015) or the achieving approach (Biggs, 1987a). Other researchers, such as Biggs, 1993; Entwistle, 1991; Galloway and Bretz, 2015, have also recognised a further AL, the strategic approach, besides the deep and surface approaches. “Originally this approach referred to students’ ambition and organisation, but recently the strategic approach has lost the achievement element but rather concerns students’ everyday study practices” (Hailikari & Parpala, 2014, p. 814).

According to Beyaztas and Senemoglu (2015), “In achieving, the student is encouraged on winning, competition, and achieving outstanding success” (p. 195). The strategic or achieving approach refers to “organised studying” and it is considered more an approach to studying than an approach to learning (Entwistle & McCune, 2004; Entwistle & Peterson, 2004). Factor analyses typically link the deep approach to the achieving approach, but, depending on the topics and learning environments, it can also fall under surface AL (Biggs et al., 2001). Students who implement the strategic AL “may appear to use attributes of deep or surface processing in line with the demands of the context, and they focus on organised study, time management, and monitor effectiveness of one’s study” (Kirkgöz, 2013, p. 32). Learners who adopt the strategic AL seek to maximise academic performance through effective study organisation which includes analysing the structure and content of previous examinations to predict questions, and that these learners are motivated by the desire to succeed and will therefore use any strategy that they believe will make them score high grades (Kirkgöz, 2013). However, a previous study carried out by Entwistle et al. (2001) revealed that the strategic approach could be linked with either the deep or the surface AL. They also found that a learner who usually adopts a deep AL may use the strategies of the surface AL to meet the requirements of a specific activity such as a test or an examination. Furthermore, a study carried out by Case and Marshall (2009) revealed that the way in which students perceive the learning context greatly influences their use of a specific approach.

Though subsequent studies have been conducted by researchers on AL, no study has reproduced the strategic approach as a distinct approach to learning. Subsequent studies carried out by Biggs (1987a, 1987b) found that each AL comprises two elements: motive and strategy. According to him, students’ own dominant learning motive determines their implementation of a specific learning strategy, that is, a surface strategy is supported by a surface motive, while a deep strategy is supported by a deep motive. Entwistle and Tait (1990) confirmed this motive-strategy congruence within AL. In a qualitative study carried out with eleven second-year chemical engineering students, Case and Gunstone (2003) identified three AL; a conceptual approach in which the intention of students is to understand concepts, an algorithmic approach in which students' focus is on calculation methods, and an information-based approach in which the students' goal is to gather and remember information. They considered that the latter two approaches can be considered forms of surface approaches given that the fundamental intention does not involve understanding. Their study did not identify the strategic approach as a distinct approach. "This relates to the nature of the strategic approach, which involves the use of either deep or surface where appropriate" (p. 816). They suggested that all the students in their study "were to quite a large extent strategic, in that they were adopting approaches that they thought likely to bring them success in this course" (p. 816).

According to Ramsden (2003), there are significant differences between the deep and surface AL in several subject disciplines. According to him, the surface approach to learning mathematics (ALM) could mean repeatedly using an algorithm; in biology, however, it might mean matching certain species with their characteristics. He also believed that the varying ways that students approach learning in various subject disciplines may be related to how they conceptualise the requirements in various subject areas grounded in past experiences. Various scholars in science education have conducted studies on AL in certain subject disciplines, such as science, in response to Ramsden's (2003) hypothesis that the same student may employ diverse AL in different subjects (Lee et al., 2008; Liang & Tsai, 2010). Chiou et al. (2012) argued that it would be more relevant to examine students' AL in certain scientific fields given the differences in the natures of biology, chemistry, and physics. This study especially examined students' ALB based on this notion.

Kember et al. (2004) carried out a study with 841 students from 20 secondary schools in Hong Kong. For the purpose of their study, they produced an amended two-factor version of the Learning Process Questionnaire (LPQ), with deep and surface approach scales, adapted from Biggs et al.'s (2001) amended two-factor version of the Study Process Questionnaire (SPQ) designed for tertiary level students. Initially, the LPQ and SPQ each offered three AL scores: surface, deep, and achieving, along with their separate elements of motive and strategy scores. However, Kember et al.'s (2004) study discovered that the achieving-related scales' role was not as obvious when utilising the LPQ as those of the deep and surface scales. They agreed that "approaches to learning have a hierarchical dimensionality with motive and strategy elements" (p. 261). Consequently, they proposed a framework for AL consisting of two constituents: deep and surface AL, divided into two subscales, motive and strategy. Lee et al.'s (2008) findings substantiated that science learners' AL had two individual factors; deep strategy and surface strategy. Previous studies carried out by Wong et al. (1996), and Kember and Leung (1998) have shown that for both the LPQ and SPQ, a two-factor (deep, surface) solution is the most parsimonious.

Chiou and Liang (2012) assert that surface motivations and surface strategies encourage surface AL. Their research confirmed that students with surface learning methods are scared of failing, therefore they memorise lessons in order to succeed on tests. Additionally, they discovered that deep motivations lead to deep learning strategies and that learners who use a deep AL have a deep comprehension of the material being studied, blending their past knowledge with the information they are learning. They were of the opinion that a learner may use both the deep and surface AL at various times, even though the learner prefers one over the other in certain situations. "The surface approach is related to extrinsic motivation (such as fear of failure and passing an examination), and uses lower-level cognitive activities, for example, rote learning, to memorise the fragmentary bits of knowledge" (p. 170). Conversely, "the deep approach is associated with intrinsic motivation (such as inner interest and self-satisfaction), and aims to pursue a thorough understanding of the main ideas and principles involved in the learning material" (p. 171). They believed that whether or not students could derive meaning from the learning materials marked the main distinction between surface and deep learning approaches.

3.5 The Theoretical Lens for Approaches to Learning Biology

Many distinct methods of learning have been uncovered by researchers. Deep AL and the surface AL, however, are the two most common methods of learning that have been taken into account in earlier studies of education (Chin & Brown, 2000; Li et al., 2013). Consequently, the focus of this study is only on the deep and surface AL. To explore students' ALB, Kember et al.'s (2004) theoretical framework was adopted for this study because it is well established in the science domain and has been used by other researchers in science (Lee et al., 2008; Liang & Tsai, 2010; Lin et al., 2012; Park & Jeon, 2015), biology (Chiou et al., 2012), chemistry (Li et al., 2013), physics (Chiou et al., 2013; Mahinay, 2014), computer science (Liang et al., 2015), earth science

(Shen et al., 2016). Furthermore, Lee et al. (2008) identified the factor structure of the ALS (for science in general) by factor analysis as comprised of four components: surface motive, surface strategy, deep motive and deep strategy. According to Kember et al.'s (2004) framework, AL consists of two main scales; surface AL and deep AL, and each of these has two subscales, motive and strategy: (1) Surface motive, (2) Surface strategy, (3) Deep motive, and (4) Deep strategy.

Reid et al. (2007) point out that surface and deep approaches "are not mutually exclusive" (p. 754) and that learners might move between them because of contextual dependence (Cassidy, 2004) and influence on students' learning approaches (Byrne et al., 2009). The AL of a student may vary depending on the subject. At the secondary school level, a learner could select a particular approach to learning science but a different one for history.

However, the "approaches to learning" framework has come under criticism (Haggis, 2003, 2009; Malcolm & Zukas, 2001; Webb, 1997) for two reasons. The first reason is if the concept of an AL could be measured and the second reason is what could and should be done with knowledge about a learner's AL. AL is a cliché in educational research with the widespread use of AL in research for higher education implying that conceptual slippage has been inevitable (Marshall & Case, 2005). This is problematic because a student cannot and must not be classified as a surface or deep learner (Lucas & Mladenovic, 2004).

3.6 The Relationship Between Students' Conceptions of Learning and Approaches to Learning

Dart et al. (2000) and Burnett et al. (2003) discovered that COL are related to AL. The study by Dart et al. (2000) also revealed that learners who favoured lower-level COL, such as memorising and recording, applied predominantly surface AL such as rote learning. However, those students with advanced, higher-level COL, for example, comprehending and perceiving things in a new way used predominantly deep AL, for example, applying knowledge to real life.

In Taiwan, Lee et al. (2008) researched high school learners' COLS and ALS. Their findings revealed that testing and calculating and practising affected surface ALS including their surface motives and surface strategies. Testing had a strong tendency to use the surface ALS (including both their surface motives and surface strategies), but not on the deep ALS (including both their deep motives and deep strategies). Calculating and practising affected both deep and surface learning motives, showing a mixed pattern. Memorising had statistically no effect on Taiwanese students' ALS. Learners who considered science learning as an "increase of knowledge" appeared to be unable to predict what ALS they applied, besides negatively predicting the surface strategy. Students who perceived learning science as "understanding and seeing in a new way" were inclined to use deep ALS. However, students who viewed learning science as "applying" were inclined to use a mixed motives (both deep and surface motives) ALS. Their study also revealed that learners who have an interpretive perspective of learning tend to apply deep ALS, whereas those who hold a reproductive view are likely to use surface ALS.

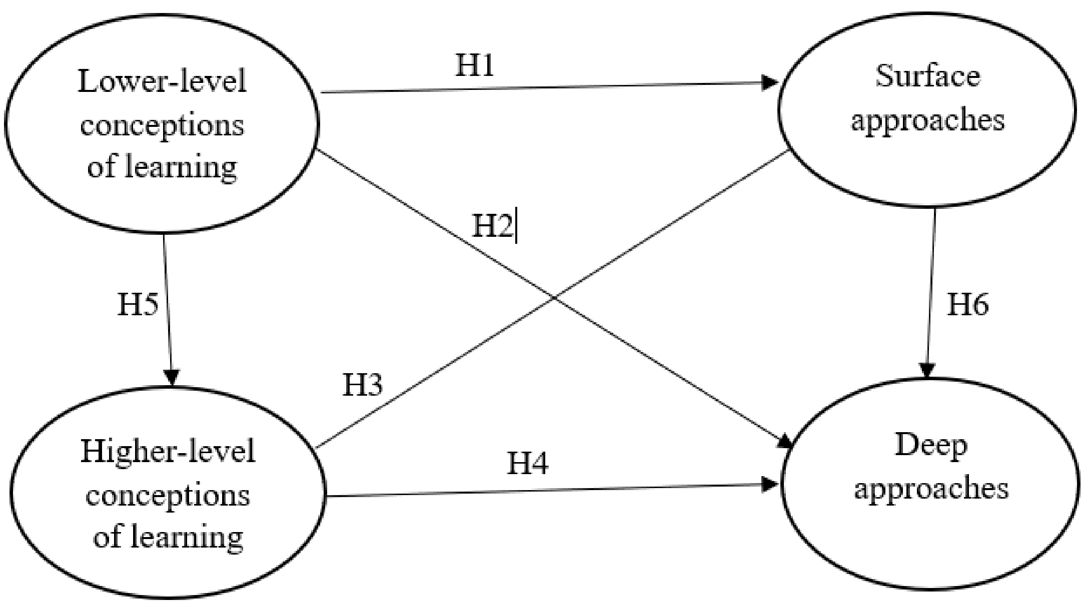
Lin and Tsai (2009) discovered that most of the participants they questioned used more than one category to represent their views on COL in a study with undergraduate engineering students. They believe that one category could function as the dominant concept for coordinating the others. Based on their findings, they concluded that there might be two components to COL; a developmental component and an experimental component. They also proposed that an individual may have several COL even if they have previously developed a more sophisticated view than the naïve one. Tsai (2004) also argued that most of the participants in his study used more than one conception when expressing their views about learning. Therefore, it can be claimed that sophisticated and naïve conceptions could either align with each other or be used simultaneously as mixed conceptions (Dahlin & Watkins, 2000; Tavacol & Dennick, 2010).

Chiou et al. (2012) investigated undergraduate students' COLB. They discovered that students who expressed lower-level COL had a tendency to adopt a surface AL, while those who had higher-level COL tended to use a deep AL. Li et al. (2013) analysed tertiary students' conceptions of learning chemistry (COLC) and approaches to learning chemistry (ALC). They found that the students possessed higher-level COLC and had a tendency to use deep ALC. Zheng et al. (2018) explored the interrelationships between COLS, ALS and self-efficacy. They discovered that students' lower-level COLS influenced their surface ALS in a beneficial way. They also discovered that higher COLS had a positive effect on deep ALS and a negative effect on surface ALS.

Some studies (Duarte, 2007; Edmunds & Richardson, 2009) surmise that there may be a causal relationship between learning ideas and techniques, even if this is still up for debate. This causal relationship seems promising given that people's understanding of how to do a task (COL) is somewhat dependent on how they perform that activity (AL). Past research and the research topics that guided this study anticipated that students' COL might influence their AL. Using biology as the learning discipline, the current research used structural equation modeling (SEM) to determine any potential causal relationships between COL and AL. Figure 3.1 illustrates the proposed theoretical model.

Table 3.2

Proposed Theoretical Model



In this study, pupils were categorised using conceptions of learning biology (COLB) and approaches to learning biology (ALB), and any correlations between the two were then examined. Based on the model, the following hypotheses were proposed:

Hypothesis 1: Surface ALB will be significantly and favourably influenced by the lower-level COLB held by upper secondary school students.

Hypothesis 2: Deep ALB will be significantly and favourably impacted by upper secondary students' lower-level COLB.

Hypothesis 3: Higher-level COLB held by upper secondary school students will have a considerable and negative impact on surface ALB.

Hypothesis 4: Higher-level COLB among upper secondary school students will have a considerable and favourable impact on deep ALB

Hypothesis 5: Lower-level COLB in upper secondary school students will have a substantial and positive effect on higher-level COLB.

Hypothesis 6: Surface ALB in upper secondary school students will have a substantial and negative impact on deep ALB.

3.7 Synthesis

This chapter was linked to Chapter 2 in which a review of the literature on COL and AL was presented. The fundamental theoretical components that supported this investigation into students' views on their COLB and ALB are outlined in this chapter. These theoretical constructs may enlighten us in our efforts to provide explanations for students' COL and AL. The gaps derived from the literature review and the theoretical framework were identified leading into the theoretical lens that guided this study. The following chapter presents an in-depth discussion of the methodological approach employed for this study as well as the data production strategies adopted and the analytical approach.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

In Chapter 3, I elaborated on the theories used to construct the theoretical framework that guided this research. This chapter discusses the steps that were taken during the study. In my study, *Exploring Mauritian Upper Secondary School Students' Conceptions of and Approaches to Learning Biology*, I attempted to answer these critical questions:

(a) What are Mauritian upper secondary school students' conceptions of learning biology?

(b) What are Mauritian upper secondary school students' approaches to learning biology?

(c) How do students' conceptions of learning influence their approaches to learning biology?

(d) Why do students have specific conceptions of learning biology?

(e) Why do students have specific approaches to learning biology?

(f) Why do students' conceptions of learning biology influence their approaches to learning biology, in the way/s that they do?

These questions were addressed by analysing and interpreting data from both the survey and the interviews. These research questions guided the study and created the foundation for the design of the data collection instruments. The methodological explorations of this chapter serve as a preparatory stage for obtaining information from the field relating to this study. This chapter outlines the methodological approach, steps and processes that this study employed to obtain data from the field. In this chapter, the questions of research methodology and method, the research design, data collection and the data analysis used in this study, are addressed.

4.2 The Research Paradigm

A paradigm is defined by Kivunja and Kuyini (2017) as a set of assumptions or beliefs about fundamental aspects of reality that give rise to a specific worldview. It attends to basic faith-based assumptions including convictions about the nature of truth (ontology), the affiliation between the knower and the known (epistemology), and methodological assumptions. What we think of the world is represented by paradigms. It includes our actions in the world such as inquiries. In educational research, a paradigm describes the researcher's "worldview" (Mackenzie & Knipe, 2006). A worldview is a fundamental of beliefs that guide action (Creswell, 2014). In terms of a study, it acts as a lens or set of principles by which truth is perceived. The researcher can also create interpretations of data and find meaning for what is happening by selecting an appropriate worldview without being judgmental of the participants. Researchers may use a variety of worldviews or paradigms to respond to research problems. Greene et al. (1989) suggested that it is not necessary to adopt a single research paradigm, especially when a mixed techniques approach (quantitative and qualitative) is required. Researchers such as Johnson and Onwuegbuzie (2004) added to the current discussion on mixed methods paradigms by claiming that in a mixed methods approach, the research question is more relevant to the study than the research design paradigm.

This study adopted a pragmatic paradigm based on the research questions (Creswell, 2014). Creswell and Plano Clark (2011, p. 46) asserted that "Pragmatism allows the researcher to adopt a pluralistic stance of gathering all types of data required to answer the research questions." In this study, I am trying to figure out how students learn biology. In other words, I am approaching the study with the goal of learning from students' experiences rather than passing judgment on them. I worked inside both the post-positivist and constructivist worldviews in order to acquire the most relevant data for my study. For example, I positioned myself as a post-positivist when creating the questionnaire since I was guided by the research on existing categories for student responses (Avramidis & Norwich, 2002; Deters, 2003; Grosser, 2007). A post-positivist researcher believes that through experiment and observation, they may come to a conclusion. By defining the hypothesis, the researcher puts the theory to the test. The data gathered can either support or reject the theory (Creswell, 2009). Later on, I was able to read the students' interviews via a constructivist lens in order to understand their views on how they learn biology. As a result, because the nature of the study required both qualitative and quantitative data, pragmatic paradigm, as described by Creswell (2009), was used for this research study to allow for a mixed methods approach.

According to Johnson and Onwuegbuzie (2004), pragmatism aids in shedding light on how research methods can be mixed to provide optimal opportunities for answering research questions. Pragmatism considers qualitative and quantitative methods to be compatible since their fundamental principles are similar enough to enable them to be combined in a single study. The reality, according to pragmatists, is "what works best" to understand a specific research issue. Furthermore, Johnson and Onwuegbuzie (2004) argue that "the present meaning of an expression is built on the experiences or practical outcomes of believing in or using the expression in the world". So, in this study, I adopted the pragmatic paradigm to explore and explain students' conceptions of learning (COL) and approaches to learning (AL) in Mauritian secondary schools.

Pragmatism is widely recognised as the methodological companion of the mixed methods approach. It offers a collection of assumptions about knowledge and inquiry that support mixed method approaches founded on post-positivist beliefs and strictly qualitative approaches founded on constructivist beliefs (Denscombe, 2008; Johnson & Onwuegbuzie 2004). Denscombe (2008) states that pragmatism allows for a fusion of methods, allowing for similarities and congruency among ancient research philosophies. Therefore, it offers a foundation for applying the mixed methods approach for social researchers who are of the opinion that neither sole quantitative nor qualitative research can offer sufficient insights for the specific research study they are working on. As a result, I chose the mixed methods approach because it provided an avenue to explain the quantitative data. The decision was also influenced by the study's research questions and objectives.

Kivunja and Kuyini (2017) assert that the pragmatic paradigm is a way of resolving philosophical disagreements that might otherwise go on indefinitely. In other words, when judging theories, it considers the scientific and practical implications. This means that the researcher uses pragmatism to build awareness about real-world problems. This emphasises the importance of seeking answers to research questions. It facilitates contextual analysis, utilising various approaches, and versatility in selecting only appropriate techniques for answering the research questions. Kivunja and Kuyini (2017) describe pragmatism as the strongest philosophical foundation for justifying the use of multiple approaches in a single analysis. Similarly, Bryman (2007) stated that most mixed methods researchers identify themselves as pragmatists. Mixed methods research, according to Johnson and Onwuegbuzie (2004), employs the pragmatic perspective, method, and philosophical system.

Induction (identification of patterns), deduction (testing of theories and hypotheses) and abduction (revealing and depending on the most appropriate of a collection of reasons for interpreting one's findings) are all part of the logic of inquiry of mixed methods. As a result, I adopted this paradigm because it works well when combining research methods. It allows for contextual interpretation as well as versatility in selecting the best techniques for addressing the research questions using a variety of methods (Bryman, 2007). A mixed methods approach with auxiliary methods may improve the credibility and validity of a study's findings (Clark, 2019).

A mixed methods study is one in which the researcher collects and analyses data, incorporates the results, and derives conclusions employing both quantitative and qualitative viewpoints and approaches (Clark, 2019). Mixed methods can represent the results quantitatively while also explaining the reason it was acquired (qualitative). To answer the study research questions, Kivunja and Kuyini (2017) added that the researcher collects both numeric and text material, such as survey instrument scores or ratings as well as open-ended interviews or observations. A mixed methods analysis, according to MacMillan and Schumacher (2014), incorporates characteristics of both quantitative and qualitative research approaches.

Researchers must complement one approach with another because today's research environment is increasingly interdisciplinary, complicated, and dynamic. To encourage cooperation, facilitate communication and provide superior analysis, researchers must have a comprehensive knowledge of various methods. The mixed methods research design, as stated by Onwuegbuzie and Jonson (2009), attempts to justify using more than one approach for answering research questions rather than limiting researchers' options, rejecting dogmatism. This method is a type of research that is both expansive and imaginative, rather than one that is restrictive. It is open-ended, pluralistic and complementary in nature. Therefore, when it comes to method selection and study design, researchers should be eclectic. Mixed research strategies have the best and most complete answers to many research questions and combinations of questions (Onwuegbuzie & Johnson, 2009). The essential philosophical assumptions (belief systems) of a research paradigm are ontology, epistemology, axiology and methodology (Kivunja, & Kuyini, 2017).

4.2.1 Ontology

Ontology is concerned with the assumptions to make sense of something or figure out if it is real (Scotland, 2012). It examines the researcher's underlying ideology concerning the nature of being and existence. Philosophical assumptions about the nature of reality are essential to understanding how meaning was made of the data gathered. These assumptions helped to orientate the researcher's view on the research problem, its importance and the manner in which the researcher might proceed to answer the research question, understand the problem investigated and contribute to its solution. Both singular and multiple versions of truth were considered relevant for this study (Vogl et al., 2019). The quantitative dimension satisfied the singular notions of truth and the qualitative dimension ensured that multiple COLB and ALB were explored.

4.2.2 Epistemology

Epistemology describes how we know the truth or reality, what counts as knowledge in the world and how it can be shared with people (Cooksey & McDonald, 2019). Epistemology emphasises the nature of human knowledge which I, as a researcher, can gain to enable me to expand and deepen comprehension in my field of study. From an epistemological standpoint, both objective and subjective truths concerning the phenomenon were generated through interactions with the participants (Williams, 2022).

4.2.3 Axiology

Axiology refers to the ethical issues to take into consideration when developing a research proposal. It considers what value the researcher attributes to the various facets of his/her research, the respondents, the data and the audience to whom the outcomes of the research are reported. Therefore, the researcher demonstrated best ethical conduct by showing what was right or wrong behaviour as the research was conducted. This consideration is based on the understanding that all people have a fundamental right to make choices which should be respected by the researcher. The axiological stance of the researcher was ethical during the quantitative data generation phase and aesthetical when generating qualitative data (Wahyuni, 2012). This implied that the quantitative data generation process involved administering questionnaires with minimum interaction with the participants, while the qualitative phase entailed social interactions through interviews.

4.2.4 Methodology

The fourth philosophical assumption is the methodology. It establishes the link between the focus and the methods of the study (Vogl et al., 2019). The first learning experiment (Marton 1976) used a qualitative approach to better understand how individuals approach their studies. Interviews and open-ended questions were used to gather qualitative data, which resulted in rich explanations of how people learn and experience their learning setting. However, these approaches necessitate extensive analysis and interpretation and do not permit for the generalisation of findings. To simplify the process of qualitative analysis and quantify the detection of COL and AL, inventories were established based on the categories defined in prior studies. A study by Dart et al. (2000) relied exclusively on a quantitative method including questionnaires to assess learning conceptions and learning approaches simultaneously. The limitation that respondents face when selecting from a collection of statements is a strong disadvantage when using inventories.

Furthermore, various considerations including instrument duration, deceptive item translation when employing an unfamiliar instrument, bad responses or ambiguity of items, failure to respond, participants' indifference and confusion over items, among others, could have been sources of error that led to biased or unreliable instrument completion. In addition, Richardson (2011) indicated that how participants complete surveys might indicate a connection between constructs. Differences in instrument scores measuring COL and AL may be due to learners' automatic inclination to agree with inventory items or select the extreme responses, which could mean that both constructs are related. Examining other forms of evidence obtained with research methods without the restrictions of inventories can circumvent instrument limitations and mitigate participant inclinations and, as a result, methodological shortcomings.

However, some studies (Monroy and González-Geraldo, 2017; Vedenpää and Lonka, 2014) have used a range of instruments and test designs, revealing differences in the outcomes of the same participants when a specific factor was evaluated both qualitatively and quantitatively. This method incorporates the distinctive benefits of the approaches to provide a more complete and clearer picture of a phenomenon.

4.3 The Research Approach

According to Johnson and Onwuegbuzie (2004), pragmatism allows researchers to use a variety of methods of research to answer their research objectives. As a result, based on the notion that the precise issues that led this study might be effectively answered by combining qualitative and quantitative data collection methods than either of them alone, quantitative and qualitative data were both collected to provide a more complete understanding of the research problem (Creswell, 2014; Shan, 2022; Vogl et al., 2019), I used a mixed methods approach for this study. I began the study with a broad quantitative survey in order to generalise results to a population and then, in a second phase, I laid emphasis on qualitative open-ended interviews to collect detailed views from participants to help explain the initial quantitative survey (Creswell, 2014). As a result, this study used a quantitative approach to determine secondary school students' conceptions of learning biology (COLB) and approaches to learning biology (ALB), followed by a qualitative approach to explain what informed their conceptions and why they adopted specific learning approaches. It was expected that new COL subscales would emerge during the quantitative data generation, which might enable the researcher to develop and propose a new theoretical framework.

4.4 The Research Design

There are a variety of permutations in mixed methods research. The most suitable methodology for addressing this study's research issues was an explanatory sequential mixed methods design (Howell Smith & Shanahan Bazis, 2021). Consequently, the results of the various methodologies could be corroborated, allowing for a more comprehensive understanding of the two datasets.

This study used quantitative then qualitative techniques sequentially for data collection. The timing of the two strands is also decided by researchers. The temporal relationship between the quantitative and qualitative strands within a study is referred to as timing (also known as pacing and implementation). Timing is often discussed in terms of when data sets are obtained, but it also relates to the order in which researchers use the findings from two sets of data, that is, timing encompasses the qualitative and quantitative aspects which is not limited to data collection (Howell Smith & Shanahan Bazis, 2021). This study adopted sequential timing whereby the qualitative and quantitative strands were implemented in two separate stages. Here the collection and analysis of one type of data occur after the collection and analysis of the other type. With sequential timing, a researcher can begin by collecting and analysing quantitative data or by collecting and analysing qualitative data. For this study, I started by collecting and analysing quantitative data first, then collected and analysed qualitative data. The first phase entailed administering a quantitative survey questionnaire to establish the students' COLB and ALB.

In the second phase, I conducted face-to-face individual interviews to collect detailed views from a selected subgroup of participants in order to explain the observed COLB and ALB. The rationale behind this was that the quantitative data along with the subsequent analysis would provide a general understanding of the phenomenon, while the qualitative data and their analysis would augment and explain any statistical results through the in-depth exploration of participants' views (Creswell, 2014; Shan, 2022). This means that the quantitative data was collected and analysed first which informed the design of the interview protocol. The second phase focused on qualitative data collection and analysis, which was viewed as complementary to the quantitative data.

Researchers usually make decisions about the importance of quantitative and qualitative strands relative to each other within the design. The relative value or weight of these approaches while seeking answers for the study's questions is referred to as a priority. This research followed a quantitative priority, with quantitative methods taking precedence and qualitative methods serving to explain the quantitative data.

Finally, researchers must choose how they can combine the two approaches in their mixed methods studies. The researcher uses mixing to explicitly link the qualitative and quantitative strands of the study in order to apply the interactive or independent relationship of the mixed methods analysis. Howell Smith and Shanahan Bazis (2021) refers to this as mixing and integrating. When it comes to establishing when and how mixing happens, there are two concepts to consider: mixing methods and the point of interface. The latter, also known as the integration stage, is where the quantitative and qualitative strands are combined (Huynh et al., 2019). According to Howell Smith and Shanahan Bazis (2021), interpretation, data analysis, data collection, and design are four potential points where mixing can occur during the research phase of a study.

Researchers use mixing strategies that are specifically related to these interface points. Creswell (2011) further argued that for mixed methods designs that maintain the independence of the two strands, mixing only takes place during the final interpretation step of the study process. As a result, for this study, mixing took place during interpretation, when the quantitative and qualitative data strands were merged after the researcher had acquired and examined both sets of data. It involved making judgments or inferences based on the combined findings from the two lines of inquiry. This was done by comparing or synthesising the findings in a discussion.

4.5 The Participants

Convenience sampling was used for this study with respect to the schools where the participants were drawn from. There are 69 state secondary schools (public schools), 79 private grant-aided secondary schools and 24 private non-grant-aided (fee-paying) secondary schools in Mauritius. State secondary schools and private grant-aided secondary schools were conveniently selected for the study because they were English medium schools that followed the national curriculum and they offered biology at the Cambridge School Certificate examinations. Private non-grant-aided (fee paying) secondary schools were excluded because some were French medium schools and others did not offer biology at SC level.

As Mauritius is a small island, all the schools were easily accessible to the researcher. Therefore, data were collected from 20 secondary schools from different regions of the island. The choice of schools took into account the different characteristics of English-medium Mauritian secondary schools. These included private and public, and single-sex and co-educational schools. Equal numbers of public and private grant-aided secondary schools were selected for the study.

The participants of this study were Grade 11 biology learners. The assumption was that the learners had completed about 50% of the biology School Certificate syllabus in Grade 10. Also, in Grade 11 most students choose the subjects they intend to study at Higher School Certificate level. The average Grade 11 biology class size in Mauritian secondary schools is 25 students; hence, 497 students from 20 schools participated in the study. The participants for the qualitative data generation were selected based on the results of the quantitative data analysis. Sixteen learners, that is, four learners from each of the four ALB subscales (deep motive, deep strategy, surface motive, surface strategy) of the quantitative survey, were selected to be interviewed.

The quantitative results informed the types of participants to be purposefully selected for the qualitative phase. Students who strongly agreed with all the items of a particular ALB subscale were pre-selected. The highest score of each ALB subscale was calculated by multiplying the number of its items by the score for strongly agree (5). Therefore, the highest score for students who strongly agreed with all the items of the deep motive would be 40 (8 items x 5), for deep strategy 30 (6 items x 5), for surface motive 30 (6 items x 5), and for surface strategy 35 (7 items x 5).

The SPSS software identified the student numbers on the data file with the highest score for each ALB subscale. The student numbers with the highest score for each ALB subscale were noted and their respective questionnaires were identified. For example, 14 students bearing numbers 21, 30, 31, 37, 43, 110, 129, 134, 159, 162, 354, 398, 441 and 445 obtained the highest score of 40 for the deep motive scale. The questionnaires of these students were identified. The identification numbers of the students were obtained from the questionnaires, for example, questionnaire 21 had student identification number B3. Then, the name of student 3 was identified from the list of students from school B. The schools and the names of the other students who obtained the highest score for the deep motive, deep strategy, surface motive and surface strategy scales were identified in the same manner. Four students from each subscale, among those identified, were chosen for the interview.

4.6 Ethical Issues

The questionnaires were distributed to the participants earmarked for the study and interviews were carried out with them only after having obtained permission from the Ministry of Education of Mauritius (see Appendix A) and ethical clearance from UKZN (see Appendix B). The participants' parents were requested to fill in a consent form (see Appendix C) before proceeding with the survey. It was clearly stated on the cover page of the questionnaire (see Appendix D) that taking part is voluntary and that the participant may leave the survey whenever they wish to. I also ensured that the identities of all participants would remain unknown and that any information given would remain confidential. It will be under lock and key or password protected to prevent access by unauthorised personnel.

Quantitative survey research is often conducted in a way that maintains the anonymity of the participants. However, for this study, I had to gather the information that can identify participants so that they may be contacted for a qualitative follow-up phase. This required that I justify the need for gathering and identifying information and put safeguards in place for protecting that information.

To maintain the anonymity of the schools, the twenty schools earmarked for the study were assigned identifying alphabets, A to T. The participants of school A were allocated identification numbers A1, A2, A3, etc., those of school B were identified as B1, B2, B3, and so on. The names of the students with their respective identification numbers were kept in the custody of the researcher. However, for data capturing purposes, the questionnaires were renumbered chronologically from 1 to 497. Therefore, each questionnaire had two identification numbers; one was the participant's identification number (A1, A2, A3, etc.), and the other one was its corresponding number (1, 2,3, etc.) on the SPSS data file. This allowed the researcher to easily identify any student who participated in the survey.

For the qualitative follow-up phase, the 16 participants were interviewed at random depending upon their availability, and each of them were given code names in a bid to maintain their anonymity. The first student interviewed, student 1, was given the code name S1; the second student interviewed, student 2, was given the code name S2, and so on.

4.7 Data Collection Methods

This study's quantitative data were collected through survey questionnaires disseminated to 497 participants. Qualitative data were gathered through face-to-face individual semi-structured interviews with 16 of the participants from the quantitative survey.

4.7.1 The Survey Questionnaires for Assessing Students' COLB and ALB

The questionnaire is a quantitative data generation instrument used to collect survey information (Williams, 2022). There are three types of questionnaires: structured, unstructured and semi-structured. I used a structured survey questionnaire for this study (see Appendix E) which comprised close-ended questions. Close-ended questions generate limited responses that can be coded easily in a database and are easier for respondents to answer. A survey questionnaire has the following advantages: it can be administered in the absence of the researcher, it is considered the cheapest among all surveys, it can be sent to a vast geographical area and can be conducted by a single researcher, data can be obtained from many participants within a short time and, the participants have the freedom to complete the questionnaire since they are safeguarded from the possible influence of the researcher. Another advantage of a questionnaire is that participants are more likely to give valid answers because of the aspect of anonymity.

To investigate students' COLB and ALB a two-part 5-point Likert scale survey questionnaire was used in this study, which comprised Section A: the COLB questionnaire, and Section B: the ALB questionnaire (see Appendix E). The two questionnaires were adapted from Lee et al.'s (2008) COLS and ALS. All items in the two questionnaires were modified to adapt it to the biology domain. The word "science" was replaced with "biology". Items under each subscale of the COLB and ALB questionnaires ranged from five to eight and coded in a five-point Likert scale. Items on the scale were anchored at 5 representing strongly agree, 4 representing agree, 3 representing no opinion, 2 representing disagree, and 1 representing strongly disagree. Therefore, higher scores in some categories reflected stronger agreement with the items in the categories regarding COLB and AL. Furthermore, all the questionnaire items were assessed and further amended by two secondary school biology teachers who provided expert validation for the survey.

4.7.1.1 The Conceptions of Learning Biology Questionnaire.

The COLB questionnaire for this study (see Appendix E) was adapted from Lee et al.'s (2008) COLS questionnaire based on Tsai's (2004) conceptual framework. Lee et al.'s (2008) COLS questionnaire comprised six factors, memorising, testing, calculate and practice, increase of knowledge, applying, and understanding and seeing in a new way.

The six subscales of the COLB questionnaire with tentative factor labels, and their respective sample items and item numbers are indicated below:

Memorising: Learning biology is conceptualised as a process of memorising. Learning biology is conceptualised as a process of memorising special terms, definitions and formulae, for example, "Learning biology means memorising the definitions, formulae and laws found in biology textbooks" (7 items).

Testing: Learning biology is to pass the examinations or to achieve high scores in biology tests, for example, "Learning biology means getting high scores on examinations" (7 items).

Calculating and practicing: Learning biology is viewed as a series of calculating, practicing tutorial problems, and manipulating formulae and numbers, for example, "I think that learning calculation or problem-solving will help me improve my performance in biology courses" (6 items).

Increasing one's knowledge: An increase of knowledge is seen as the primary purpose of learning biology, for example, "Learning biology means acquiring knowledge that I did not know before" (5 items).

Applying: The purpose of learning biology is to apply of this knowledge, for example, "Learning biology means learning how to apply knowledge and skills I already have to unknown problems" (6 items).

Understanding and seeing in a new way: A true understanding is perceived as major reason to learn biology, it is depicted in terms of gaining new insights, and acquiring biological knowledge means interpreting natural phenomena in a new way, for example, "Learning Biology means understanding biological knowledge; learning biology means understanding more natural phenomena and knowledge" (6 items).

4.7.1.2 The ALB Questionnaire.

The ALB questionnaire for this study (see Appendix E) was based on Kember et al.'s (2004) framework for AL and adapted from Lee et al.'s (2008) ALS questionnaire. Lee et al.'s (2008) ALS questionnaire consisted of four factors: deep motive, deep strategy, surface motive and surface strategy.

The four subscales of the ALB questionnaire with provisional factor labels, and their corresponding sample items and item numbers are indicated below:

1) *Deep motive:* Students display their intrinsic motivation when learning biology, for example, learning biology is motivated by their own interest or curiosity. An example

would be "I find that at times studying biology makes me feel really happy and satisfied" (8 items).

2) *Deep strategy:* Students utilise more meaningful strategies to learn biology, such as making connections and coherent understanding, for example, "I try to relate what I have learned in biology subjects to what I learn in other subjects" (6 items).

3) *Surface motive:* Students possess extrinsic motivation to learn biology, for example, learning biology for others' expectations or course grades. An example would be "I am discouraged by a poor mark on biology tests and worry about how I will do on the next text" (6 items).

4) *Surface strategy:* Students use more rote-like strategies (for instance remembering or narrowing targets) to learn biology, for example, "I see no point in learning biology materials that are not likely to be on the examinations" (7 items).

4.7.1.3 Instrument Reliability (Testing the Reliability of the COLB and ALB Questionnaires).

The COLB and ALB data were captured on SPSS 25 to verify how reliable the instrument was and to establish their descriptive statistical values. The internal consistency of the items for the COLB and ALB questionnaires was tested. Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are in a group. To measure the internal consistency of the COLB and ALB questionnaires, the Cronbach alpha value for each set of items was calculated; the reliability coefficient ranged between zero and one. In fact, the internal consistency of the items in each scale relies on how close the coefficient is to 1.0; the closer the alpha to 1.0, the higher is the internal consistency. These descriptions were created by George and Mallery (2019): $\alpha > 0.9$ – Excellent, $\alpha > 0.8$ – Good, $\alpha > 0.7$ – Acceptable, $\alpha > 0.6$ – Questionable, $\alpha > 0.5$ – Poor and $\alpha < 0.5$ – Unacceptable.

Apart from the coefficient on the Cronbach alpha, I also examined the inter-items correlation on the table for "scale if items deleted" to verify if items were sufficiently correlated to form the construct/scale.

Part A of the survey questionnaire contained items which measure variables related to learners' COLB. There were six constructs: memorising, testing, calculating and practicing, increasing one's knowledge, applying, and understanding and seeing in a new way. The reliability or Cronbach's alpha/coefficients for the COLB factors were 0.60, 0.61, 0.79, 0.73, 0.70 and 0.75, respectively. Cronbach alpha values of 0.70 or higher and inter-item correlations exceeding 0.3 (scale if items deleted) indicate internal consistency and reliability of scale. The Cronbach alpha for each conception exceeded the conventional level of 0.70 with the exception of memorising (α = 0.60) and testing (α = 0.61), which is still acceptable in the field of exploratory research (Cronbach, 1951; Williams, 2022). This means that there were adequate internal consistencies for all the scales of the COLB. Thus, these factors could be used to assess the learners' COLB.

Part B of the survey questionnaire contained items which measured variables related to learners' ALB. The four constructs were "deep motive, deep strategy, surface motive, and surface strategy". The reliability coefficients (Cronbach's alpha) for the ALB factors were 0.81, 0.72, 0.69 and 0.70, respectively. The Cronbach's alpha for each ALB was above the conventional level 0.70 except for surface motive (α = 0.69). Cronbach alpha values of 0.70 or higher and inter-item correlations exceeding 0.3 (scale if items deleted) indicate internal consistency and reliability of scale. However, the Cronbach alpha coefficient of 0.69 for surface motive was still acceptable because a Cronbach Alpha of 0.60 is acceptable for explanatory research (Cronbach, 1951; Williams, 2022). This means that the internal reliability coefficients of all the scales of the ALB were adequate, suggesting that these factors had highly sufficient reliability in assessing the students' ALB.

4.7.1.4 Piloting the Survey Questionnaire.

A pilot test was performed to assess the data generation instruments' reliability and validity indices, as well as the feasibility of administering the research instruments (Williams, 2022). According to Williams (2022), the pilot tested the validity and reliability of all research instruments; determined the logistic feasibility required to administer all research instruments and enhanced the research method. It obtains input on the study's design and methodology for administration; test the comprehensibility and clarity of the instruments' items and directions given to the respondents; and determine the estimated time for administering the research instruments. Piloting, according to Clark (2019), delivers feedback on the questionnaire's structure, its duration and how long it takes to complete it, as well as the consistency and clarity of the instruments' instructions and items respondents are provided.

A pilot study was conducted to establish any unanticipated issues with the questionnaire. Following the pilot study, the latter was refined in terms of structure, relevance, validity and reliability. The pretesting sample comprised ten Grade 11 biology students from one of the schools earmarked for the study. Only one school was chosen for the pilot study because it was more convenient for the researcher due to time and budgetary constraints. The ten respondents were asked the following questions about the instrument's usability, which were taken from Fink (2003): (a) Whether the instructions for answering the questionnaire were clear; (b) Which items/questions, if any, were unclear or disturbing; (c) Were they aware about how to choose their answers; (d) Were the options for answers mutually limited; (e) Were the response options complete; (f) Was their privacy respected and protected; and (g) Did they have any suggestions for adding or removing questions, clarifying directions, or improving the questionnaire layout. They were also asked to provide an estimate of how much time they would take to complete the survey. The following were the respondents' answers: (a) the instructions were clear; (b) there were no unclear or disturbing questions; (c) the method of indicating responses was understood; (d) the answer options were mutually exclusive; (e) the response options were complete; (f) they thought their privacy had been protected and respected; and (g) they had no responses to this question. They took about thirty minutes to complete the questionnaire.

For each of the listed statements in the questionnaire, the students were asked to tick (√) the one response from the 5-point Likert scale that best expresses the degree to which they agreed or disagreed with the statement. They all responded correctly to the questionnaire except for two of them who not only inserted a tick for each statement, but also inserted a tick beside the subtitles of the COLB and the subtitles of the ALB. Therefore, the questionnaire had to be amended by inserting the five responses of the Likert scale in the boxes besides the subtitles (see Appendix E) so that the participants do not tick the boxes besides the subtitles.

The reliability coefficient for each factor of the COLB questionnaire ranged between 0.84 to 0.91, and the overall Cronbach α was 0.91 and, for the ALB questionnaire, the reliability coefficient for each dimension ranged from 0.84 to 0.90, and the overall Cronbach value was 0.89. This means that the internal reliability coefficients of all the scales of the COLB and ALB were acceptable, suggesting that these factors had high reliability in evaluating the students' COLB and ALB, respectively.

When the pilot study was successfully completed, the modified questionnaires were disseminated to the 497 participants from the 20 schools earmarked for the study. The original survey from the pilot study was not included in the main study because subsequent modifications were made to the questionnaires.

4.7.1.5 The Questionnaire Administration Process.

I administered the questionnaires on-site with the help of the biology teachers of the schools concerned. Each participant was given a questionnaire with a preassigned identification number. The cover page of the questionnaire informed the student about the aim and objectives of the study and their right to withdraw. The students earmarked for the study were asked to read the cover page before responding to the questions. To maintain the anonymity of the participants, they were asked not to write their names on the questionnaire. The participants were asked to respond to the questionnaires voluntarily. They were requested to answer both sections A and B of the questionnaire in the same session. This process lasted approximately 30 minutes. The questions included in the two sections of the questionnaire and the use of structural equation modeling (SEM) to investigate the structural connection between students' COLB, and their ALB sought to answer this research study's questions.

4.7.1.6 Limitations of Questionnaire.

The questionnaire may produce limited results in a quantitative approach since respondents have limited answer options. Consequently, the outcomes may not always represent the actual situation. When researching a phenomenon, quantitative researchers appear to miss more information because they are outsiders (Mays & Pope, 1995). Since quantitative researchers depend heavily on procedures (Jogulu & Pansiri, 2011), many high-quality data are lost in the name of standardisation (Stenbacka, 2001).

The questionnaire was administered to 497 Grade 11 biology students. The questions could be interpreted in a variety of ways by the participants; however, this is covered by the high reliability coefficient from my pilot study. Furthermore, since the respondents volunteered for the study, there was no way of determining how honest they were with their answers. There was a chance they wouldn't be completely truthful when answering the questions. To reduce the risk, a letter describing the questionnaire and stating that it would be used for research purposes and that the respondents would be anonymous was included. It is also possible that the participants would think that the questionnaire was time-consuming, which would have resulted in just ticked boxes or even unanswered questions. A 5-point Likert scale was employed to reduce that risk.

4.7.2 The Face-To-Face Individual Semi-Structured Interviews

The qualitative method of data generation for this study involved interviews. Flick (2018) defines an interview as a purposeful conversation between a researcher and participant which aims at collecting data that will help to answer research questions. Interviews allow the researcher to read the participant’s mind (Jentoft & Olsen, 2019). In order to know how people have organised their world and what meaning is given to happens in their environment we have to ask them questions about it. A mixture of structured and open-ended questions was used in semi-structured interviews (Jentoft & Olsen, 2019). In this study, semi-structured interviews were used because structured interviews would not allow for enough flexibility and unstructured interviews would be too flexible. According to Willig (2013), semi-structured interviews combine features from formal and informal interviews focusing on personal experience, which can lead to unexpected results that may enhance findings. Another benefit of a semi-structured interview is that the interviewer maintains control over the method of extracting information from the interviewee while remaining free to pursue new leads as they emerge (Sarstedt et al., 2021).

Various approaches exist for gathering qualitative data, but for this study’s aims, face-to-face individual interviews were deemed more suitable than focus group interviews given that the 16 participants selected for the qualitative survey were from different schools. The purpose of using an individual interview tool was to perceive the world from the participants' point of view and collect rich, descriptive data to aid in understanding the participants' COLB and ALB (Jentoft & Olsen, 2019).

Using the interview method gave me the opportunity to elicit additional information and clarification from the students who participated in the study. With the help of interviews, the researcher can discover fresh, pertinent lines of inquiry that are immediately related to the report and can be further explored. If participants become side tracked by unimportant issues, they can direct them to concentrate on study-related factors (Kivunja & Kuyini, 2017). Conversely, interviews could be expensive and time-consuming. While interviews are frequently criticised for being misleading in that participants may include information and perspectives that the interviewer wants to hear, this is not always the case (Clark, 2019; Creswell, 2008). Inconsistencies may arise as a result of the willingness to satisfy the interviewer and the flexibility with which interviews are conducted. However, academics have kept using interviews in their research. This is due to the benefit of semi-structured interviews, which enable the interviewer to compel participants to provide in-depth responses (Creswell, 2009). The interview schedule, in this case, was also intended to supplement data from the quantitative method.

It is important to prepare participants for the interviews so that a more comprehensive and in-depth discussion can take place. Since the students were likely to be nervous and unsure about the conditions of attending an interview, the topics that would be discussed were included in the invitation letter (see Appendix F). This enabled students to prepare their reflections and feel more confident about the content of the discussions, encouraging them to participate. A short meeting was arranged with each participant in their respective schools a few days before they were interviewed. The meeting was held during school hours in the presence of the head of the school. After having introduced myself and briefly explained the purpose of my study, I personally handed the invitation letter for the interview to the participant. The participant and the head of the school were informed that the duration of the interview would be about thirty minutes. After having obtained their agreement, we decided upon the time and the venue of the interview.

4.7.2.1 Interview Schedule.

To gain further understanding of the students' COLB and ALB, data was collected through semi-structured interviews. I designed the questions in such a way as to assist the interviewees to think about their COLB and their ALB. The questions were related to the theoretical framework (see Chapter 3) and were guided by the quantitative findings (see Chapter 5). I used an interview schedule (see Appendix G) with similar basic questions for all interviewees in semi-structured interviews (Bell et al., 2022). However, depending on how interviewers reacted to the fundamental questions, they were asked additional questions. My role as the interviewer was to direct the conversation and remain neutral so that the participants' comments were not biased by my behaviour, and as well as to clear up any doubt before the interview ended (Beaudry & Miller, 2016). I conducted sixteen (16) interviews in total. The first question was meant to find out the students' COLB. Through the second question, I wanted to find out the students' COLB when a test/exam had been scheduled because students have a tendency to change their learning strategies when exams are near. The students' answers to the first and second questions and the additional questions enabled me to find out what strategies (conceptions) they used to learn biology. Through the third question, I wanted to find out why the students used specific strategies to learn biology.

4.7.2.2 Piloting the Interview.

Pilot interviews were conducted first, as advised by Magnusson and Maracek (2015), to test the questions in the semi-structured interviews, allowing for adjustments and input before the actual interviews. It was an excellent way to fine-tune both the content and the process (Carson et al., 2005). Pilot interviews were conducted with 2 participants purposely selected from the participants of the first phase (the quantitative phase) of the study. Because changes to the interview schedule were made after the pilot study, the interviews of the pilot study respondents were not included in the main study.

Following the completion of the pilot interviews, 16 participants were interviewed in their respective school facilities such as a spare room or library, and within school hours. The interview schedule is in Appendix G. The duration of each interview was about thirty minutes. At the beginning of each interview, the objective of the study was introduced to the participants, and they were informed that their collaboration was voluntary and their responses were confidential. Creswell (2008) and Whiting (2008) recommend audio taping the interview because it allows the interviewer to take a more relaxed, conversational approach with the participants rather than focusing on writing down their experiences. The qualitative semi-structured interviews were audio recorded after having obtained the consent of the participants and their parents. Audio recording allows for a much fuller record than taking down notes. The audio recordings were subsequently transcribed into text for close analysis.

I asked participants questions (see Appendix G) to get them talking, and I used extra questions (see Appendix K) to prompt and probe them when I needed more information in response to their comments. I appealed to the participants to be honest in their responses. I gave the participants plenty of time to think about the questions, organise their ideas, react, or seek clarification on any areas they didn't understand. There was the possibility that participants would withhold certain details in order to protect themselves or not want others to know personal information about them. As a researcher who needed this information, I treated the participant with respect and vigilance in order to maintain the interview's serious tone. During the interview, I tried to create a relaxed atmosphere so that participants would feel free to answer the questions without feeling compelled or afraid of my presence. While the interview was being audio recorded, I also took notes on my observations of the participant, such as verbal and non-verbal clues that improve the significance of the responses.

When doing individual face-to-face interviews, my goal was not to ask a specific number of questions but to pose a few provocative questions and enable the person to react freely. According to Williams (2022), an interview is a social encounter between a participant and the researcher, not just a process of asking a set number of questions to collect data. As a result, Williams (2022) recommends that the researcher should encourage participants to speak freely about the topic by probing them appropriately to obtain depth in their comments.

Participants were able to talk about their understandings and experiences of COL in depth during the interviews. They spoke clearly and confidently, and they were not hesitant or restricted in sharing their experiences and thoughts with me. I was happy to see how honestly and willingly individuals shared their experiences with me. It showed that they had faith in me and valued the opportunity to share their stories.

As a validity check, I returned each interview transcript to each participant (face-to-face) to evaluate and authenticate that they made those remarks; it was also an opportunity for them to add or retract earlier comments. The goal of this procedure was to collect any additional information that the participant could have forgotten during the interview. It could have been any fresh information they had come upon while reading the transcript. All the participants agreed that I had appropriately transcribed the interviews, and none of them requested that any of the responses be added or removed.

4.8 Data Generation Process

Data generation was done in two phases. I began by gathering quantitative data, analysing the findings, and using the information to plan and advance to the second qualitative stage. The qualitative phase's planned selection of participants and the questions which would be posed to them were both influenced by the quantitative findings (Creswell, 2014). Having carried out the quantitative survey with many participants (497), I then used qualitative semi-structured individual interviews to collect detailed views from a few of these participants (16) to obtain their specific views in a bid to help explain the initial quantitative survey.

4.9 Data Analysis

The research generated both quantitative and qualitative data. In line with an explanatory sequential mixed methods design's principles, quantitative data were first collected and analysed followed by the collection and analysis of the qualitative data which were used to explain the initial quantitative results.

4.9.1 Quantitative Data

Quantitative data gathered through students' questionnaires provided numerical data that were explored statistically and yielded a result that can be generalised to a larger population. The data analysis included Cronbach's Alpha, mean, standard deviation (SD), percentages, correlation, independent t-test, exploratory and confirmatory factor analysis, and multiple regressions. For the purpose of this research, quantitative statistical data obtained from the questionnaire survey was analysed by making use of the Statistical Package for Social Sciences (SPSS) version 25 software and the second-generation multivariate technique SmartPLS version 3. Then, after analysing the correlations between the COLB and the ALB factors, PLS-SEM analysis (Hair et al., 2019) was used to evaluate the relationships between the COLB factors and the ALB factors. The COLB factors were considered as the predictor (exogenous) variables whereas the ALB factors were processed as outcome (endogenous) variables (Chiou et al., 2012). McQuitty & Wolf (2013) defined SEM as a system of equations that allows one to model the relationships between any number of observed and unobserved (latent) variables. SEM is a method that is used to test and improve theoretical models. It is used to test a model of the relations among the variables that the researcher hypothesises before the research is made, through data acquired from the research (Kocakaya & Kocakaya, 2014). The partial least square structural equation modeling (PLS-SEM) was used for analysis because of the existence of latent variables.

4.9.2 Qualitative Data

The analysis of the qualitative data (phase two of the study), served to explain the quantitative data (phase one of the study). When the fieldwork was done, I was faced with a vast amount of data and had to decide how to organise it. Analysing qualitative data, according to Williams (2022), entails organizing and accounting for an explanation of the data. Williams (2022) explained that making sense of data and recognizing patterns, themes, categories, and regularities are components of qualitative data analysis. He furthermore contends that there are no set guidelines on how to analyse and display qualitative data, but the type of analysis being conducted should exist by binding with the principle of fitness for purpose. The qualitative data set for this study was analysed by transforming it to explain the quantitative data set.

Qualitative data analysis consisted of three steps namely, data reduction, data simplification and data transformation, all of which took place at the same time (Lester et al., 2020). The information gathered during interviews was first transcribed into a word processing document before being analysed (Flick, 2018, Howell Smith & Shanahan Bazis, 2021). Transcribing data entails transferring information from an oral interview into a scripted format for review (Creswell, 2005). Transcription was completed by me in order to protect the participants' anonymity. After consultation with the participants, the face-to-face interviews were conducted in Mauritian Creole (Kreol Morisien), their native language, to allow them easy expression of their opinions and to obtain more data without being limited by a language barrier. Furthermore, I listened to the audios many times before moving into the data transcription. We always think of transcription as a simple and straightforward technical process, but it is actually a very careful task that requires judgment and understanding, to present the data most effectively (Bailey, 2008). I transcribed the data obtained from the interviews for all sixteen participants. I had to return to the raw data several times to ensure that it correctly transcribed the rich data and accurately represented all the occurrences. Nonetheless, the quotes were translated from Kreol Morisien (KM) to English under the supervision of an expert translator.

Qualitative data analysis is a process that seeks to reduce and make sense of vast amounts of information. The data obtained through individual interviews of students were indexed using pre-defined codes and new codes were added. The codes were then grouped into common, salient and significant themes and that could shed light to the research questions. A preliminary qualitative codebook (Guest, MacQueen, & Namey, 2012) was developed, that is, a table that contained a list of predetermined codes based on the theory and the quantitative data analysis. The codebook was allowed to develop and change according to the information obtained during the data analysis.

Coding can be characterised as a word or brief phrase that symbolically assigns a summative, significant, essence-capturing, and/or evocative feature for a section of language-based or visual data (Saldana, 2021). According to Skjott Linneberg and Korsgaard (2019), the basic coding operation can be carried out in various ways. Simple colour coding with markers, with one colour for each code, may suffice in smaller applications with less data. For this study, each of the COLB and ALB subscales were identified in the text transcribed from the audio recording of the interviews and colour coded with the highlighter from the Word software, with one colour for each predetermined code. It was expected that new codes that were not anticipated at the beginning of the study would emerge during the data analysis. Each new code identified from the interview data was highlighted with a different colour (see Appendix K).

4.10 Trustworthiness of Qualitative Data

In order to meet the inquiry's trustworthiness expectations, I incorporated a few strategies (Creswell, 2012). Validity in a mixed methods analysis refers to the researcher's ability to draw meaningful conclusions from all the data collected (Howell Smith & Shanahan Bazis, 2021). The different issues addressed under both the quantitative and qualitative approaches should be included in the data's trustworthiness in a mixed methods study (Bernard & Bernard, 2013). According to Baxter and Jack (2008), using multiple data generation approaches strengthens the data's legitimacy, compensates for individual shortcomings, and maximises the benefits of each process.

4.10.1 Credibility

The credibility of qualitative data can be ensured by using multiple views throughout data gathering to ensure adequate data. This was accomplished through data triangulation, participant validation or member checks, and rigorous data collection approaches.

4.10.2 Transferability

Because generalisability is not sought in qualitative research, qualitative data transferability ensures that study findings are transferable to similar situations or persons. Clear assumptions and contextual inferences regarding the research context and participants established transferability.

4.10.3 Dependability

Dependability refers to the extent to which the reader can be persuaded that the results of the report are worthy of their attention and the analysis is of a good quality. The dependability of qualitative data is proved by assurances that the results were established despite changes in the research setting or participants during data collection. Again, thorough data collection techniques and procedures helped to ensure the dependability of the final data set.

4.10.4 Confirmability

Confirmability of qualitative data is ensured when data is reviewed and rechecked throughout the data collecting and analysis process to guarantee that the results are likely to be repeatable by others. A clear coding scheme that identifies the codes and patterns observed in analyses helped to document this. Finally, prior to analysis, a data audit assured dependability.

4.11 Validity and Reliability of Quantitative Data

"Validity is an essential criterion for evaluating the quality and acceptability of research" (Burns, 1999, p. 160). Therefore, it is imperative that the data and instruments be validated. To ensure content validity, I asked two secondary school biology teachers to review the research instruments and data following which questions were reviewed and difficult items rephrased. To enhance the internal validity of the research data and instruments, I made use of triangulation by collecting data from multiple sources, that is, questionnaires and interviews. Through triangulation, I can obtain both quantitative data and qualitative data to corroborate my findings. As each researcher has their own particular values, beliefs, and worldviews, I tried to collect, analyse, and interpret data as impartially as possible. I stuck to ethical rules and principles, performed the evaluation as accurately as possible and reported the findings honestly. To ensure external validity, the research has been designed in such a way that the findings can be generalised beyond the subjects under investigation to a wider population. As a result, the validation and piloting procedures increased the study's validity and reliability.

The reliability of research refers to the extent to which the same answers can be obtained using the same instruments more than one time (Howell Smith & Shanahan Bazis, 2021). In quantitative research, similar results can be obtained quite easily because the data are in numerical form. In qualitative research, obtaining similar results is fairly demanding and difficult because the data are in narrative form and subjective. Therefore, it is better to think in terms of the dependability and consistency of the data which can be ensured through the use of three techniques: the investigator’s position, triangulation and an audit trail.

To increase the reliability of the data findings, I explained the different processes of the inquiry, elaborated on all the study’s aspects, detailed the study’s rationale, the study’s design and the subjects. Gathering varied types of information through different sources enhanced the reliability of the data and results. Detailed information on how the data were collected, how they were analysed and how the results were obtained can help replicate the research and contribute to its reliability. Other techniques included tape-recording interviews in order to obtain reliable and reasonably complete records which improved the findings' credibility (Olton, 2012).

4.12 Synthesis

This study was conducted using a mixed methods approach founded on a pragmatic paradigm. Its data collection and analysis were guided by an explanatory sequential mixed methods design. To conduct an in-depth investigation of Mauritian upper secondary school students’ conceptions of and approaches to learning biology, data were accumulated from twenty conveniently selected schools comprising a total of 497 learners who I consider being representative of the population of all upper secondary pupils studying biology. A survey questionnaire was used for quantitative data collection, while student interviews collected qualitative data. The quantitative data was processed using SPSS version 25 and SmartPLS version 3 to generate descriptive statistical values which were then used to identify the students' conceptions and ALB. The qualitative data analysis (phase two of the study) served to explain the quantitative data (phase one of the study). As a result, for the second (qualitative) phase of my research, I used a hybrid thematic content analysis that combines deductive and inductive approaches. This study's findings are presented in the next two chapters. Chapter 5 deals with quantitative data presentation and analysis while chapter 6 deals with qualitative data presentation and analysis.

CHAPTER 5

STUDENTS' CONCEPTIONS OF AND APPROACHES TO LEARNING BIOLOGY: QUANTITATIVE FINDINGS

5.1 Introduction

In Chapter 4, I justified my reason for adopting the pragmatic paradigm in terms of the mixed methods approach, and provided the sampling strategy and data collection methods. Four research questions (see Chapter 1) guided this study and the design of data collection instruments (see Chapter 4). The questions explored upper secondary school students' conceptions (COLB) of and approaches to learning biology (ALB). These research questions were answered by interpreting the data collected from both the questionnaire and the interviews. The quantitative data provided answers to research questions 1 and 2 while the qualitative data provided answers to research questions 3 and 4.

In this chapter, I explain the main findings of the quantitative research. Quantitative data were obtained through a survey questionnaire administered to 497 Grade 11 biology students. The responses of 497 students (N) were captured on SPSS 25 and were analysed. An exploratory factor analysis (EFA) was used to scrutinise all factor structures and to decrease the items for each of the two questionnaires (Williams, 2022). Results were then entered into a SEM to cater for structural relations between students' COLB and their ALB. The COLB factors were predictor variables and the ALB factors were processed as outcome variables.

5.2 Students' Responses to the COLB and ALB Questionnaires

To general tendencies regarding Mauritian upper secondary school students' COLB and ALB, descriptive statistics and inferential statistics were used for analysing the data. To get an overall idea or picture of the data set, descriptive statistical parameters such as mean (M) and standard deviation (SD) were utilised to classify the learners collectively in terms of their COLB and ALB. To get the COLB and ALB data, the questions falling under each construct were grouped and then the average scores were calculated. Subsequently, the mean agreement scores of the constructs under each conception (see Table 5.1) and under each approach (see Table 5.8) were calculated.

As mentioned in Chapter 4, this study used a two-part 5-point Likert scale survey questionnaire to investigate students' COLB and ALB (see Appendix E). Items on the scale were coded where 5 represented strongly agree, 4 represented agree, 3 represented no opinion, 2 represented disagree, and 1 represented strongly disagree. Therefore, for this survey, the mean agreement scale used was: 1.00 - 1.99 indicating high disagreement, 2.00 – 2.99 indicating low disagreement, 3.00 – 3.99 indicating moderate agreement, and 4.00 – 5.00 indicating high agreement. The mean can be used to represent the typical value and therefore serves as a yardstick for all observations. Therefore, the mean was compared with the scale to determine whether the students who participated in this study fell under "memorising, testing, calculating and practicing, increasing one's knowledge, applying or understanding and seeing in a new way" for COLB, and whether they fell under "deep strategy, deep motive, surface strategy or surface motive" for ALB.

The standard deviations for each construct of the COLB (see Table 5.1) and ALB (see Table 5.8) were also calculated. The SD is an important indicator of spread or dispersion. It tells us how far, on average, the results are from the mean. Therefore, if the SD is small, then this tells us that the results are close to the mean (more reliable), whereas if the SD is large, then the results are more spread out (less reliable). One way to interpret the magnitude of the SD is to divide it by the mean. This is called the coefficient of variation (CV). It shows the extent of variability in relation to the mean of the population. The higher the CV, the greater the level of dispersion around the M. The lower the value of the CV, the more precise the estimate. As a rule of thumb, a $CV \geq 1$ indicates a relatively high variation while a $CV < 1$ can be considered low (Simon, 2009).

To get a better and more detailed idea of the data set, the students' responses to the items of the COLB questionnaire are presented in Tables 5.2 to 5.7, while those of the ALB questionnaire are presented in Tables 5.9 to 5.12. The constructs and their corresponding items are structured in a sequence identical to that of the questionnaire (see appendix E). However, for ease of reference, the "strongly agree" and "agree" have been summarised under one value and categorised as "strongly agree and agree". Likewise, the "strongly disagree" and "disagree" have been summarised under one value and categorised as "strongly disagree and disagree." Please refer to Appendix F for the students' responses to the 5-point Likert scale of the COLB and ALB questionnaires.

5.2.1 Students' Responses to the COLB Questionnaire

Section A of the questionnaire (see Appendix E), the COLB part, consisted of 6 COL with a total of 37 items and the data were used to categorise learners according to their COLB. Table 5.1 shows the average item scores and the standard deviations of the six extracted factors of the COLB for the 497 students.

Table 5.1

Summary statistics for students' responses to COLB

Conceptions	**Number of participants N**	**Mean M**	**Standard deviation SD**
Memorizing	497	3.53	1.29
Testing	497	3.10	1.43
Calculating and practicing	497	2.80	1.51
Increasing one's knowledge	497	4.16	0.96
Applying	497	3.74	1.13
Understanding and seeing in a new way	497	3.94	1.05

Agreement scale: from 1.00 to 1.99 = very low agreement; from 2.00 to 2.99 = low agreement; from 3.00 to 3.99 = moderate agreement; from 4.00 to 5.00 = high agreement.

Table 5.1 illustrated the mean agreement scores for the "increasing one's knowledge" conception (M = 4.16, SD = .96) is high, which might suggest the students' desire to increase their knowledge while learning biology. Moderate mean agreement scores for "memorising" (M = 3.53, SD = 1.29), "testing" (M = 3.10, SD = 1.43) and "applying" (M = 3.74, SD = 1.13) implies that a considerable number of the students make use of these conceptions during the process of learning biology. "Calculating and practicing" (M = 2.80, SD = 1.51) was the only conception with a low mean agreement score, suggesting that a smaller number of students make use of the "calculating and practicing" conception. However, these results imply that Mauritian upper secondary school learners are currently holding both higher-level and lower-level COLB, with a strong conception of "increasing one's knowledge." The coefficient of variation (CV = standard deviation ÷ mean) for each construct is less than 1, indicating that the data points tend to be clustered around the centre. All the six constructs have small standard deviations, indicating that results are close to the mean and are reliable.

5.2.1.1 Memorising.

Table 5.2 depicts the responses of the participants towards the items under the "memorising" construct.

Table 5.2

Conceptions of learning biology – Memorising

	Memorizing	Strongly Agree and Agree %	No opinion %	Strongly Disagree and Disagree %
M1	Learning biology means memorizing the definitions, formulae, and laws found in a biology textbook.	66.8	7.8	25.4
M2	Learning biology means memorizing the important concepts found in a biology textbook.	78.2	9.1	12.7
M3	Learning biology means memorizing the proper nouns found in a biology textbook that can help solve the teacher's questions.	57.0	20.1	22.9
M4	Learning biology means remembering what the teacher lectures about in the biology class.	74.5	8.4	17.1
M5	Learning biology means memorizing biological symbols, biological concepts, and facts.	64.6	17.3	18.1
M6	Learning biology is just like learning history or geography, the most important thing is to memorize the content of the textbook.	29.2	14.1	56.7
M7	When learning biology, I need to memorize the biological definitions and formulae well or I will forget them.	69.6	14.5	15.9

As Table 5.2 illustrates, out of the seven items measuring the 'memorising' construct, six items obtain a score of more than 57% of students who "strongly agree/agree" and only one item (M6) scores less (29.2%). The results show that most of the students perceive "memorising" as part of the learning process in terms of memorising definitions, important concepts, laws, teachers' notes, symbols, formulae, facts, and what the teacher discusses in the biology class. However, 56.7% of the students "strongly disagree/disagree" to item M6, which states that, "learning biology is just like learning history or geography, the most" important thing is to memorise the content of the textbook".

5.2.1.3 Testing.

Table 5.3 shows the responses of the participants towards the items under the "testing" construct.

Table 5.3

Conceptions of learning biology – Testing

	Testing	Strongly Agree and Agree %	No opinion %	Strongly Disagree and Disagree %
T1	Learning biology means getting high scores in examinations.	43.1	19.1	37.8
T2	If there are no tests, I will not learn biology.	32.1	10.3	57.6
T3	There are no benefits to learning biology other than getting high scores in examinations. In fact, I can get along well without knowing many biological facts.	28.5	11.3	60.2
T4	The major purpose of learning biology is to get more familiar with test materials	44.2	18.9	36.9
T5	I learn biology so that I can do well in biology-related tests.	67.8	12.5	19.7
T6	There is a close relationship between learning biology and taking tests.	52.0	24.5	23.5
T7	Learning biology means answering the questions correctly in the examination.	49.1	18.3	32.6

Table 5.3 reflects that out of the seven items measuring the "testing" construct, only two items (T5 & T6) get percentages of more than 52% of students who agree, while five items (T1, T2, T3, T4 & T7) are less than 50%. The responses of the students show that they tend to "strongly agree/agree" that the idea behind testing is to answer questions correctly in examinations (49.1%) and to ensure that they will familiarise themselves with test materials (44.2%) despite the fact that many of them (24.5%) could not decide on whether there is a close association between taking tests and learning biology. The response to item T3 shows that 60.2% of the students "strongly disagree/disagree" that testing is not an important requirement for them to learn biology and biological facts, while their response to item T2 shows that 57.6% of them "strongly disagree/disagree" that if no test was done, they would not learn biology.

5.2.1.4 Calculating and Practicing.

Table 5.4 shows the responses of the participants towards the items under the "calculating and practicing" construct.

Table 5.4

Conceptions of learning biology – Calculating and Practicing

	Calculating and Practicing	Strongly Agree and Agree %	No opinion %	Strongly Disagree and Disagree %
CP1	Learning biology involves a series of calculations and problem-solving.	25.1	15.1	59.8
CP2	I think that learning calculation or problem-solving will help me improve my performance in biology courses.	43.3	18.1	38.6
CP3	Learning biology means knowing how to use the correct formulae when solving problems.	46.5	18.9	34.6
CP4	The way to learn biology well is to constantly practice calculations and problem solving.	29.7	18.5	51.8
CP5	There is a close relationship between learning biology, being good at calculations, and constant practice.	38.1	22.0	39.9
CP6	Learning biology means constantly practicing calculations and problem solving.	27.3	18.9	53.8

As Table 5.4 indicates, all the six items measuring the construct "calculating and practicing" get percentages of less than 47% of students who "strongly agree/agree". Three items (CP1, CP4 & CP6) get percentages of more than 51% who "strongly disagree/disagree". However, when we analyse each item in this scale on its own, we find that for three (CP2, CP3 & CP5) out of the six items, students could not decide on how they felt. This is a limitation of the Likert scale questionnaires.

5.2.1.5 Increasing One's Knowledge.

Table 5.5 shows the responses of the participants towards the items under the "increasing one's knowledge" construct.

Table 5.5

Conceptions of learning biology – Increasing one's knowledge

	Increasing one's Knowledge	Strongly Agree and Agree %	No opinion %	Strongly Disagree and Disagree %
IK1	Learning biology means acquiring knowledge that I did not know before.	85.8	8.2	6.0
IK2	I am learning biology when the teacher tells me biological facts that I did not know before.	82.9	10.9	6.2
IK3	Learning biology means acquiring more knowledge about natural phenomena and topics related to nature.	82.1	9.9	8.0
IK4	Learning biology helps me acquire more facts about nature.	82.7	8.5	8.8
IK5	I am learning biology when I increase my knowledge of natural phenomena and topics related to nature.	75.7	13.5	10.8

Table 5.5 depicts that over 75% the students agree with the five items on the scale measuring the "increasing one's knowledge" construct, and that the percentages of responses with "no opinion" do not affect the pattern. The students believe that learning biology means acquiring and increasing their knowledge about nature, biological facts, natural phenomena and other topics that they did not know about before.

5.2.1.6 Applying.

Table 5.6 shows the responses of the participants towards the items under the "applying" construct.

Table 5.6

Conceptions of learning biology – Applying

	Applying	Strongly Agree and Agree %	No opinion %	Strongly Disagree and Disagree %
A1	The purpose of learning biology is learning how to apply methods I already know to unknown problems.	58.7	23.9	17.4
A2	Learning biology means learning how to apply knowledge and skills I already know to unknown problems.	58.8	21.7	19.5
A3	We learn biology to improve the quality of our lives.	81.9	8.9	9.2
A4	Learning biology means solving or explaining unknown questions and phenomena.	56.9	25.6	17.5
A5	Learning biology means acquiring knowledge and skills to solve the problems happened in the real life.	69.7	17.1	13.2
A6	Learning biology means acquiring knowledge and skills to enhance the quality of our lives.	73.2	14.3	12.5

As seen in Table 5.6, around 56% of the students expressed their agreement with the six items on the questionnaire that measured "applying" as a conception of learning biology, with item A3 obtaining the highest score (81.9%). The data show that students feel that learning biology enables application of methods, skills and knowledge to unknown problems, solve real life problems, and subsequently improve the quality of lives.

5.2.1.7 Understanding and Seeing in a New Way.

Table 5.7 depicts the responses of the participants towards the items under the "understanding and seeing in a new way" construct.

Table 5.7

Conceptions of learning biology – Understanding and seeing in a new way

	Understanding and seeing in a new way	Strongly Agree and Agree %	No opinion %	Strongly Disagree and Disagree %
US1	Learning biology means understanding biological knowledge.	82.7	9.9	7.4
US2	Learning biology means understanding the connection between biological concepts.	72.5	19.1	8.4
US3	Learning biology helps me view natural phenomena and topics related to nature in new ways.	78.1	12.5	9.4
US4	Learning biology means changing my way of viewing natural phenomena and topics related to nature.	72.5	15.5	12.0
US5	Learning biology means finding a better way to view natural phenomena or topics related to nature.	77.6	15.6	6.8
US6	I can learn more ways about thinking about natural phenomena or topics related to nature by learning biology.	67.0	19.1	13.9

Table 5.7 demonstrates that more than 67% of the students "strongly agree/agree" to the six items that measure the COL of "understanding and seeing in a new way." Despite the considerable percentage of "neither disagree nor agree" on all items in the scale (ranging from around 10% to 19%), there is a clear-cut pattern whereby learning biology is seen as comprehending biological knowledge, concepts, natural phenomena or nature related topics, changing and finding better ways to view them.

5.2.2 Students' Responses to the ALB questionnaire

The ALB survey questionnaire had 27 items and the resulting rich data served to categorise students as adopting a deep motive, deep strategy, surface motive or surface strategy to learning biology.

Table 5.8 shows that pupils attained moderate mean scores for “deep motive,” “deep strategy,” “surface motive,” and “surface strategy.” These results imply that upper secondary school students in Mauritius are inclined to have both deep and surface ALB, with mixed motives and strategies for learning biology. The coefficient of variation (CV = standard deviation ÷ mean) for each construct is less than 1, indicating that the data points tend to be clustered tightly around the centre. All four constructs have small standard deviations, indicating that results are close to the mean and are reliable. Table 5.8 presents the average item scores along with the standard deviations of the four extracted factors of the ALB for the 497 students.

Table 5.8

Summary statistics for students' responses to ALB

Approaches	Number of participants N	Mean M	Standard deviation SD
Deep motive	497	3.66	1.32
Deep strategy	497	3.64	1.20
Surface motive	497	3.85	1.42
Surface strategy	497	3.09	1.61

Agreement scale: from 1.00 to 1.99 = very low agreement; from 2.00 to 2.99 = low agreement; from 3.00 to 3.99 = moderate agreement; from 4.00 to 5.00 = high agreement.

Table 5.9 to Table 5.12 represent each construct with its corresponding items of measurement and the frequency of disagreement and agreement for individual items of the ALB questionnaire.

5.2.2.1 Deep Motive.

Table 5.9 illustrates the responses of the participants to the items under the "deep motive" construct.

Table 5.9

Approaches to learning biology – Deep motive

	Deep motive	Strongly Agree and Agree %	No opinion %	Strongly Disagree and Disagree %
DM1	I find that at times studying biology makes me feel really happy and satisfied.	71.5	15.3	13.2
DM2	I feel that biology topics can be highly interesting once I get into them.	80.3	10.1	9.6
DM3	I work hard at studying biology because I find the material interesting.	66.0	18.3	15.7
DM4	I always greatly look forward to go to the biology class.	67.0	16.5	16.5
DM5	I spend a lot of my free time finding out more about interesting topics which were discussed in the biology class.	51.5	18.3	30.2
DM6	I come to the biology class with questions in my mind that I want to be answered.	67.8	18.1	14.1
DM7	I find that I continually go over my biology classwork in my mind even whenever I am not in the biology class.	44.5	24.7	30.8
DM8	I like to work on biology topics by myself so that I can form my own conclusions and feel satisfied.	57.5	22.2	20.3

Table 5.9 shows that more than 51% of the students "strongly agree/agree" with the items of the "deep motive" construct except for one item, DM7 (44.5%). A considerable percentage (24.7%)

could not decide on whether or not they found themselves continuously going over their biology classwork even if they were not in class. However, a high percentage of students (80.3%) find biology topics of interest once they get into them. Most of the students also feel that learning biology makes them feel happy and satisfied and enables them to form their own conclusions. Most of the students also view that learning biology through a deep motive signify looking forward to going to biology class, to seek answers to the questions that are in their minds and to discuss what was done in class.

5.2.2.2 Deep Strategy.

Table 5.10 depicts the responses of the participants to the items under the “deep strategy” construct.

Table 5.10

Approaches to learning biology – Deep strategy

	Deep strategy	Strongly Agree and Agree %	No opinion %	Strongly Disagree and Disagree %
DS1	I try to relate what I have learned in biology to what I learn in other subjects.	59.6	19.5	20.9
DS2	I like constructing theories to fit odd things together when I am learning biology topics.	50.7	27.6	21.7
DS3	I try to find the relationship between the contents of what I have learned in biology.	63.6	22.1	14.3
DS4	I try to relate new material to what I already know about the topic when I am studying biology.	60.6	20.9	18.5
DS5	I try to understand the meaning of the contents I have read in biology textbooks.	73.7	12.1	14.2
DS6	I can ask myself, possibly, to understand the subject matter I have learned in the biology class.	67.5	23.5	9.0

Table 5.10 depicts that over 50% of the students “strongly agree/agree” with the six items of the “deep strategy” construct. However, a considerable percentage of respondents opted for ‘neither disagree nor agree’ ranging between 12% to 28%. Nevertheless, most of the students try to relate what they have learned in biology classes to other classes, construct theories to fit odd things together, and find the relationship between contents. They also try to question themselves on the subject, understand their meaning, find interconnected concepts in biology and relate new material to what they already know.

5.2.2.3 Surface Motive.

Table 5.11 shows the responses of the participants towards the items under the “surface motive” construct.

Table 5.11

Approaches to learning biology – Surface Motive

	Surface motive	Strongly Agree and Agree %	No opinion %	Strongly Disagree and Disagree %
SM1	I am discouraged by a poor mark in biology tests and worry about how I will do on the next test.	72.0	11.7	16.3
SM2	Even when I have studied hard for a biology test, I worry that I may not be able to do well in it.	68.2	12.9	18.9
SM3	I worry that my performance in the biology class may not satisfy my teacher's expectations.	65.6	15.7	18.7
SM4	I want to get a good achievement in biology so that I can get a better job in the future.	73.9	13.7	12.4
SM5	I want to do well in biology so that I can please my family and the teacher.	67.6	13.9	18.5
SM6	No matter if I like it or not, I know that getting a good achievement in biology could help me to get an ideal job in the future.	71.1	16.5	12.4

As demonstrated in Table 5.11, over 65% of the students “strongly agree/agree” to the six items measuring the “surface motive” construct. The students are discouraged by poor marks and are worried of their inability to do well in tests and inability to satisfy their teachers’ expectations. Their fundamental aims of learning biology seemed to be the desire to please one’s family and is linked to getting a job.

5.2.2.4 Surface Strategy.

Table 5.12 displays the responses of the participants to the items under the “surface strategy” construct.

Table 5.12

Approaches to learning biology – Surface Strategy

	Surface strategy	Strongly Agree and Agree %	No opinion %	Strongly Disagree and Disagree %
SS1	I see no point in learning biology materials that are not likely to be on the examinations.	25.2	25.1	49.7
SS2	As long as I feel I am doing well enough to pass the examination, I devote as little time as I can to studying biology. There are many more interesting things to do with my time.	38.9	22.7	38.4
SS3	I, generally, will restrict my study to what is specially set because I think it is unnecessary to do anything extra in learning a biology topic.	26.5	28.0	45.5
SS4	I find that studying each topic in depth is not helpful or necessary when I am learning biology. There are too many examinations to pass and too many subjects to be learned.	34.0	21.3	44.7
SS5	I find the best way to pass biology examinations is to try to remember the answers to likely questions.	58.3	13.9	27.8
SS6	When learning biology, I try to memorize the content again and again till I remember it very well.	68.0	13.3	18.7

Table 5.12 shows that most of the students find that memorising is the key aspect of passing the subject, for example, memorising answers to potential questions and content without the need of understanding them. Most of them also stated that the easiest way to pass biology examinations is to try to remember the answers to likely questions and to try to memorise the content repeatedly until they remember it very well. However, for four items (SS1, SS2, SS3 & SS4), a considerable percentage (21% to 28%) of the students neither "strongly agree/agree" nor "strongly disagree/disagree" on whether or not they would devote time to study non-examinable materials, learn in depth or do anything extra apart from what is required to pass the examinations in biology.

5.3 Identifying Learning Conceptions and Learning Approaches

As conveyed in Chapter 4, this research is based on a 37-item COLB questionnaire and a 27-item ALB questionnaire. An exploratory factor analysis (EFA) was conducted on the 37 conceptions COL items and on the 27 AL items within their respective questionnaire. EFA is a statistical method that increases the reliability of the scale by identifying inappropriate items that can be removed. EFA was used because "its key objective is reducing a larger set of variables to a smaller set of factors, fewer than the original variable set, but capable of accounting for a large portion of the total variability in the items" (Williams, 2022). Therefore, for this study, EFA was adopted to identify clusters within the various items on the COLB and ALB questionnaires and to reduce the number of items to simplify results pertaining to COL and AL. As recommended by Howard (2016), only those items with loadings exceeding .4 were retained. The SPSS version 25 was used for all EFA analyses.

Prior to carrying out the EFA of the COLB and ALB questionnaires, I examined two indicators, the Keiser-Meyer-Olkin (KMO) which measures sample adequacy together with the Bartlett's test of sphericity which determines the adequacy of the sample (N = 497) for this type of analysis. KMO returns values between 0 and 1 (Williams, 2022). Any variable used during the calculation of the overall KMO value must exceed 0.50. If the KMO value is close to 1, it shows that the correlation patterns are rather compact, and the factor analysis will give reliable factors (Field, 2013).

To identify learning conceptions, learning approaches and their respective items, a promax oblique rotation was done on the scores of the COLB and the ALB. The promax oblique rotation was chosen because this suited the sample size (N = 497) used in this study and better captured the items (Brown, 2009). Orthogonal rotation was deemed inappropriate as the Component Transformation Correlation for COLB (see Appendix G) exceeded the conventional level of ± .32 (Brown 2009). Besides, the psychological approach has proven that concepts are interrelated (Field, 2013) and, hence, assuming orthogonal rotations, especially in the COL and AL would yield misleading results. The number of factors to be eventually retained was based on Eigen values more than 1 and scree plots.

5.3.1 Identifying Learning Conceptions

To establish the adequacy of the sample (N = 497) for the factor analysis of the COLB questionnaire, I examined the determinant, the Bartlett's Test and KMO measure of sampling adequacy (Williams, 2022). Results are displayed in Table 5.13.

Table 5.13

Determinant, KMO and Bartlett's Test

Determinant		0.006
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.797
Bartlett's Test of Sphericity	Approx. Chi-Square	2521.744
	Degrees of Freedom	276
	p-value	0.000

As Table 5.13 confirms, there is no problem with multicollinearity, as the determinant is above the required .00001 level. The KMO measure ensures the adequacy of the sample before results from EFA may be interpreted. The conventional level of KMO should exceed .7 (Field, 2013)**.** The sample size is good, as advocated by Howard (2016) since the KMO measure is around .8. The highly significant coefficient ($p < .001$) of Bartlett's Test confirms the existence of clusters. Items on the questionnaire are sufficiently correlated to form different COL. Therefore, these items are quite suitable for further factor analysis. Consequently, further factor analysis was performed on the 37 COLB items within the questionnaire to reduce the number of items to simplify results pertaining to conceptions of learning. For each conception, only those items with loadings exceeding .4 were retained (see Table 5.14). The commonality value, which is always equal to 1.0 for correlation analyses, is also a deciding factor to include or exclude a variable in the factor analysis. Communalities for COLB are displayed in Appendix H.

As Table 5.14 indicates, around 53% of variations in COL are explained by the following six components: “calculating and practicing,” “exploring real life and natural phenomena,” “increasing one’s knowledge”, “testing,” “memorising,” and “applying.” Table 5.14 presents the factor loadings of the items of the six components of COLB.

Table 5.14

Pattern Matrix for COLB

Items and Conceptions	1	2	3	4	5	6
	Loadings					
Calculating and practicing						
The way to learn biology well is to constantly practice calculations and problem solving.	0.787					
Learning biology means constantly practicing calculations and problem solving.	0.727					
Learning biology involves a series of calculations and problem-solving.	0.714					
I think that learning calculation or problem-solving will help me improve my performance in biology courses.	0.634					
Learning biology means knowing how to use the correct formulae when solving problems.	0.629					
There is a close relationship between learning biology, being good at calculations, and constant practice.	0.614					
Exploring real life and natural phenomena						
Learning biology means finding a better way to view natural phenomena or topics related to nature.			0.771			
Learning biology means acquiring knowledge and skills to enhance the quality of our lives.			0.737			
We learn biology to improve the quality of our lives.			0.677			
I can learn more ways about thinking about natural phenomena or topics related to nature by learning biology.			0.612			
Learning biology means acquiring knowledge and skills to solve the problems happened in the real life.			0.606			
I am learning biology when I increase my knowledge of natural phenomena and topics related to nature.			0.522			

Increasing One's Knowledge				
I am learning biology when the teacher tells me biological facts that I did not know before.	0.850			
Learning biology means acquiring knowledge that I did not know before.	0.758			
Learning biology means acquiring more knowledge about natural phenomena and topics related to nature.	0.621			
Testing				
There is a close relationship between learning biology and taking tests.		0.717		
I learn biology so that I can do well in biology-related tests.		0.694		
Learning biology means getting high scores in examinations.				
Learning biology means answering the questions correctly in the examination		0.635		
		0.585		
Memorizing				
Learning biology means memorizing the definitions, formulae, and laws found in a biology textbook.			0.782	
Learning biology means memorizing the proper nouns found in a biology textbook that can help solve the teacher's questions.			0.714	
Learning biology means remembering what the teacher lectures about in the biology class.			0.590	
Applying				
The purpose of learning biology is learning how to apply methods I already know to unknown problems.				0.831
Learning biology means learning how to apply knowledge and skills I already know to unknown problems.				0.753

	Summary Statistics for EFA on COLB					
	Calculating and Practicing	**Exploring real life and natural phenomena**	**Increasing One's Knowledge**	**Testing**	**Memorizing**	**Applying**
Total Variance Explained	18.00%	11.14%	7.67%	5.65%	5.42%	4.73%
Eigenvalues	4.315	2.675	1.840	1.355	1.302	1.135
Cronbach Alpha	0.787	0.763	0.649	0.582	0.508	0.628

Rotation converged in 6 iterations.

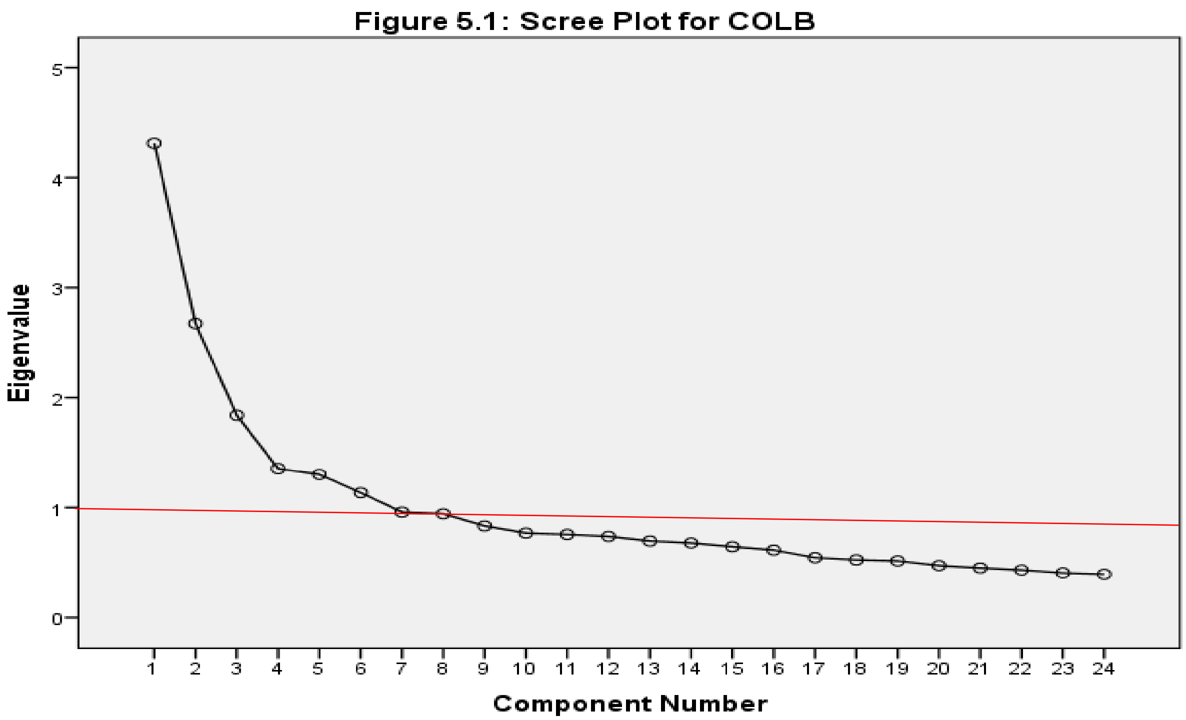
Total variance explained = 53%

Thus, the theoretical model converges towards six components which are in line with the theoretical framework discussed in Chapter 3. However, this research introduced a new element of COLB which is "exploring real life and natural phenomena." I did not find the emergence of the conception "understanding and seeing in a new way" as put forward by Lee et al. (2008). For each component, only items with factor loadings greater than 0.4 were retained. A total of 24 items for six factors were retained for further analysis.

As seen in Figure 5.1, the scree plot shows that the inflection point occurs at the 7th component, thus justifying the six components extracted from the analysis. All eigenvalues of the six components exceed 1 as required by the Kaiser criterion (Kaiser, 1960).

Figure 5.1

Scree Plot for COLB



In Table 5.14, the first component "calculating and practicing" explains the highest percentage of variances in COLB (18%), followed by "exploring real life and natural phenomena" (11%), "increasing one's knowledge" (7.7%), "testing" (5.7%), "memorising" (5.4%) and "applying" (4.7%). The results seem to imply that Mauritian upper secondary school students prioritise "calculating and practicing" over the other conceptions. They place the greatest emphasis on this COLB.

However, Table 5.4 shows that they display negative attitudes towards the idea that learning biology involves the use of formulae, a series of calculations and constant practice if they want good performances in biology (*M* = 2.80, *SD* = 1.51). The second component the students prioritise is entitled 'exploring real life and natural phenomena'. They study more to acquire and increase knowledge so as to solve nature related and real-life problems and to ultimately improve their quality of life (*M* = 3.92, *SD* = 1.08). This component is a contribution to the theoretical framework. The third COLB is "increasing one's knowledge," suggesting that the learners believe in attaining knowledge that they did not have before, especially about facts and natural phenomena (*M* = 4.22, *SD* = .88).

The fourth conception is “testing,” suggesting that they learn biology to perform well in tests and score high marks in examinations (*M* = 3.34, *SD* = 1.46). The fifth conception is “memorising,” suggesting that the students believe that it is important to memorise definitions, laws, formulae, proper nouns and whatever the teacher lectures in class (*M* = 3.60, *SD* = 1.31). The EFA results show that the last COLB, according to the students, is “applying,” suggesting that they believe that learning biology is synonymous to applying the knowledge, skills and methods to unknown problems (*M* = 3.74, *SD* = 1.13).

5.3.2 Identifying Learning Approaches

To determine whether the sample (N = 497) was adequate for the factor analysis of the ALB questionnaire, I examined the determinant, the KMO measure of sampling adequacy and Bartlett’s Test (Williams, 2022). The results are displayed in Table 5.15.

Table 5.15

Determinant, KMO and Bartlett’s Test

Determinant		0.017
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.837
Bartlett’s Test of Sphericity	Approx. Chi-Square	2005.664
	Degrees of Freedom	153
	p-value	0.000

As seen in Table 5.15, the constructs are not multicollinear as the determinant coefficient is above the required 0.00001 level. The sample size is good as advocated by Howard (2016) since the Kaiser Meyer Olkin measure exceeds 0.8. Therefore, the sample size is sufficient to conduct factor analysis. The Bartlett’s test for sphericity reveals a highly significant coefficient ($p < .001$) and thus items are adequately correlated to form subgroups. Therefore, these items are quite suitable for further factor analysis. Consequently, further factor analysis was conducted on the 27 ALB items within the questionnaire to reduce the number of items so as to simplify results pertaining to COL. Only those items with loadings exceeding .4 were retained (see Table 5.15). Communality value, which is always equal to 1.0 for correlation analyses, is also a deciding factor to include or to exclude a variable in the factor analysis. Communalities for ALB are displayed in Appendix G. Table 5.16 shows the factor loadings of the items of the four components of approaches to learning biology.

Table 5.16

Pattern Matrix for ALB

Items and Conceptions	1	2	3	4
	Loadings			
Deep motive				
I find that at times studying biology makes me feel really happy and satisfied.	0.755			
I always greatly look forward to go to the biology class.	0.728			
I work hard at studying biology because I find the material interesting.	0.723			
I spend a lot of my free time finding out more about interesting topics which were discussed in the biology class.	0.699			
I feel that biology topics can be highly interesting once I get into them.	0.630			
I find that I continually go over my biology class work in my mind even whenever I am not in the biology class.	0.602			
I come to the biology class with questions in my mind that I want to be answered.	0.517			

Surface strategy			
I, generally, will restrict my study to what is specially set because I think it is unnecessary to do anything extra in learning a biology topic.	0.763		
I see no point in learning biology materials that are not likely to be on the examinations.	0.695		
As long as I feel I am doing well enough to pass the examination, I devote as little time as I can to studying biology. There are many more interesting things to do with my time.	0.694		
I find that studying each topic in depth is not helpful or necessary when I am learning biology. There are too many examinations to pass and too many subjects to be learned.	0.672		
Deep strategy			
I like constructing theories to fit odd things together when I am learning biology topics.		0.764	
I try to relate what I have learned in biology to what I learn in other subjects.		0.710	
I try to find the relationship between the contents of what I have learned in biology.		0.666	
Surface motive			
Even when I have studied hard for a biology test, I worry that I may not be able to do well in it.			0.782
I worry that my performance in the biology class may not satisfy my teacher's expectations.			0.751
I am discouraged by a poor mark in biology tests and worry about how I will do on the next test.			0.748

Summary Statistics for EFA on ALB				
	Deep motive	**Surface strategy**	**Deep strategy**	**Surface motive**
Variance Explained	23.94%	12.48%	8.78%	6.16%
Eigenvalues	4.309	2.247	1.581	1.109
Cronbach Alpha	0.801	0.624	0.678	0.657

Rotation converged in 5 iterations.

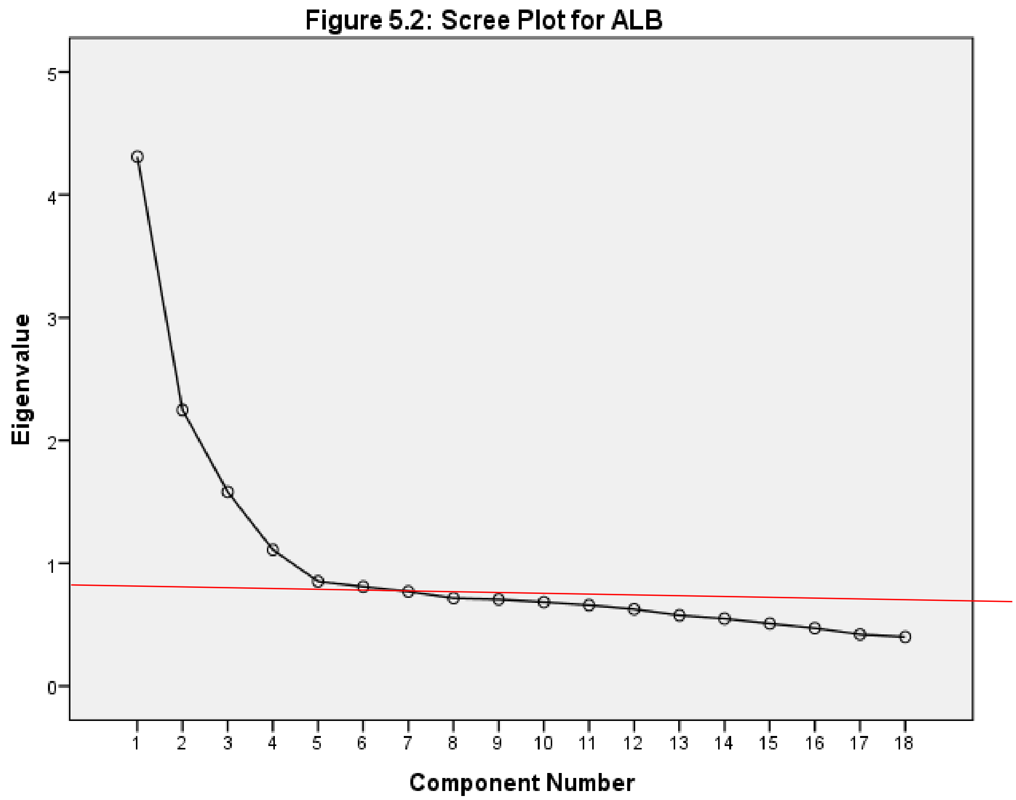
Total variance explained = 51%

Table 5.16 depicts that around 51% of variations in approaches to learning are explained by four components: deep motive, surface strategy, deep strategy, and surface motive. Thus, the model extracts only 4 components which align with the theoretical framework proposed in Chapter 3. For each component, only items with factor loadings greater than 0.4 were retained (Howard, 2016). A total of 18 items for 4 factors were retained for further analysis.

As seen from Figure 5.2, the scree plot shows that the inflection point occurs at the 5th component thus justifying the four components extracted from the analysis. As per the Kaiser criterion, all eigenvalues of the four components exceed 1 (Kaiser, 1960).

Figure 5.2

Scree Plot for ALB



The items within the four components are displayed in Table 5.16. The deep motive approach to learning biology has the highest score (24%), followed by the surface strategy (12.5%), deep strategy (9%) and surface motive (6%). The results suggest that Mauritian upper secondary school learners primarily value the "deep motive" approach to learning biology. It makes them happy and enthusiastic. They simultaneously look for interesting topics and go to class to seek answers to their questions (M = 3.67, SD = 1.30). Secondly, the students adopt the "surface strategy" approach (M = 2.80, SD = 1.57). They do not believe that they should devote little time to studying biology to pass their examinations. The students "strongly agree/agree" that they should study non-examinable materials and they do not believe that studying a topic in-depth does help them. Thirdly, the "deep strategy" approach was used by the students (M = 3.56, SD = 1.26). The students "strongly agree/agree" that they use this approach to construct theories and connect content. They also relate new things and other subjects to what they have learnt in biology. The last approach to learning biology as rated by the students is the "surface motive" (M = 3.78, SD = 1.45). The students expressed their concerns about not passing a test despite the fact that they had studied hard, not doing well in future tests once they score low marks and not meeting their teachers' expectations.

5.4 Structural Equation Modeling

Once the Exploratory Factor Analysis (EFA) was done and the six components for COLB and four components for ALB were extracted, SEM analysis was carried out to determine the extent to which the theoretical model is supported by sample data (Sarstedt et al., 2017). SEM tests theoretical models by using the scientific method of hypothesis testing, enabling us to better comprehend the complicated relationships among constructs. Confirmatory factor analysis (CFA) is the measurement part of SEM, which shows relationships between latent variables and their indicators (Brown, 2015). CFA is used to confirm and trim these constructs and items (measurement model). SEM is used to confirm if relationships exist between these items and constructs (structural model). The SmartPLS version 3 which is a second-generation technique for multivariate regression was used for the structural equation modeling (Ringle et al., 2015).

A confirmatory factor analysis (CFA) was performed to assess the theoretical framework proposed in Chapter 3 and the research model proposed in Chapter 4. It should be noted that the component "understanding and seeing in a new way" was not found in this study and instead 'exploring real life and natural phenomena' was extracted through EFA. Thus, the theoretical framework and research model were modified to include this component. The structural model consists of four latent variables namely, lower-level conceptions, higher-level conceptions, surface approaches, and deep approaches. The latent variable, lower-level conceptions, included items from the three components namely, "testing, calculating and practicing, and memorising". The latent variable, higher-level conceptions, included items from the three components namely, "exploring real life and natural phenomena, applying, and increasing one's knowledge". The latent variable surface approaches were constructed from the constructs surface motive and surface strategy. However, the latent variable, deep approaches, were constructed from the constructs of the deep motive and deep strategy. All latent variables were measured reflectively.

5.4.1 The Measurement Model

As per Wong (2013), all items with low outer loadings whereby if the square of the indicator loadings failed to meet at least the value of 0.4 were deleted from further analysis to ensure indicator reliability. Table 5.16 illustrates the items retained under each construct and their respective indicator reliability, t-statistics, p-values, and confidence intervals.

Table 5.17

Indicator Reliability and t-statistics

Items on the questionnaire	Loadings	Indicator reliability	T Statistics	P-values	Confidence Intervals	
Higher-level conceptions					Lower limit	Upper limit
A6	0.702	0.493	19.107	0.000	0.618	0.765
IK5	0.721	0.520	21.001	0.000	0.644	0.779
US5	0.708	0.501	18.110	0.000	0.619	0.775
US6	0.768	0.590	25.500	0.000	0.698	0.817
Lower- level conceptions						
CP1	0.687	0.472	17.773	0.000	0.607	0.757
CP2	0.732	0.536	21.307	0.000	0.660	0.795
CP3	0.706	0.498	19.061	0.000	0.623	0.769
CP4	0.696	0.484	18.569	0.000	0.611	0.761
CP5	0.707	0.500	19.711	0.000	0.629	0.770
Deep approaches						
DM1	0.739	0.546	23.015	0.000	0.667	0.794
DM2	0.781	0.610	30.181	0.000	0.723	0.825
DM3	0.770	0.593	30.151	0.000	0.712	0.812
DS4	0.710	0.504	23.819	0.000	0.646	0.764
Surface approaches						
SS1	0.789	0.623	12.536	0.000	0.656	0.900
SS3	0.707	0.500	9.967	0.000	0.518	0.812
SS4	0.728	0.530	9.647	0.000	0.567	0.860

Note. A = applying, IK = increasing one's knowledge, US = understanding and seeing in a new way, CP = calculating and practicing, DM = deep motive, DS = deep strategy, SS = surface strategy (see Appendix E).

As seen in Table 5.17, all loadings of each reflective construct are either close or above .7 and these are highly statistically significant ($p < .001$). None of the confidence intervals included a zero, thereby upholding the significance of each item in each construct (Sarstedt et al., 2017, Sarstedt et al., 2021).

In Table 5.18, the reflective latent variables show good internal consistency reliabilities. In Partial Least Square Structural Equation Modeling, Dijkstra and Henseler (2015) advocated the use of composite reliability instead of Cronbach alpha. The coefficients of the composite reliability of each reflective exceed 0.8. A general rule is that 0.6 – 0.7 indicates an acceptable level of reliability, whereas above 0.8 indicates very good reliability (Hulin et al., 2001). Table 5.18 confirms that this research meets the requirements for convergent validity as ensured by the Average Variance Extracted (AVE) values above 0.5. This implies that each latent variable captures above 50% of the variations that it seeks to represent. At least 80% of variations is being explained by each construct used for this research, which indicates very good reliability.

Table 5.18

Construct Reliability and Convergence Validity

Latent variables	Cronbach Alpha	Composite Reliability	Average Variance Extracted (AVE)
Deep approaches	0.743	0.838	0.565
Higher-level conceptions	0.701	0.816	0.527
Lower-level conceptions	0.755	0.831	0.500
Surface approaches	0.619	0.832	0.561

Discriminant validity was examined by the Fornell and Larcker (1981) criteria, the Heterotrait-Monotrait (HTMT) ratio and cross loadings (Klein & Rai, 2009). The values are displayed in tables 5.19a and 5.19b.

Table 5.19a

Discriminant Validity – Fornell Larcker Criterion

	Deep approaches	Higher-level conceptions	Lower-level conceptions	Surface approaches
Deep approaches	0.751			
Higher-level conceptions	0.505	0.725		
Lower-level conceptions	0.29	0.209	0.742	
Surface approaches	0.111	0.149	0.003	0.844

Table 5.19b

Discriminant Validity – HTMT

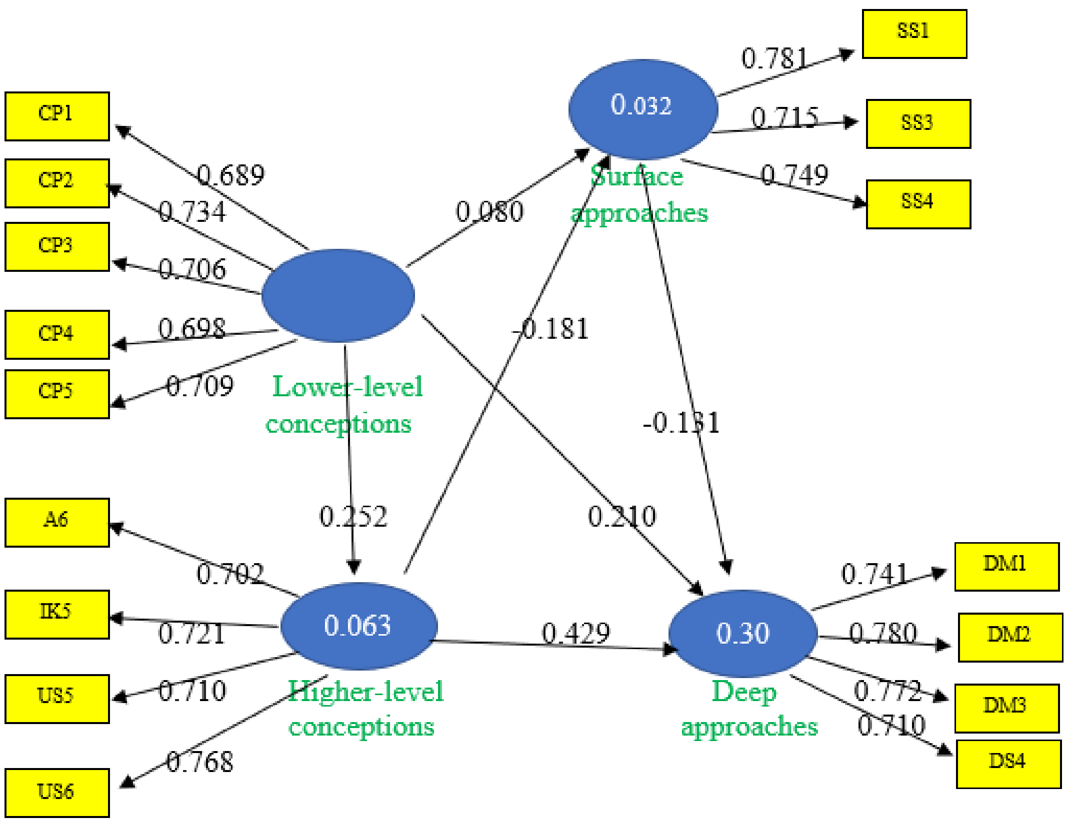
	Deep approaches	Higher-level conceptions	Lower-level conceptions	Surface approaches
Deep approaches				
Higher-level conceptions	0.681			
Lower-level conceptions	0.377	0.291		
Surface approaches	0.160	0.225	0.094	

As per Fornell and Larcker (1981), none of the correlations relating to the latent variables exceed the square root values of AVE. Also, the HTMT values are below 0.85 and the cross-loadings of each indicator ensure that each indicator has the highest loadings in its respective construct. These support the fact that the constructs differ from one another. Similarly, all cross-loadings were examined. All items have the highest loadings in their respective components. All three measures of discriminant validity support the fact that each construct is sufficiently distinct from the other and all constructs can be used for further analysis.

The measurement model represents the theory that specifies how measured variables or constructs come together to represent the theory. It examines the relationship between the latent variables or constructs and their measures. All items with outer loadings lower than 0.4 were deleted from further analysis to ensure indicator reliability (see Table 5.16). Figure 5.3 depicts the proposed measurement model.

Figure 5.3

The Measurement Model



The Standardised Root Mean Square Residual (SRMR) value of 0.076 confirms the model, as a good fit value lies below 0.08 for the PLS-SEM approach within the Smart PLS software (Sarstedt et al., 2021). The model is stable and stops after 7 iterations. Geisser (1975) and Stone (1974) state that predictive relevance can be ensured if the cross-validated redundancy Q^2 value is above zero. Here the predictive accuracy for deep approaches and surface approaches are guaranteed with Q^2 values of .15 and .013, respectively. Also, according to the benchmarks provided by Hair et al. (2011), Chin (1998) and Henseler et al. (2009), the proposed model (Figure 5.3**),** indicates weak predictive accuracy (R^2 = .31) for deep approaches whereas the R^2 values for higher level conceptions and surface approaches are very low coefficients (R^2 = .06 and R^2 = .03, respectively).

5.4.2 The Structural Model

The bootstrapping method of the software Smart PLS-3 was executed to analyse the structural model. This technique is a re-sampling procedure whereby 5000 sub-samples are used to generate path coefficients and t-statistics. The path coefficient (β value) shows the extent to which the predictor construct is related to the outcome construct and the significance of this association is indicated by T-statistics (Sarstedt et al., 2021). Figure 5.4 shows the path diagram of the hypothesised path relationships among the constructs tested by the structural equation model and Table 5.20 shows the results of the path analysis.

Figure 5.4

The structural model

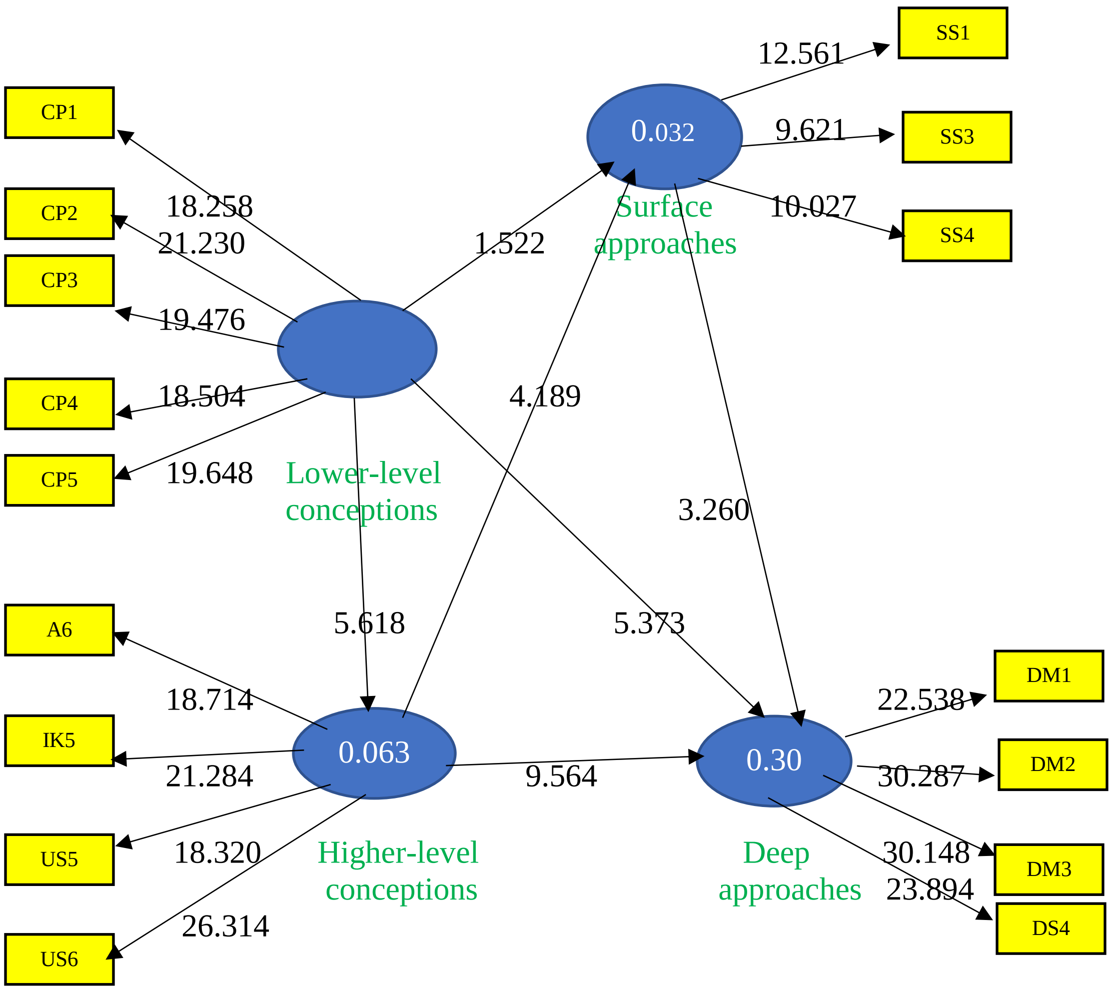


Table 5.20

Results of Hypothesis Testing

	Hypothesis	Path values (β)	T statistics	P-value (p)	Confidence Intervals		Supported
					Lower limit	Upper limit	
H1	lower-level -> surface approaches	0.085	1.524	0.128	-0.030	0.180	No
H2	lower-level -> deep approaches	0.211	5.323	0.000	0.130	0.284	Yes
H3	higher-level -> surface approaches	-0.186	4.162	0.000	-0.263	-0.092	Yes
H4	higher-level -> deep approaches	0.431	9.520	0.000	0.335	0.512	Yes
H5	lower-level -> higher-level	0.257	5.805	0.000	0.159	0.329	Yes
H6	surface approaches -> deep approaches	-0.133	3.289	0.001	-0.205	-0.051	Yes

Table 5.20 establishes that the hypothesised paths are statistically significant ($p \leq 0.05$) except for H1. There is a positive relationship between higher-level conceptions and deep approaches, lower-level conceptions and deep approaches, lower-level conceptions and surface approaches, and lower-level conceptions and higher-level conceptions. However, higher-level conceptions have a negative relationship with surface approaches. Similarly, there exists a negative relationship between surface approaches and deep approaches.

When examining the path coefficients, it can be concluded that higher-level conceptions ($\beta = .431$) exert the biggest influence on deep approaches when compared to lower-level COLB ($\beta = .211$). Hence, learners who adopt the higher-level conceptions tend to put more emphasis on deep strategies and deep motives. However, surface approaches have negative impacts on deep approaches ($\beta = - .133$). Students who use surface motives and surface strategies tend to neglect the use of deep motives and deep strategies while learning biology.

Effect size is a statistical concept that measures the strength of the relationship between two variables on a numeric scale. Cohen's f^2 was used for calculating effect size. According to Cohen's (1988) guidelines, $f^2 \geq .02$, $f^2 \geq 0.15$, and $f^2 \geq .35$ represent small, medium and large effect sizes respectively. The effect sizes between different factors are shown in Table 5.21.

Table 5.21

Effect Sizes

	Deep approaches	Higher-level conceptions	Lower-level conceptions	Surface approaches
Deep approaches				
Higher-level conceptions	.240			.032
Lower-level conceptions	.059	.068		.006
Surface approaches	.024			

Agreement scale: $f^2 \geq .02$ = small effect, $f^2 \geq .15$ = medium effect, $f^2 \geq .35$ = large effect

In Table 5.21, higher-level conceptions have a medium effect on deep approaches to learning (f^2 = .240). On the other hand, lower-level conceptions (f^2 = .059) and surface approaches (f^2 = .024) have small effects on deep approaches to learning. Also, the lower-level conceptions have small impacts on higher-level conceptions (f^2 = .068) and no impact on the use of surface approaches (f^2 = .006) to learning.

Additionally, adopting higher-level COLB discourages the use of surface strategies and surface motives (β = -.186) whereas the use of lower-level conceptions does not impact on the use of surface strategies and motives (β = -.805, $p > .05$, f^2 = .006). Finally, the use of lower-level conceptions including “testing, memorising, and calculating and practicing” eventually leads to the use of higher-level conceptions such as “increasing one’s knowledge, applying, and exploring real life and natural phenomena” implying that COLB are interlinked and the student cannot abstain from ultimately adopting both spectra (β = .257). However, lower COLB have small impacts on the student’s willingness to adopt higher level of conceptions (f^2 = .068).

5.5 Synthesis

This chapter explicated how the quantitative data in the first phase one of the study was collected and analysed. The internal reliability coefficients of all the scales of the COLB and ALB were determined to be acceptable. The responses of the students who participated in the quantitative survey were reported. Six COL were identified; however, this research introduced a new element of conception to learning biology which is "exploring real life and natural phenomena" instead of "understanding and seeing in a new way" as proposed by Lee et al. (2008). AL are explained by four components which are in line with the approaches to AL put forward by Kember et al. (2004). The next chapter presents the qualitative data obtained from the face-to-face individual interviews of sixteen participants chosen from among the participants of the quantitative survey.

CHAPTER 6

STUDENTS' CONCEPTIONS OF AND APPROACHES TO LEARNING BIOLOGY: QUALITATIVE FINDINGS

6.1 Introduction

A description of the findings of the quantitative phase of the study which made use of the conceptions of learning (COL) and approaches to learning (AL) questionnaires to explore Mauritian upper secondary school students' conceptions of learning biology (COLB) and approaches to learning biology (ALB) was presented in the previous chapter. Given that this study adopted an explanatory sequential mixed-methods design (see Chapter 4, Section 4.4), data from the COLB and ALB questionnaires were further supported by face-to-face individual interviews. The qualitative data obtained through the interviews were used to explicate the quantitative results.

The quantitative data presented in Chapter 5 provided answers to research questions 1 and 2. The summary statistics for students' responses to the COLB questionnaire (see Chapter 5, Section 5.3.1, Table 5.1) suggest that Mauritian students tend to hold both higher-level COLB including "increasing one's knowledge, applying, understanding and seeing in a new way" and lower-level COLB including "memorising, testing, calculating and practicing", with a strong conception of "increasing one's knowledge" and a weak conception of "calculating and practicing". However, the factor loadings of the items of the six components of COLB identified show that the "calculating and practicing" conception was predominant (see Chapter 5, Section 5.4.1, Table 5.14). Also, a new COL, "exploring real life and natural phenomena", was identified instead of "understanding and seeing in a new way".

The summary statistics for the students' responses to the ALB questionnaire (see Chapter 5, Section 5.3.2, Table 5.8) suggest that Mauritian upper secondary school students hold both deep and surface ALB with mixed motives and strategies for learning biology. However, the factor loadings of items of the four components of ALB namely, "deep motive, deep strategy, surface motive and surface strategy" identified (see Chapter 5, Section 5.4.2, Table 5.16) show that the deep motive was the predominant approach followed by the surface strategy approach and the deep strategy approach, while the surface motive was the least preferred approach. These findings suggest that the majority of Mauritian upper secondary school students had deep motives to learn biology and that they made use of the surface as well as the deep strategies to study the subject.

In the previous chapter, the quantitative results also shed light on the relationship between COLB and to ALB. The quantitative data revealed a positive relationship between higher-level conceptions and deep approaches, lower-level conceptions and deep approaches, and lower-level conceptions and surface approaches. Higher-level conceptions had a negative relationship with surface approaches (see Chapter 5, Section 5.5.2).

In this chapter, I present the qualitative data which provide answers to research questions 3 and 4. In a bid to explain the students' choice of demonstrating particular COLB and specific approaches to ALB, these areas were probed during the interviews. The questions asked of each of the 16 students interviewed and their respective responses are in Appendix K. The salient themes are supported by relevant quotes.

6.2 Students' Conceptions of Learning Biology

Seven broad themes were identified from the qualitative data which are in line with the COLB questionnaire (see Chapter 4) and the quantitative results (see Chapter 5): (1) Learning biology as memorising and reproducing, (2) Learning biology as calculating and practicing, (3) Learning biology as preparing for tests and examinations, (4) Learning biology to increase one's knowledge, (5) Learning biology as applying, (6) Learning biology as understanding, and (7) Learning biology as exploring real life and natural phenomena. The seven categories or COLB are now described, along with some students' interview quotes.

6.2.1 Learning Biology as Memorising and Reproducing

Learning biology was defined in this category as the memorisation of formulae, definitions, special terms and laws. The goal of studying biology was to effectively retain all these bits of information. Fourteen out of the 16 students interviewed revealed that they memorised certain concepts when they learn biology which includes memorising definitions, diagrams and the answers to past examination questions so that they do not miss anything, answer questions correctly and score high marks in examinations, as evidenced by the following excerpts:

> I understand definitions first and then I memorise them so that I don't miss anything for the exams so that I score maximum marks. I must also practice drawing diagrams and memorising the labelling. I make a summary of each chapter and I memorise the main points and definitions. (Student 2)

> I prepare my own notes, first I understand them, and then I memorise them. I write down the notes in my own words. Some words are difficult to remember, I repeat them several times till I remember. (Student 7)

The quotes show that the students privilege understanding before memorising. Most likely they also learned biology by replicating knowledge through rote memorisation or rehearsal. They could memorise biological information in this manner, which is a key criterion in demonstrating their scientific learning. "Memorising" appears to be a dissonant or pragmatic conception of learning given that the students write their own notes (synthesising) first and then memorise these notes ahead of exams. Preparing own notes is consistent with higher-order cognitive engagement. The excerpts also suggest that students adopted a pragmatic approach to learning biology, combining understanding and memorisation. The students understood the topics before memorising biological information. It seems that the purpose of "memorising" was mainly for securing good marks in exams.

Two of the students interviewed admitted that they did not learn biology by rote as evidenced by the following quotes:

> I can't learn so much by rote. I prefer to watch video films and read bullet points. (Student 8)

> I don't learn by rote. I prefer to write it down in my own words; then I can remember. (Student 12)

6.6.2 Learning Biology as Calculating and Practicing

In this category, biology learning was seen as a series of practicing tutorial problems, calculating and manipulating formulae and numbers. The tutorial problem-solving processes and calculation were designed to generate the correct answer. The students were quite confident that they had already learned something if they could effectively get correct answers for tutorial problems. All the 16 students interviewed revealed that they practiced questions, particularly those from past examination papers because, according to them, questions were recycled which made it easier for them to answer questions and score full marks.

The statement of Student 1 seems to indicate that the nature of the biology exams influences the students' COLB. The student practices past exam papers so as to score high marks in exams, and also to memorise answers to questions which tend to repeat year after year.

> I find that it makes it easier because when I work out past exam papers, I find that the questions are similar. There are questions which change but most of them are the same. Then, I can answer questions correctly and score maximum marks in exams. I memorise the answers, particularly those of "essay type" questions so that I may get full marks. (Student 1)

The excerpt from Student 3 suggests that he went beyond self-assessment to seek appraisal and approval of his study strategies and academic performance. He works out questions from past exam papers by himself and then seeks appraisal from the teacher.

> I read my notes and I practice past exam papers. I read the questions and their answers again and again. After each chapter, I work out classified questions. In the end, just to test myself, I work out a whole past exam paper, which I give my teacher to correct. It makes it easier for me to answer questions in tests and exams. (Student 3)

The statements of Students 4 and 6 seem to indicate that teaching strategies influence the students' COL. Noting main points (synthesis) and then memorising them is again evidence of dissonance/pragmatism, that is, doing what works.

> I work out past exam questions. The teacher gives us to work out past exam questions at the end of each chapter. It becomes easier, I think, instead of working out the questions

> when we finish the syllabus. If I can memorise the answers to past exam questions, it becomes easier because it is only 2 or 3 lines. The answer to an essay-type question would be more difficult to memorise in detail, therefore I memorise only the main points. … But we have to practice a lot of essay-type questions. (Student 4)

> The teacher gives some work to do in class. We practice the questions in class, and when I reach home, I do some research on that chapter in my biology textbook. I note the key points. Then I learn them. After that, I practice questions from past exam papers. (Student 6)

The above extracts highlight the impact of teaching strategy on students' COL. Researching, noting key points and then memorising them is again evidence of dissonance. Student 13 stated that he prepares his own notes, works out past exam questions, and practices how to draw diagrams.

> I work out past exam questions. I prepare my own notes and I practice how to draw diagrams. I work out past exam questions because they show us how the questions that usually come out are structured. Then. If I get a similar question for the exams, I can answer it very easily. (Student 13)

It appears that the student assumes that if ever in an examination he gets a question similar to that from a past exam paper, he would be able to answer it very easily. Students 15 and 16 stated that they practiced past exam questions in a bid to identify what they do not know, and eventually bring corrective measures.

> The first step is to read my notes, try to understand their meaning. Once it is done, I study to grasp the concept and then perhaps go towards the past exam papers to find out which type of questions I can get for the exams. I work more of past exam papers to see what my mistakes are and then correct them but, also to review all that I thought I knew but in fact I don't know. When exams are near, I will perhaps work a bit more on past exam papers. (Student 15)

> The teacher gives questions to work on at home. When he corrects them, I know what the mistakes that I have done are and also how to answer the questions. (Student 16)

Instructional strategies may have influenced students to learn biology by calculating and practicing. Formulas, equations, and computations are frequently used to convey scientific knowledge in biology textbooks and educational activities. Many students may be proficient at computing the right answer to a biology problem, but they might not fully comprehend the answer's significance or the nature of the issue. These students saw learning biology as a process of becoming accustomed to formalities and algorithmic processes. It appears that students also practice past exam papers for self-assessment, indicating a deep motive for learning biology. It also appears that teaching and learning to test are very dominating in this context.

6.2.3 Learning Biology as Preparing for Tests and Examinations

Students in this category conceptualised learning biology as test and exam preparation. The nature of the examination seems to influence learners to view learning as tests and exam preparation. The purpose of learning biology was to pass examinations or to score high marks on tests and examinations. For example, Students 2, 15 and 16 responded as follows:

> When I work out past exam questions, I find that sometimes questions repeat. You can predict which questions may come out for the exams. Sometimes if you have already worked out a question, and it comes out, it becomes easier to answer the question. I also consult the examiner's comments. How to answer the question. The examiner also tells you for which answers you get maximum marks, and for which answers you don't get marks. Working out questions allows me to score maximum marks in exams… I understand definitions first and then I memorise them so that I don't miss anything for the exams so that I score maximum marks. I must also practice drawing diagrams and memorise the labelling. (Student 2)

> In fact, it's more about how to prepare for the exams because one can see which type of questions are given and, what is interesting is that the same type of questions repeats. Finally, I become used to how to answer correctly and how I can get maximum marks. (Student 15)

> The teacher gives questions to work on at home. When he corrects them, I know what are the mistakes are and also how to answer the questions. When I work out past exam

questions, I refer to my notes. It’s a way for me to better understand the chapter and learn it at the same time. Most of the time, the questions repeat. It becomes easier if you know what to write. I memorise definitions and main points so that I don’t forget and score maximum marks in the exams. (Student 16)

It appears that importance of success in tests and examinations was highly valued by students in this category. The standard for learning outcomes assessment was primarily determined by test scores.

6.2.4 Learning Biology to Increase One’s Knowledge

The main feature of learning biology in this category was seen as an increase in knowledge. The primary goals of learning biology were the acquisition and accumulation of (correct) biological knowledge. All the 16 students interviewed revealed that they learned biology to increase their knowledge. The statements made by the students seem to indicate that viewing “learning biology as increasing one’s knowledge” implied a dual perspective.

On one hand, the following statements made by Students 1 and 7 seem to imply that they conceived increasing one’s knowledge as the discovery of the unknown:

> There are things that I didn’t know in the past, but which I came to know when I learned biology. There are things which I was not doing well in the past but now that I know, I know what to do. (Student 1)

> Yes. I have learned a lot about things I did not know before. For example, how my body functions, how plants carry out photosynthesis, carbon cycle, greenhouse effect, pollution, how animals and plants reproduce. (Student 7)

On the other hand, the following statement made by Student 10 seems to indicate that this conception refers to the acquisition and accumulation of knowledge:

> There are videos that show, for example, how and why we have to recycle plastic, paper, glass. There are also videos which show the causes of pollution, how to conserve forests, how animals and plants reproduce, the process of photosynthesis and many other topics. (Student 10)

6.2.5 Learning Biology as Applying Knowledge

Learners in this category emphasised the significance of applying biology to real-world settings. As a result, the goal of biology learning was to apply previously acquired knowledge. All the 16 students interviewed stated that they applied what they had learned in biology in new contexts and in their everyday life (real-life situations). Students understood the application of and/or applied their knowledge of biology in their everyday lives, for example, to maintain personal hygiene, observe a balanced diet, take preventive measures against diseases, and avoid substance abuse. Students 1, 2, 10, and 16, for example, responded as follows:

> There are things that I didn't know in the past, but which I came to know when I learned biology. There are things which I was not doing well in the past, now that I know, I know what to do. … For example, a balanced diet, reproductive system, how my body works. Sometimes I share this information with my family. (Student 1)

> There are topics like pollution, genetics, biotechnology, biodiversity that have increased my general knowledge. For example, Covid 19; I know that it is caused by a virus, and I know what a virus is. Topics like balanced diet and taking care of the teeth helps me to stay in good health. (Student 2)

> Yes, for example, I used to brush my teeth only in the morning. The teacher has explained why we must also brush our teeth at night. Now I brush my teeth both in the morning and at night. (Student 10)

> I have learned how to take care of my body. I also avoid alcohol, cigarette and drugs because they can cause harm to my health. (Student 16)

According to these interview responses, learning biology for these students involved not only applying what they learn to resolve various problems but also improving life quality. The students' responses seem to suggest that "applying" had dual meaning for the students; applying knowledge in new contexts and applying knowledge in everyday life situations. This is an unexpected finding. It should be noted that "applying," which involves knowledge and development of intellectual skills, is considered a cognitive ability under Bloom's taxonomy and is defined as the use of information in a new situation (Adams, 2015).

6.2.6 Learning Biology as Understanding

Students conceptualised learning biology as achieving a genuine comprehension of relevant knowledge. Learning biology means comprehending the connections between biological concoctions. They knew that they had learned something when they really understood biological concepts. All the 16 students interviewed acknowledged that they studied biology to understand biological concepts. For instance, Students 2 and 4 stated the following:

> I ask my teacher to send me “links”. When I watch the videos on the internet, I find that it explains more in detail. The “links” help me to understand the topic better. When it is done in class, it takes me some time to understand it. When I watch videos on that topic, I understand it better. (Student 2)

> When the teacher has finished explaining a topic, at home, I watch films on that topic on YouTube. This enables me to understand the topic better. I understand the topics better because they are visual. (Student 4)

The statements of the students seem to indicate that the teacher uses online resources (technology) as a scaffolding strategy and technique to enable the student to better understand a biology topic. The students’ learning styles also play a significant role in their COL. It appears that the student uses technology (online resources) as a self-learning strategy to better understand biology topics.

Student 8 stated that he watches video films on YouTube to better understand a particular biology topic.

> In fact, for me, it depends on the chapter that I have to learn. There are certain chapters that are interesting. I find that I understand them and I can learn them. For example, “inheritance”. We have not yet done it, but it is a chapter that I want to do because I can understand certain things. There are other chapters that are easy for me to learn because I am interested and I know that I can understand how my body works. When a chapter is bulky and there is a lot of information to learn, I watch video films on YouTube. There are cartoon versions that help me to better understand the topic. When I do practicals in the laboratory, I understand the chapter better. (Student 8)

This indicates the impact of the complexity of the biology content on COL. The student is intrinsically motivated for a deep understanding of the topic. It also indicates that teaching and learning strategies have an impact on understanding. Watching video films is a learning strategy used by the student to cope with challenging topics. Investigations are carried out in the laboratory to achieve understanding.

Students 9 and 14 stated that they sought the help of the teacher whenever they had difficulties understanding a particular chapter in biology. Student 14 further stated that teaching and learning aids such as the DNA model enabled them to better understand the topic and remember.

> The explanation given by the teacher in class is very important to understand the chapter. I must understand it first and then I can learn it. Sometimes I work out questions in past exam papers and I have to write to be able to understand and remember. I read my notes again. Whenever I don't understand something, I seek the help of my teacher. (Student 9)

> It becomes easier for me to understand when the teacher uses models to explain and makes us manipulate the models. For example, I constructed a DNA model; it has become easier for me to understand and remember. Whenever I get encounter difficulty in a chapter, I go and see my teacher. Then he explains it to me again. When it has been explained in class, then, to enable me to better understand what the teacher has explained, I look for that topic on YouTube. Sometimes the teacher sends me videos. (Student 14)

It appears that teaching strategies, learning strategies and scaffolding have an impact on the students' understanding of biology topics.

6.2.7 Learning Biology as Exploring Real Life and Natural Phenomena

In this category, students view learning biology as a process to develop biological thinking to obtain new ways of thinking and biologically interpret things in real life. Students feel that they have learned something if they can interpret real life and natural phenomena. The "exploring real life and natural phenomena" conception of learning emerged during the quantitative data analysis. All the 16 students interviewed showed interest in biology topics related to real life (e.g., reproduction, growth and development, energy processing, regulation, response to the environment and evolutionary adaptation) and natural phenomena (e.g., photosynthesis, metabolism, respiration, fertilisation and transpiration). If all the interviewees had similar views, then a salient theme would either be dissonance or pragmatism. Dissonance implies that they were not conscious of what they were doing and pragmatism implies that they knew what they were doing. However, it appears that the students consciously adopted the “exploring real life and natural phenomena” conception of learning biology as evidenced by the extracts below.

For instance, Student 7 stated that visits to places of biological interest made it easier to understand biology topics, such as biodiversity.

> When there are outings, for example on an island like “Ile aux Aigrettes”, it helps me to better understand biodiversity, you interact with nature. Once there was a caravan which came to school. They brought a microscope and showed us very interesting slides. They also showed us films on coral reefs. We visited the “Rajiv Gandhi Science Centre”. I saw very interesting things there. (Student 7)

Students 9 and 12 stated that watching films on topics such as respiration, photosynthesis, nutrition, ecology, pollution, inheritance, and wildlife helped them to better explore real life and natural phenomena.

> I watch films on YouTube after the teacher has explained a topic on biology. Films on reproduction in animals and plants, respiration, photosynthesis, nutrition, ecology, pollution and inheritance. (Student 9)

> I watch video films on YouTube. It is well explained. I understand it better and I learn many additional things which are related to the chapter. For example, wildlife, pollution and all that. (Student 12)

6.3 Students' Approaches to Learning Biology

AL refer to the ways or methods that students or learners learn or process their academic tasks. Four broad themes were identified from the qualitative data namely, "surface motive, surface strategy, deep motive, and deep strategy".

6.3.1 Surface Approaches to Learning Biology

The surface AL has two subscales: surface motive and surface strategy. All 16 students interviewed stated that they practiced past exam questions and most of them revealed that they memorised important themes so that they can answer questions correctly and score maximum marks in exams.

6.3.1.1 Surface Motive.

In this category, extrinsic motivations drive biology learning, such as learning biology to meet educator or parent expectations or to achieve better grades. All 16 students interviewed stated that they learned biology to do well in exams. For example, Student 12 and 15 stated:

> I practice past exam questions because they can come out again for the exams. … So that I know what mistakes I have done and so that I do not repeat the same mistakes for the exams. Thus, I minimise the number of mistakes. My aim is to minimise mistakes in the exams. (Student 12)

> In fact, it's more about how to prepare for the exams because one can see which type of questions are given and, what is interesting is that the same type of questions repeats. Finally, we become used to how to answer correctly and how we can get maximum marks. (Student 15)

The above quotes seem to suggest that the students learned biology not just to obtain passing marks but to score maximum marks in examinations. Therefore, it appears that tests and examination preparation is considered a deep motive for learning biology in the Mauritian context.

6.3.1.2 Surface Strategy.

In this category, biology is learned through surface strategies, such as memorising specific terms or parts, to pass class exams. All the 16 students interviewed revealed that they memorised definitions, formulae, laws, and special terms, and also practiced questions in a bid to prepare for tests and exams. For example, Student 2 and 16 responded as follows:

> When I work out past exam questions, I find that sometimes questions repeat. You can predict which questions may come out for the exams. Sometimes if you have already worked out a question, and it comes out, it becomes easier to answer the question. I also consult the examiner's comments. How to answer the question. The examiner also tells you for which answer you get maximum marks, and for which answers you don't get marks. … Working out questions allows me to score maximum marks in exams. … I understand definitions first and then I memorise them so that I don't miss anything for the exams so that I score maximum marks. I must also practice drawing diagrams and memorise the labelling. (Student 2)

> The teacher gives questions to work at home. When he corrects them, I know what are the mistakes that I have done are and also how to answer the questions. … When I work out past exam questions, I refer to my notes. It's a way for me to better understand the chapter and learn it at the same time. Most of the time, the questions repeat. It becomes easier if you know what to write. … I memorise definitions and main points so that I don't forget and score maximum marks in the exams. (Student 16)

The above quotes seem to suggest that the students use surface strategies such as "memorising" and "practicing past exam questions" to prepare for exams because they believed that these strategies would enable them to score maximum marks in exams.

6.3.2 Deep Approaches to Learning Biology

The deep AL consists of two subscales: deep motive and deep strategy. All the 16 students interviewed admitted that they learned Biology to understand biological concepts in a bid to increase their knowledge, to explore real life and natural phenomena, and to enable them to apply what they have learned in everyday situations.

6.3.2.1 Deep Motive.

Learning biology is stimulated by intrinsic motivation of the students, for example, their own interest and curiosity in this category. All the 16 students interviewed revealed that they learned biology to increase their knowledge, which they eventually applied in new contexts and in everyday life situations, as evidenced by the quotes of Student 1 and 7:

> There are things that I didn't know in the past, but which I came to know when I learned biology. There are things which I was not doing well in the past, now that I know, I know what to do. … For example, balanced diet, reproductive system, how my body works. Sometimes I share this information with my family. … Sometimes I watch films on YouTube. For example, I didn't understand how cells developed during reproduction. Those films have helped me to understand. (Student 1)

> I have learned a lot about things I did not know before. For example, how my body functions, how plants carry out photosynthesis, carbon cycle, greenhouse effect, pollution, how animals and plants reproduce. … Now I know what to eat to remain healthy. I know what effect pollution has on the environment. … I watch films on YouTube at home. I do some research. When there are outings, for example in an island like "Ile aux Aigrettes", it helps me to better understand biodiversity, you interact with nature. Once there was a caravan which came to school. They brought a microscope and showed us very interesting slides. They also showed us films on coral reefs. … We visited the "Rajiv Gandhi Science Centre". I saw very interesting things there. (Student 7)

The above quotes seem to suggest that the students had deep motives to learn biology because they stated they learned the subject to increase their knowledge, which they applied in every day and real-life situations.

6.3.2.2 Deep Strategy.

In this category, biology is learned when using more meaningful strategies, for example, trying to acquire coherent understandings or making connections with prior knowledge. All the 16 students interviewed acknowledged that they adopted the deep strategies such as "understanding and exploring real life and natural phenomena" to learning because they had deep motives such as “increasing one’s knowledge and applying” to learn biology, as evidenced by the quotes of Student 2 and 4:

> There are topics that help me understand how my body functions. There are topics like pollution, genetics, biotechnology, biodiversity that have increased my general knowledge. For example, COVID-19; I know it is caused by a virus, and I know what a virus is. Topics like balanced diet, care of the teeth helps me to stay in good health. I ask my teacher to send me ‘links’. When I watch the videos on internet, I find it explains more in detail. The ‘links’ help me understand the topic better. When it is done in class, it takes me some time to understand it. When I watch videos on that topic, I understand it better. There are topics like pollution, genetics, biotechnology, biodiversity that have increased my general knowledge. (Student 2)

> When the teacher has finished explaining a topic, at home, I watch films on that topic on YouTube. This enables me to understand the topic better. I understand the topics better because they are visual. There are films on the environment, on genetically modified organisms which are very interesting. Topics on environment, ecology, microorganisms, genetics. … There are topics like nutrition. I try to eat a balanced diet but sometimes it is not possible. There is a topic on care of the teeth; this I do apply. (Student 4)

6.4 Synthesis

In this chapter, a thematic analysis of the face-to-face individual interviews was carried out. The interviews involved a total of 16 participants purposely selected from the participants of the quantitative study. The aim of the qualitative aspect was to explain the findings of the initial quantitative study. The qualitative data revealed that Mauritian upper secondary school students had a tendency to use both the lower-level conceptions such as “memorising, testing, calculating and practicing”, and the higher-level conceptions such as “increasing one’s knowledge, applying, understanding and, exploring real life and natural phenomena” to learn biology. It should be noted that whilst both the quantitative and the qualitative data identified a new conception of learning “exploring real life and natural phenomena”, the qualitative data also identified the “understanding” conception of learning. The qualitative data revealed that “applying knowledge” had dual meaning for the students: applying knowledge in new contexts, and applying knowledge in everyday life situations. This was an unexpected finding. Another unexpected finding was that the students used online resources (technology) as a self-learning strategy to better understand biology topics. The teaching strategies also seemed to influence the students' COL and AL. The main reasons given by the students as to why they used particular COLB were because they wanted to understand the biology topics and because they wanted to score maximum marks in exams.

The data also revealed that the students tended to employ both the surface and the deep ALB. The deep motive to ALB was dominant, and the students employed both the surface and the deep strategies to learn biology. The students revealed that they used the deep strategies because they wanted to understand the biology topics, and the surface strategies because they wanted to score high marks in exams.

The qualitative data were used to explain the quantitative data. Coupled findings in terms of their relationship with literature are discussed in the next chapter.

CHAPTER 7

DISCUSSION OF FINDINGS

7.1 Introduction

The previous two chapters related the main findings from the quantitative research (see Chapter 5) and the qualitative research (see Chapter 6). This chapter provides a discussion of the major findings of the study conducted to explore Mauritian upper secondary school students' COLB and ALB. The research was conducted in twenty secondary schools in Mauritius. There were 497 students who participated in the study. The reviewed literature aided me in obtaining perspectives from other authors on students' COL and AL by comparing existing knowledge and study findings. This study used a mixed method approach, with data collected through questionnaires and interviews. The questionnaires were extremely useful in the study because students provided information on their COLB and ALB. Face-to-face individual interviews also helped me in gathering the necessary information on the participants' COLB and ALB through their experiences, feelings, and opinions.

In this chapter, the research findings (quantitative and qualitative) are discussed in terms of the themes that were identified during data analysis. These discussions are based on the findings generated from the data that were gathered. The purpose of doing this was to establish a connection between existing knowledge and the knowledge gained from the study. This chapter presents the coupled findings of the quantitative and qualitative surveys by relating them to the critical questions raised in Chapter 1 while focusing on the scope within which these questions have been addressed, as well as the unexpected outcomes. The study set out to explore Mauritian upper secondary school students' conceptions of and ALB. Some crucial concerns are not addressed in the general theoretical literature on this topic, particularly in the Mauritian context.

The main findings from the quantitative data and the qualitative data are reported and discussed next in terms of their relationship to the literature and in light of the education system in Mauritius. At the end of this section, I outline additional key findings that were prominent but were not directly associated to the research questions.

7.2 Mauritian Upper Secondary School Students' Conceptions of Learning Biology

Students who participated in the study expressed their opinions about their conceptions of learning biology (COLB). The following COL emerged from the data (see Chapters 5 & 6) "memorising, calculating and practicing, testing, increasing one's knowledge, applying, understanding, and exploring real life and natural phenomena". These COL, are similar to those identified by other researchers such as Chiou et al. (2012), Lee et al. (2008), Tsai (2004), and Tsai (2010).

The findings of this study have similarities with previous studies on COL, and also differences. Six of the conceptions identified in this study are similar to those identified in other studies (e.g., Chiou et al., 2012; Lee et al., 2008; Li et al. 2013; Liang et al. 2015; Park and Jeon, 2015; Shen et al., 2016), namely, "memorising, testing, calculating and practicing, increasing one's knowledge, applying, and understanding". However, this study revealed an additional conception of learning, which had not previously been discussed, "exploring real life and natural phenomena." In addition, this study did not show the presence of the "seeing in a new way" conception of learning as reported in earlier studies (Chiou et al., 2012; Lee et al., 2008; Tsai, 2004). In this respect this study's findings are in line with the study of Tsai (2004) who found out that very few students possessed the COL as "seeing in a new way" which led Lee et al. (2008) to group "understanding" and "seeing in a new way" into on factor called "understanding and seeing in a new way".

7.2.1 Learning Biology as Memorising and Reproducing ("Memorising")

The data indicate that most of the participants in the research considered "memorising" as a part of the learning process in terms of memorising definitions, important concepts, teachers' notes, facts, and what the teacher discusses about in class. The participants emphasised the importance of learning by rote, and memorising when describing learning as memorising or remembering information. The "memorising" conception of learning biology (COLB) identified in this study is in line with the theoretical framework and the studies carried out by researchers such as Chiou et al. (2012), Li et al. (2013), Liang et al. (2015), Park and Jeon (2015) and Shen et al. (2016) who also identified the "memorising" conception as a subscale of COL.

The participants in this study revealed that they understood the topics first before memorising them. It appears that the students use memorising as a precursor to understanding. According to the students, memorisation and repetition aided them in achieving high marks in exams. This study's findings align to the findings of Marton et al. (1996) and Zhu et al. (2008) who discovered that Chinese pupils regarded memorisation as a means of better understanding what they had learned, and they saw repetition as important in developing memorisation. This study's findings are also similar to those of Dahlin and Watkins (2000) who found that Chinese pupils used memorisation as a technique for improving their understanding of previously studied content. On the other hand, this study's findings are different from those of Marton et al. (1996) who revealed that memorisation was seen by Uruguayan students as a by-product of studying instead of a process that helped them grasp things better. This study's findings are also different from those of Dahlin and Watkins (2000) who revealed that German students used memorisation to reinforce their comprehension.

In general, it is now accepted practice to promote pupils' comprehension rather than memorization (Dahlin & Watkins, 2000). This is due to the notion that remembering and understanding seem to be mutually exclusive ideas. It also implies that students' emphasis on cramming hinders their comprehension of material that is unfamiliar to them when it comes to learning biology (Chiou et al., 2012; Momsen et al., 2010). Even so, educators contend that pupils can successfully complete learning activities by combining the processes of memorization and comprehension (Marton et al., 2005; Tsai et al., 2011). Some students think that memorization enhances their knowledge of the material as they learn it (Dahlin & Watkins, 2000; Kember, 1996, 2000; Marton et al., 1997). In order to make sense of and grasp biological knowledge, biology education researchers emphasize the importance of conscious memorization (Anderson & Schönborn, 2008). The discussions that have resulted on the role of memorization and comprehension in learning biology have created the study space to look at these two perceptions of students in biology-related topic domains.

7.2.2 Learning Biology as Preparing for Tests ("Testing")

The data showed a moderate agreement score (M = 3.10) for "testing" (see Chapter 5, Section 5.3.1, Table 5.1). Students' responses indicate that they agreed that the purpose of "testing" (test preparation) was to ensure that they became more familiar with test materials so that they answered questions correctly in exams. However, the data (see Chapter 6) also revealed that all the students interviewed stated that they prepared for tests and exams (testing) by reviewing their notes, practicing past exam questions, and memorising definitions and diagrams because they wanted to attain good marks in tests and exams. The “testing” conception of learning biology identified in this study aligns with that of other studies, for example, Chiou et al. (2012), Li et al. (2013), Liang et al. (2015), Park and Jeon (2015), and Shen et al. (2016).

A study carried out by Tsai (2004), which examined the COL of Taiwanese high school pupils in the science domain, revealed that their COL such as studying for exams were shaped by culture, creating a unique educational environment in Taiwan. Tsai claimed that culture may have a significant impact on parental expectations and education, which may then have an effect on students' beliefs about learning. In Mauritius, several assessments at the national and school levels continue to be crucial in assessing students' performance and determining their eligibility for higher studies. Teachers, parents, and students frequently draw attention to test results. In addition, biology is usually a subject in school where exam success is challenging (Maulloo & Naugah, 2017). For many students, there is a direct correlation between learning biology and test scores, which are frequently low (Maulloo & Naugah, 2017). Mauritian students may therefore view learning biology as nothing more than studying for tests and exams. Cambridge International Examinations (CIE) data suggest that Mauritian students perform very well compared to students from other countries. This might explain the sharp focus of Mauritian students on tests and examinations.

7.2.3 Learning Biology as Practicing Tutorial Problems (“Calculating and Practicing”)

Calculating and practicing corresponds to a quantitative stance of learning. The data revealed that a smaller number of students made use of the “calculating and practicing” conception as compared to the other COL (see Chapter 5, Section 5.3.1, Table 5.1). However, the data also revealed that all the 16 students practiced past exam questions to familiarise themselves with tests and exams materials to score high marks in exams. In an earlier study Tsai (2004) discovered that, contrary to domain-general learning, at least one type of COL, "calculating and practicing tutorial problems," was exclusive to science.

The data (see Chapter 5) revealed that the mean score for “calculating and practicing” was the lowest of all the six factors of the COLB. This was in line with the study on COLB and ALB carried out by Chiou et al. (2012) among undergraduate students in Taiwan. However, this study’s findings were unlike the findings of the study carried out by Yang et al. (2019) on approaches to and conceptions of learning mathematics in China whereby "calculating and practicing" was the leading factor among all the six factors of the COL mathematics. This may be because the domain-specificity of mathematics encourages students to conceptualise "calculating and practicing" more than science-related subjects such as biology. In fact, according to Yang et al. (2019), calculating and practicing exercises are an essential part of learning mathematics. Furthermore, Cai and Nie (2007) stated that because of exam pressure in China, pupils are frequently involved in massive quantities of practice of various skills to solve various types of problems solve them rapidly.

The data also revealed the students practiced past exam questions intensively to score high marks in tests and examinations. The practice of past exam questions was encouraged by the teacher who used it as a strategy to prepare students for tests and examinations. It appears that the practice of past exam questions is a teaching and learning strategy typical to the Mauritian education context.

7.2.4 Learning Biology as the Increase of Knowledge ("Increasing One's Knowledge")

The data (see Chapter 5, Section 5.3.1, Table 5.1) showed a high mean agreement score (M = 4.16) for "increasing one's knowledge." The learners believed that learning biology entails acquiring and expanding their knowledge of nature, biological facts, natural phenomena, and new information. All the students who took part in the qualitative survey stated that they learned biology to increase their knowledge. However, the data revealed that views about the "increasing one's knowledge" COLB implied a dual viewpoint. On the one hand, this conception might be a lower-level COLB and might refer to the gathering and acquiring of knowledge. On the other hand, it may be seen as the discovery of the unknown, which would share the essence of a productive higher-level COLB. This was similar to the findings of Chiou et al. (2012), Lee et al. (2008), Lin and Tsai (2009), Park and Jeon (2015), and Tsai (2004). In their analysis, Lee et al. (2008) concluded that given this dual viewpoint, "increasing one's knowledge" does not totally correspond to either the lower-level or higher-level COLS.

It is worth noting that, according to Säljö (1979), the most basic learning conception was "increasing knowledge," and that, five decades later, despite all technological advances in information access, this is still the most salient COL for Mauritian secondary school learners.

7.2.5 Learning Biology as Application of Knowledge ("Applying")

The data revealed a moderate agreement score for the "applying" conception of learning. The students believed that learning biology allowed them to apply methods, skills, and knowledge to unknown problems, solve real-life problems, and thus improved their quality of life. The data also revealed that "applying" knowledge had dual meaning for the students; applying knowledge in new contexts, and applying knowledge in everyday life situations. These findings are in line with those of Park and Jeon (2015) who concluded that learners who viewed science education as the process of using information to solve new problems and understanding the relationship between various scientific notions were intrinsically motivated and employed constructive methods to acquire scientific knowledge.

7.2.6 Learning as Exploring Real Life and Natural Phenomena ("Exploring Real Life and Natural Phenomena")

The data revealed a new conception of learning; "exploring real life and natural phenomena." The data also revealed that the students found it more interesting to learn biology by exploring real life and natural phenomena which enabled them to better understand certain biology topics. The students interviewed stated that the use of online resources and visits to places of biological interest enabled them to explore real life and natural phenomena. In his study on conceptions of learning science (COLS) among Taiwanese high school pupils, Tsai (2004) identified a similar COL: "developing new perspective on natural phenomena." However, no other study has been able to identify this COL.

7.2.7 Learning Biology as Understanding ("Understanding")

The "understanding and seeing in a new way" conception of learning did not emerge from the data (see Chapter 5, Section 5.4.1, Table 5.14). However, the data revealed that the students used various techniques, such as self-learning and the use of online resources to understand biology topics which means that the students adopted the "understanding" conception to learning biology. These findings are in line with those of Tsai (2004) who found that very few students possessed the COL as "seeing in a new way" which led other researchers such as Chiou et al. and Lee et al. (2008) to group "understanding" and "seeing in a new way" into a single factor called "understanding and seeing in a new way." The "understanding" COL identified in this study corroborated with Park and Jeon's (2015) findings which revealed that "understanding" was related with the qualitative COL because it focuses on how effectively students learn.

The data also revealed that the students believed that understanding biology topics made it easier for them to learn these topics, which made it easier for them to answer questions correctly and to score high marks in tests and exams.

7.3 A Unique Structure of the Outcome Space

The outcome space in this study has a unique structure for Mauritian upper secondary school biology students. The outcome space has traditionally been regarded as hierarchical, with some conceptions proposed to be at lower levels and others at higher levels. However, this study adopts Bonsaksen and Thorrisen's (2017) structure in which all categories of COL have an equal status with no category inferior or superior to others. The six items of COL might preferably be used as a unidimensional scale with all the six items reflecting different aspects of one higher-order concept of learning, instead of considering them to be two different lower-level and higher-level conceptions, as considered originally.

The participants of this study identified all seven categories and none of the learners regarded biology learning as "memorising" or "understanding or increasing one's knowledge" prioritised one before the other. On the contrary, they considered their experiences and perspectives in each category to be crucial to their biology learning processes and motivations. This finding upheld the non-stratified structure of this research.

The data collected from the learners implies that the lower-levels of some of the COL in Marton et al.'s (1993) nested hierarchy, namely "memorising and reproducing, testing, and calculating and practicing", which were also found in this study, will include its upper-levels of COL. In Marton et al.'s (1993) hierarchy, for example, "memorising" is considered as a lower-level COL, while "understanding" is considered as a higher-level COL. "Understanding," according to their nested hierarchy include "memorising", but "memorising" is exclusive to "understanding". Nevertheless, the literature (Ho, 2020; Marton et al., 1993) and the current study show that "memorising" frequently occurs before or after a deep comprehension of the content being memorised.

Mauritian students consider memorising and comprehension to be intertwined and not mutually exclusive. Even though the literature backs the integration of memorisation and understanding as unique to Chinese learners, researchers (Chiou et al., 2012; Li et al., 2018; Park & Jeon, 2015; Tsai, 2004) continue to classify memorising as a lower-level COL.

The variation in students' COLB stems from differences between learners relative to the sub-categories rather than variations in the seven categories that comprise the outcome space, which forms a holistic circular structure. All the students surveyed, for example, would eventually take part in tests and exams. However, different students would attend to the tests and exams dependent on their individual priorities. Some learners would simply want to pass and avoid stress, while other learners would want to compete with their fellow learners and be ranked highly in class. Others would want to assess their learning processes and outcomes by taking the exams. The holistic circular structure of COL does not contradict the idea that different learners perceive and learn biology in different ways.

7.4 Mauritian Upper Secondary School Students’ Approaches to Learning Biology

The data identified the surface approaches (surface strategy and surface motive) and the deep approaches (deep strategy and deep motive) to learning biology among Mauritian upper secondary school students. These four factors for ALB (deep strategy, deep motive, surface strategy and surface motive) are similar to those proposed by Kember et al. (2004) and Lee et al. (2008). Students' ALB can be classified as surface or deep, with both having a process (strategy) component and a predisposition (motive). As revealed by the data (see Chapter 5, Section 5.3.2, Table 5.8), while students scored similarly on both the deep motive and surface motive, they performed better on the deep strategy than the surface strategy. This finding is consistent with Chiou et al.’s (2012) finding that more experienced students use deep strategies to process their biology learning tasks. Furthermore, similar scores on the surface and deep motives indicate that Mauritian upper secondary students lack a fixed or stable predisposition for learning biology. Students may instead have a dual motivation for learning biology. The nature and demands of the learning tasks may influence students' motivation to learn biology (Chiou et al., 2012; Duarte, 2007; Ramsden, 2003). When students' learning tasks only require rote-based processes or their learning loads are heavy, the surface motive is more likely to be triggered for carrying out the related learning tasks. Students may be compelled to use both types of motivations simultaneously (Lee et al., 2008). As they need to pass biology, their ALB may lead to deep conceptual understanding.

According to Biggs et al. (2022), the surface approach to learning entails responding to learning situations with the least amount of effort possible and only memorising facts as required by law. The deep approach to learning, in contrast, suggests tackling academic work out of inner motivation to learn and through an investment in comprehension (Biggs et al., 2022). However, employing a deep approach does not prevent the use of memorisation. According to Entwistle and Peterson (2004), students who opt for this approach to learning might understand that, at times or for specific purposes, comprehension may necessitate memorisation. The quantitative data of this study identified the “memorising” conception of learning among Mauritian upper secondary school students which were explained by the qualitative data. According to Biggs (1991), the "achieving approach to learning" refers to the pursuit of top grades through efficient time management. Although the deep approach appears to be the most effective method of learning, data suggests that its excessive or exclusive use may not aid in students' adaptation, necessitating a mix with the achiever approach. Lonka et al. (2004), for example, found that students who study to find purpose in their lives may become disinterested in completing their degrees.

The findings revealed that there was understanding before memorisation among Mauritian upper secondary school students. This finding is similar to the approaches to learning of Asian students. “Memorising” regards learning biology as remembering bits of biological information such as definitions, terms and formulae. In terms of” understanding”, learning biology entails making sense of natural phenomena and developing coherent scientific knowledge. Many studies on science education have revealed new relationships between these two learning conceptions and students' approaches to learning. For example, Lee et al. (2008) did a survey in Taiwan on high school students and discovered that the participants' conception of memorising was positively and significantly associated to their surface strategies and surface motive for learning science. Here, for instance, cram learning is highly influenced by fear of failure. Furthermore, students' understanding of what they are learning may enhance their deep motives (e.g., intrinsic motivation) and deep strategies (e.g., meaning-making). Chiou et al. (2012), and Hazel et al. (2002) discovered similar results in their studies of university students. Memorisation and understanding appear to contribute to students' science learning in a variety of ways. The deep/surface dichotomy has been questioned in some other studies. The significant body of research on cross-cultural studies, particularly those involving Asian students, is noteworthy in this regard (Dahlin & Regmi, 1997; Dahlin & Watkins, 2000; Kember, 2000; Marton et al., 1996; Meyer, 2000). The "paradox of the Chinese learner" is the perplexing observation that Asian students report using extensive memorisation (which seemed to indicate the presence of a surface approach) while demonstrating incredibly excellent learning outcomes (which are theoretically linked to a deep approach). In light of this, two distinct forms of memorisation have been reformulated: one that involves comprehension (either before or after memorisation) and is, therefore, a deep approach, and the other that does not and is, therefore, a surface approach (or what is often known as "rote learning") (Marton et al., 1996). Some academics have even gone so far as to say that a new strategy, distinct from the traditional deep and surface approaches, should be developed that incorporates both knowledge and memorisation (Kember, 1996).

The use of surface approaches to learning may be related to the nature of the biology examination. There is evidence of repetition of questions, so, this may influence how students study. They memorise what they feel will be examined. According to Bloom's taxonomy, memorisation, which is referred as remembering, is the foundation of higher-order cognitive abilities. The question arises as to whether a student can demonstrate or develop a deep understanding of a biological phenomenon if they cannot remember the facts. So, it is possible that students memorise the facts first and then use this to develop a deep understanding. However, the data show that students say that "I understand and then memorise", which is the reverse and an unexpected sequence, shifting from deep motive/strategy to surface motive/strategy.

The data also revealed that the teaching strategies influenced the approaches to learning of Mauritian students. A discouraging fact is that current teaching methods do not encourage learners to adopt a deep approach. They are succeeding without feeling the need to engage with the materials for the course in a meaningful way (Biggs, 1987b; Darlington, 2019; Gow & Kember, 1990; Watkins & Hattie, 1985). Many studies show that the perceived requirements of teachers lead students to adjust their approaches to learning (Balasooriya, Toohey, & Hughes, 2009; Biggs, 1987b; Ellis & Bluic, 2019; Gow & Kember, 1990; Watkins & Hattie, 1985). It appears that students prefer a surface approach to learning (Zeegers, 2001). This has been attributed to a variety of factors, including workload pressures, time constraints, and the design of assessments. It is obvious that students are smart in choosing a learning strategy they believe would help them succeed in assessments (Zeegers, 2001). Given the rapid expansion of information and technological innovation in biology, it would be ideal for students to adopt a learning strategy that they can use in a variety of professional contexts after completing their studies

The data revealed that Mauritian students held mixed motives. They held both surface and deep motives for learning biology. They learned biology not only to pass exams but also to score high marks in exams and to improve their knowledge in order to apply the knowledge gained in everyday life and real-life situations. According to Chiou et al. (2012), students who perceived biology learning as calculating and practicing, applying, understanding and seeing in a different way are more likely to have mixed motives, while students who perceived chemistry learning as memorising and transforming also have mixed motives.

7.5 Relationship Between Mauritian Upper Secondary School Students' Conceptions of Learning and Approaches to Learning Biology

The findings of this study revealed that Mauritian students' COLB were associated with their ALB. This is consistent with existing literature such as Chiou et al. (2013) and Li et al. (2013) who found that COLB were positively related to ALB. This study revealed that Mauritian students' lower-level COLB had a significant and positive effect on the surface ALB, and the higher-level COLB influenced deeper ALB. Thus, students with lower-level learning conceptions tended to use surface AL, whereas students with higher-level learning conceptions often associated with deep AL. Studies carried out by researchers such as Chiou et al. (2012), Dart et al. (2000), Edmunds and Richardson (2009), Ferla et al. (2008), Lee et al. (2008), Minasian-Batmanian et al. (2006), Park and Jeon (2015), Lee et al. (2008), Liang et al. (2015), Shen et al. (2016), and van Rossum and Schenk (1984) had similar findings. They revealed that lower-level COL influenced surface approaches while higher-level conceptions influenced deep approaches to learning. In the context of this study, Mauritian students were more prone to learn biology by reciting if they thought of biology learning as memorising what is taught in class, preparing for a test, or calculating and practicing. The students, however, held deep motives and used meaningful strategies to learn biology when they saw it as increasing knowledge, applying knowledge, or understanding and seeing knowledge in a new way.

The data also revealed that Mauritian lower-level COLB had positive effects on deep ALB. These findings corroborate the findings of Park and Jeon (2015) who concluded that "even quantitative conceptions can lead to the adoption of constructive approaches depending on the intention and purpose of the study" (p. 1147). These findings could be explained by the examination-centred school culture prevalent in Mauritius. In a study carried out on secondary education in Mauritius, Maulloo and Naugah (2017) made the following observations:

> The present system is results-oriented in that educators and students see attaining good results as the clear primary objective. The reason is that a limited number of scholarships (Laureateship) for further studies are awarded to top achievers based on the aggregate HSC results. (p. 21)

The paradoxical finding of this study that lower-level COL is correlated positively to deep approaches to learning requires explanation. Biggs (1993) identified a desire to accurately recall previously understood information in a high-stress scenario such as a debate or examination, as possibly incorporating rote learning. However, he emphasised, in that context, that it may be part of a deeper approach. He described this approach as "deep memorising." Biggs also highlighted research by Hess and Azuma (1991) who revealed that Japanese and Chinese students believed that memorisation could lead to knowledge, and because the goal here is clearly to deep understanding, a memorisation strategy becomes part of a deep approach in this case. Memorisation may be linked to deep learning approaches for students who memorise material taught in class after learning it, particularly for Mauritian students.

Furthermore, the data revealed that higher-level COLB had a negative influence on surface ALB. Students with higher-level learning conceptions were less prone to have surface motivations and adopt surface strategies to learning biology. This is contrary to the findings of Liang et al. (2015) which revealed that Taiwanese students with higher-level COL computer science also expressed surface motivations for learning. This is also different from the findings of Li et al. (2013) who indicated that the higher-level conception "learning chemistry by transforming" was positively linked to a surface motive for learning chemistry. However, the data of this study also indicated that Mauritian students held both deep and surface motives and therefore employed both the deep and surface strategies to learn biology. Lonka et al. (2004) noted that while a deep approach to learning may be preferable, it is not necessarily the most effective method of learning for all students. Entwistle (1997b) concluded that the memorising techniques used in a surface approach can also be used as strategies in a deep approach to learning.

This study's findings point to the significant correlations between conceptions and learning approaches. Similar to students who support experiential COL, students who exhibit qualitative (higher-level) COL would usually use deep learning approaches and reduce the use of surface AL. Students who approach learning quantitatively, on the other hand, are more willing to employ surface approaches. Nevertheless, there is also a positive relationship between quantitative (lower-level) conceptions and deep learning approaches. When comparing higher-level COLB to lower-level conceptions, it can be seen from the path coefficients (see Chapter 5, Section 5.4.2) that higher-level conceptions have a greater impact on deep approaches. Students who adopt higher-level conceptions thus tend to lay more emphasis on deep strategies and deep motive. Deep approaches, however, are negatively impacted by surface approaches. When learning biology, students who utilise surface motives and surface strategies frequently overlook the value of using deep motives and deep strategies. Therefore, it seems that the adoption of deep learning approaches is likely to be hindered by the use of surface AL. The data also indicates that higher-level conceptions had a moderate impact on deep learning approaches. Lower-level conceptions and surface AL, on the other hand, barely affected deep AL. Additionally, lower-level conceptions had negligible effects on higher-level conceptions and no influence whatsoever on the application of surface AL. Using lower-level COLB did not affect the use of surface strategies and motives, whereas using higher-level conceptions discouraged using them.

Last but not least, this study's findings revealed that the use of lower-level conceptions (testing, memorisation, calculating and practicing) eventually leads to the use of higher-level conceptions (increasing one's knowledge, applying, and exploring real-life and natural phenomena), suggesting that COLB are interconnected and the student cannot abstain from eventually adopting both spectra. Lower COLB, however, had negligible effects on students' willingness to adopt higher conceptions. These findings are similar to the findings of Chiou et al. (2012), Park and Jeon (2015), Lee et al. (2008), Liang et al. (2015), and Shen et al. (2016).

7.6 The Influence of Teaching Strategies

The data revealed that the COLB and ALB of Mauritian students were influenced by the teaching strategies. This implies that the approaches to teaching that students encountered may have had a significant impact on their COL and, subsequently, their approaches to learning which is congruent to the findings of researchers such as Ramsden et al. (1989), and Donche et al., (2013). Students will likely have quantitative views on learning if teachers approach teaching and learning from a quantitative perspective. According to Perkins and Blythe (1993), all teachers claim to teach for understanding, but few of them do it sustainably. If that conclusion is accurate, then teachers' conceptions of teaching and learning must be changed before their students' conceptions may be adjusted. According to Gow and Kember (1993), who analysed the relevant research, changing teachers' conceptions is a difficult task.

7.7 The Use of Online Learning Technologies

The data of this study revealed that Mauritian students leveraged online learning resources to better understand biology topics. This is congruent with the findings of Ellis and Bliuc, (2019) who concluded that the use of these new tools by students was rapidly shaping the quality of their learning, and online learning technologies were becoming an essential component of the academic experience at universities. A theoretical question is raised about the nature of the association between the student approach and online technologies and how this might relate to variations in the quality of the student experience, such as perceptions of the learning context and academic achievement, when elements like online learning technologies require students to inquire regularly online. Additionally, research on approaches to learning has demonstrated a relationship between the quality of students' learning approaches and the quality of their perceptions of their learning context (Biggs et al., 2022; Prosser and Trigwell, 1999; Ramsden, 2003).

Studies have indicated that, despite some variations, positive perceptions of the learning context are associated with deep AL, whereas negative perceptions tend to be associated with surface AL. We still do not fully understand the nature of perceptions and other strategies that may aid us in modifying surface approaches to learning in a blended context. It is essential that we better comprehend the connection between the students' general AL and how they perceive the technologies in their learning context given that online learning technologies are becoming an increasingly important part of the students' approach and learning context (Ellis & Goodyear, 2013; Laurillard, 2013**)**. While some students may use technology in ways that are closely aligned with a deep learning approach, others may not comprehend the educational value of the technology and may even view it as a hindrance to learning (Ginns and Ellis, 2007). In order to describe where online learning technologies might sit and why inside the AL framework, we currently don't know enough about the underlying intentions and strategies that go along with them. Investigating students' approaches to and perceptions of the technologies is, therefore, necessary to determine how their use of online learning technologies may relate to the other elements of the AL framework.

7.8 Synthesis

This chapter examined the findings at length, and supplemented the outcomes of chapters 5 and 6 within the framework set in chapter 2, more specifically, the study's literature review. All findings were examined in light of existing literature to deduce if they upheld or extended previous findings. The qualitative findings, explained the quantitative findings as outlined in the methodology chapter. Seven COLB were identified namely, "memorising, calculating and practicing, testing, increasing one's knowledge, applying, understanding, and exploring real life and natural phenomena". The students also had recourse to online resources as a self-learning strategy to better understand biology topics. It was found that the COL were interconnected and the students could not refrain from eventually adopting both the lower-level and the higher-level conceptions. Therefore, this study proposed a unique and non-hierarchical structure for learning conceptions in which all categories of COL had equal status, represented by a circle. This study also revealed that the learners' COL influenced their AL. However, this study revealed that the students adopted hybrid approaches to learning, that is, they shifted from one approach to another depending on the demands of the task assigned to them. The next chapter deals with the summary of the findings of this study, clearly reports all emerging trends, gives a conclusion, and makes some recommendations for future research.

CHAPTER 8

SUMMARY AND CONCLUSION

8.1 Introduction

The previous chapter discussed the findings of the quantitative and qualitative data, which were compared to related literature in a bid to establish the link between the knowledge gained from this study and existing knowledge. This final chapter summarises the research problem and discusses the findings, as well as highlights the study's limitations, presents the research conclusions, and makes recommendations for future research. The conceptions of learning and approaches to learning of Mauritian upper secondary school students were the subject of this research.

This chapter comprises seven sections: **Section 8.2** summarises the key findings; **Section 8.3** discusses the implications of these findings; **Section 8.4** clearly states the contribution of the research to knowledge; **Section 8.5** examines the delimitations and limitations of the study; **Section 8.6** makes some recommendations that may guide future research; and **Section 8.7** draws the conclusions of the study.

8.2 Summary of Key Findings

This section presents a summary of the key findings is presented in relation to the research questions as listed in Section 6.1.

8.2.1 What are Mauritian Upper Secondary School Students' Conceptions of Learning Biology?

The findings from the quantitative and the qualitative data revealed that the students held the following COLB: memorising, calculating and practicing, testing, increasing one's knowledge, applying, understanding, and exploring real life and natural phenomena. These findings are similar to the COL identified in previous studies by researchers such as Chiou et al. (2012), Lee et al. (2008), Li et al. (2013), Liang et al. (2015), Park and Jeon (2015), Shen et al. (2016), Tsai (2004), and Tsai (2010), in the sense that they share certain common COL, namely, “memorising, calculating and practicing, testing, increasing one’s knowledge, applying, understanding”. These conceptions have been identified in most studies, particularly those in the science domain and related subjects such as biology, chemistry and physics. However, this study revealed a new conception of learning, “exploring real life and natural phenomena.” Liang et al. (2015) suggested that students might hold certain specific COL, besides the common ones, depending on the subject domain and the educational context. Their study, carried out in the computer science domain in Taiwan, also identified an additional conception of learning which they named “learning computer science as programming.” According to them, this may be due to how Taiwanese college students view the field of computer science.

8.2.2 What are Mauritian Upper Secondary School Students’ Approaches to Learning Biology?

The data of this study revealed that Mauritian upper secondary school students tended to adopt both the deep and the surface approaches to learning with mixed motives (deep motive and surface motive) and mixed strategies (deep strategy and surface strategy) to learning biology. According to Mogre and Amalba (2015), motives and strategies influence students' approaches to learning. The data revealed similar scores on both the deep motive and the surface motive (see Chapter 5, Section 5.3.2, Table 5.8). Similar scores on the deep and surface motives suggest that Mauritian upper secondary pupils lack a stable, or fixed, proclivity for learning biology. Instead, they may have a dual motivation for learning biology, and therefore make use of both the deep strategies and the surface strategies to learn biology. This may imply that Mauritian upper secondary school students have “hybrid approaches” to learning biology.

8.2.3 How do Students’ Conceptions of Learning Influence their Approaches to Learning Biology?

The data of this study revealed that Mauritian students had both deep and surface motives and therefore employed both the deep and surface strategies to learn biology. Students with lower-level learning conceptions tended to use surface AL, whereas students with higher-level COL tended to use deep AL. This is in line with other studies carried out in the field of science (Chiou et al., 2012; Park & Jeon, 2015; Lee et al., 2008; Liang et al., 2015; Shen et al., 2016). There was a positive relationship between higher-level COL and deep AL, lower-level COL and deep AL, lower-level COL and surface AL, and lower-level COL and higher-level COL. However, higher-level COL had a negative relationship with surface AL.

The data also seems to indicate that students who adopted higher-level COL tended to lay more emphasis on deep strategies and deep motive, whereas students who adopted the lower-level COL tended to lay more emphasis on surface strategies and surface motives. However, it seems that students who had a deep AL also made use of the surface strategies such as "memorising," and "calculating and practicing" to learn biology.

8.2.4 Why do Students have Specific Conceptions of Learning Biology?

The data seem to suggest that Mauritian upper secondary school students put a lot of emphasis on the "calculating and practicing" conception of learning biology. The participants of this study believed that practicing questions, particularly past exam questions, would enable them to answer questions correctly and score high marks in tests and exams. The "memorising" conception was also frequently used by the students in a bid to prepare for tests and exams. The education system in Mauritius is elitist. The government grants full scholarships for university education at the top universities in countries such as England and Australia to students who achieve the highest academic performance in the national Cambridge Higher School Certificate examinations at the end of secondary education. This award of laureates is a legacy of the British colonisers. Therefore, there is intense competition among secondary school students who use private tuition to boost their chances of becoming elites, thus increasing their chances of becoming laureates (Ministry of Education, Culture and Human Resources, 2008). The data also revealed that the teaching strategies had a considerable influence on the students' COL and that these teaching strategies encouraged the students to adopt the lower-level ("memorising", "calculating and practicing", and "testing") COL.

This study also revealed that the students had a proper "understanding" of biology topics, which, they believed, made it easier for them to answer questions in tests and exams. The students stated that they used online resources as a self-learning technique to better understand biology topics. They believed that understanding biology concepts made it easier for them to answer questions correctly and obtain high scores on tests and exams. A proper understanding of biology topics also enabled the students to gather and acquire new knowledge ("increasing one's knowledge"), and to discover the unknown. The students stated that they applied the knowledge gained in everyday and real-life situations ("applying"). The students also stated that learning biology by "exploring real life and natural phenomena" rendered the subject more interesting.

Studies carried out by researchers such as Chiou et al. (2012), Liang & Tsai (2010), Liang & Tsai (2013), Tsai (2004), and Tsai et al. (2011) have revealed that COL could be classified hierarchically from lower order to higher order. These studies classified "memorising, testing, and calculating and practicing as lower-level COL, while "increasing one's knowledge, applying, and calculating and practicing" were classified as higher-level COL. Furthermore, the "increasing one's knowledge" conception has a dual perspective. On the one hand, this conception might be a lower-level conception of learning biology (COLB) and might refer to the gathering and acquiring of knowledge. On the other hand, it might be seen as the discovery of the unknown, which would share the essence of a productive higher-level COLB

Therefore, this study proposes a non-hierarchical structure of COLB for Mauritian upper secondary school students with all the conceptions carrying equal status given that all the students interviewed stated that they utilised all the seven conceptions identified in this study to learn biology. Bonsaksen and Thorrisen's (2017) also drew similar conclusions, and they were of the opinion that the six COL identified in their study should be treated as unidimensional instead of lower-level and higher-level conceptions.

8.2.5 Why do Students have Specific Approaches to Learning Biology?

This study's findings revealed that the adoption of the deep or the surface AL by Mauritian students depended on the nature of tasks to be completed. They lacked a consistent or fixed inclination for learning biology. They may instead have a twofold motivation for learning biology. This is subject to how teachers engaged with learners in class, the kind of experiences they provided the learners with and the types of tasks that were proposed to them. The data revealed that the students had recourse to surface strategies such as rote learning, and practicing questions when exams were nearing. When students' learning loads are substantial, for example, or when the learning activities merely need rote-based processes, the surface motive tends to be triggered for completing the corresponding learning tasks. Students may be forced to apply both sorts of motivation simultaneously. While individuals may study biology in order to pass a test, they may also use this chance to get a profound understanding of the learning materials. Hence, it may be deduced that Mauritian upper secondary school students adopted the hybrid approach to learning biology.

8.2.6 Why do Students' Conceptions of Learning Influence their Approaches to Learning Biology, in the Way/s that they do?

Mauritian students were more likely to learn biology by reciting if they thought of biology learning as memorising what was taught in class, preparing for a test, or calculating and practicing. The students, on the other hand, held deep motives and used meaningful strategies to learn biology when they saw it as "increasing knowledge, applying knowledge, or understanding and seeing knowledge in a new way".

This study revealed the paradoxical finding that lower-level (quantitative) COL are positively correlated to deep AL. According to Park and Jeon (2015), depending on the objective and aim of the study, even quantitative COL can lead to the adoption of constructive approaches. This may occur due to a desire to accurately recall previously understood information in a high-stress scenario such as a debate or examination as possibly incorporating rote learning. The use of the "memorising" conception by Mauritian students may be considered a deep AL given that they memorise material after learning it. In this instance, the intention is deep understanding, memorising becomes part of a deep AL.

According to Maulloo and Naugah (2017), the current Mauritian education system is results-oriented in the sense that educators and students consider achieving good results as their primary goal. Therefore, these findings could be explained by the examination-centred school culture prevalent in Mauritius.

8.3 Implications of the Research Findings

There were various implications of this study for teachers. First, it was crucial to assist students in developing more sophisticated COL since they had a strong and direct impact on learning strategies. Students who adopt deep motivations and deep learning strategies may benefit from sophisticated COL. To help students understand the value of learning biology, teachers can use problem-based learning, inquiry-based learning and outdoor investigations. Learning science was meant to expand knowledge, then apply information, and interpret knowledge in new ways rather than just retain what teachers discuss in class or get ready for an examination. My argument is that the best approach for students to understand COLB is to apply what they learn in class to real-world issues. Second, teachers should motivate students to learn biology with deep motives and deep learning strategies, such as when teachers guide students in gaining a systematic understanding of what they learn in classrooms. To facilitate meaningful learning, students must connect existing knowledge to new information. Furthermore, it was critical to push students to learn biology through their own interests and curiosity.

Because this research suggests that students will hold a variety of learning conceptions that will influence their performance, teachers must be aware of these, as well as their likely developmental sequence and how they may be influenced by culture and context. Teachers must also be explicitly aware of their own conceptions of teaching and student learning and strive to ensure that they are congruent, or flexible, depending on the context and student needs. Teachers would benefit from being as clear as possible with students about their viewpoints on teaching and learning, as well as the justifications for them. Additionally, teachers will be more successful if they structure their lessons according to Ho’s (2020) description of congruent or aligned expectations, tactics, and ideas of teaching and learning.

It is important to support students in understanding their COL and how these relate to their learning strategies. The ideal situation would be for them to create a variety of deep and surface AL that they can regulate metacognitively to govern their own learning based on the situation, their motivation, and their goals. In essence, it is advocated that teachers assist learners at all levels in learning about learning. Additionally, it would be helpful if they could be guided in understanding the type of instruction they are receiving so they may decide whether it meets their needs or if they would prefer to learn in a different fashion, thereby exerting as much control over their own learning as far as possible.

This study identified the COL and AL of Mauritian students and also clarified the relationship between them. In light of the findings of this study, biology educators may face the next challenge of transforming students' lower-level COL into higher-level ones. A study by Tsai (2009) compared tertiary students' conceptions of general COL and web-based learning. The study came to the conclusion that the online setting might help pupils learn in real-world situations. Therefore, integrating state-of-the-art technologies into teaching could assist pupils in creating higher order concepts of learning. Using this as their foundation, Lin et al. (2012) carried out an experimental study to examine how internet-assisted physiology education affected university students' learning concepts. The results of the study showed that internet-assisted education raised students' COL. Research, in the future, should look into incorporating technology into instruction or learning to improve students' conceptions of learning biology or other science subjects.

8.4 Contribution of the Research

8.4.1 Contextual Contribution

This study made valuable contextual contributions given that it was carried out in Mauritius, a small island nation with a distinct population and teaching and learning context. Most literature on COL and AL from small islands come from Taiwan which probably does not have the same (cultural) diversity in its population. This study has shown that Mauritian secondary school students have typical COL and AL which may have been influenced by the unique educational context and cultural background of the students. Similar studies could be carried out in other small island nations to further enrich the literature.

8.4.2 Methodological Contribution

This study made valuable methodological advances in terms of expanding research design, data collection processes and data analysis. Most research on COL and AL have been quantitative. This mixed methods study adds a deeper understanding of COLB and ALB as it offers explanations. While the research design for this study was based on predetermined design principles, the methodology that developed during the research process implies an unfolding evolutionary methodological process. This was reflected in the research design as well as the sampling. First, the unfolding methodology was represented in the mixed method explanatory sequential design, as the quantitative process informed how the qualitative process would develop. Second, the data-gathering procedure was presented with contextual modifications. Each of the participants selected had to be interviewed on three occasions. While parts of the data collection and analysis procedures followed established research designs, gathering information from interviewees necessitated a more customised approach. This is a weakness but while also being a strength because it created relevant, honest and valuable data.

Following consultation with participants, conversations were held in the Mauritian Creole (Kreol Morisien), the participants' native language, to allow them to express their thoughts and get additional information without being hampered by a language barrier. This involved translating the recordings of the interviews into English to construct a transcript. This data collection technique also helped to develop a methodological approach that was deemed appropriate and relevant to the participants.

8.4.3 Theoretical Contribution

The findings of this study might help to understand COL and AL in other similar small island nations throughout the world. At the national level, my research can contribute to better performance in biology. This study will also build on the existing literature on COL and AL.

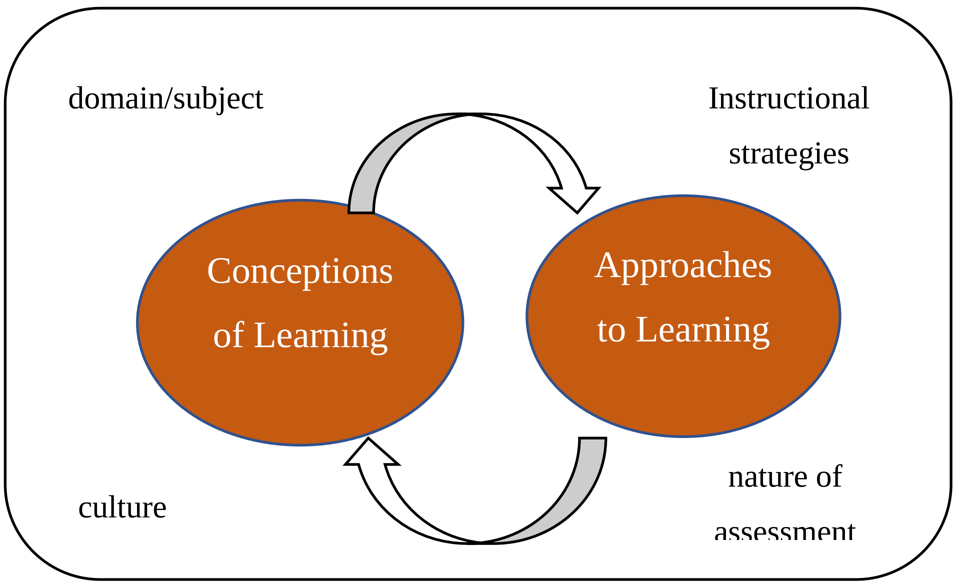
This study introduced a new element of COLB, which is "exploring real-life and natural phenomena." This is a contribution to the COL framework. However, I did not find the emergence of the conception "seeing in a new way" as proposed by Lee et al. (2008). The "exploring real-life and natural phenomena" conception is correlated with the deep AL. In fact, it is considered as a deep strategy for learning by students and teachers. The data revealed that students made use of online technologies to explore real-life and natural phenomena.

The study revealed that Mauritian upper secondary students had mixed conceptions, hence they adopted a mixed or "hybrid" ALB. The result space in this study is predicted to have a specific design for Mauritian biology students based on data analysis. Traditional and conventional views of the outcome space as being hierarchical place certain conceptions at lower levels and others at higher levels. A different structure, however, is obtained for this study, in which all categories are given equal status and are each represented by a circle, with no category being either inferior to or superior to others (see Figure 8.1). This is a contribution to the COL framework. The "hybrid approaches" to learning, identified in this study, show that the students make use of both the deep and the surface ALB depending upon the demands of the task to be completed. For example, when exams are near, even deep learners tend to switch to the surface strategies of learning, such as "memorising," and "practicing tutorial problems." This is a contribution to the AL framework.

The result of this study suggests that students' COL and AL are interrelated. According to the study's findings, the examination-focused educational system in Mauritius seems to have a major impact on students' COL and AL. It appears that teachers adopt instructional strategies to meet the demands of the educational system. It also appears that due to the nature of the assessment, deep learners, who normally make use of higher COL, may also make use of the lower COL switching from the deep AL to the surface AL whenever the need arises. This study also shows that students' COL and AL are subject/domain specific. Figure 8.1 illustrates the outcome space for COL and AL.

Figure 8.1

Outcome Space for Conceptions of Learning and Approaches to Learning



The learning model proposed offers a fresh, distinctive lens through which to observe the complex nature of learners' learning from a theoretical standpoint. The complexity of COL and AL can be distilled by depicting learners' learning in this fashion. The cycle in Figure 8.1 represents the teaching and learning context defined by the subject domain, instructional strategies, the nature of assessment, and the learning culture. COL and AL in the same cycle should be viewed as two sides of the same coin. If we see one side of the coin, we know what the other side looks like and the value of the coin. The value of the same mass of a copper/bronze coin differs from country to country depending on various factors. This is analogous to the influence of the teaching and learning context on COL and AL.

8.5 Limitations of the Study

The convenience sampling method adopted for the current study implies that the sample was not truly representative of the Mauritian Grade 11 biology student population. The impracticality of covering the whole nation and the many variables of random sampling means accessibility took precedence. To mitigate the lack of true representativeness, the choice of schools took into account the different characteristics of Mauritian schools, that is private and public, single-sex and co-educational schools. The generalisation of the findings should therefore be read with the composition of the participants in mind. The findings could also be generalised to similar small islands rather than mainland countries, where schools might have students from different cultures and countries.

8.6 Recommendations for Future Research

This study revealed varying learning conceptions held by Mauritian upper secondary school pupils. It provided great insights into students' learning experiences while also raising some significant issues.

This study has shown how important it is to look into how memorization and comprehension relate to one another. According to the research's participants, memorization and recollection are crucial for performing well on tests. Past research has shown that there are two types of memorization: rote memorization and meaningful memorization (Entwistle & Entwistle, 2003; Kember, 1996). Further research into the type of memorising practiced by Mauritian students could be very informative.

In Mauritius, secondary education is typically a seven-year program, beginning in Grade 7 and ending in Grade 13. At the end of Grade 9, students take the National Certificate of Education (NCE) assessment. It would be easier to understand how pupils learn in Mauritius if their COL at upper secondary (Grades 10–13) and lower secondary (Grades 7–9) were compared. Such a study would increase the significance of the current study by giving a comprehensive overview of the students' educational experiences in two different contexts.

Significant connections between instructors' COL and their instructional strategies have been found in prior studies (Dart et al., 2000). The need to investigate how Mauritius' secondary school teachers perceive learning is therefore significant. It would shed light on the meaning of learning to these teachers and how their views affect how they approach the subject of teaching. The learning experiences of students are influenced by teachers' views on learning. Given that student learning quality is the ultimate goal of education, the relationship between instructors' views or COL, their teaching methods, and student learning is crucial (Biggs et al., 2022). Research that examines teachers' COL and teaching may also look further at factors that may influence instructors' decisions to utilize a teacher-centred approach to instruction. In order to encourage qualitative COL and deep AL in secondary schools in Mauritius, the results of such a study are anticipated to offer recommendations for their incorporation.

The data of this study revealed that Mauritian students had access to online learning resources to better understand biology topics. In order to describe where online learning technologies might sit and why inside the AL framework, we currently do not know enough about the underlying intentions and strategies that go along with them. Investigating students' approaches to and perceptions of the technologies is therefore necessary to determine how their use of online learning technologies may relate to the other elements of the AL framework.

8.7 Conclusion

While there may be better techniques of teaching and learning that are acceptable, the research on conceptions shows that students and teachers do not always embrace or use these. The aforementioned ideas presuppose a firm commitment on the side of students and teachers to adopt improved teaching and learning methods, but it is crucial to be aware that there will be a variety of other expectations and behaviours. In order to improve learning for the majority of students, this realisation is a necessary step toward being able to cope with such beliefs, expectations, and behaviour effectively

The present investigation established important correlations that have significance for enhancing ALB and instruction at the upper secondary level in Mauritius. A student's AL is regarded as meaningful learning if it involves broad thinking, investigation, linking concepts to one another, and evaluation. The current study found a link between upper secondary school students' constructivist beliefs and ALB. Constructive conceptions such as biology learning as increasing one’s knowledge, the application of knowledge, understanding, and exploring real life and natural phenomena directed them to use deep AL, whereas the reproductive COLB to prepare for tests directed them to use surface approaches. Exams are the focus of the Mauritian educational system, and the pupils there are fiercely competitive. Private tuition is widespread and well-known in Mauritius for every topic, and students are strongly advised to prepare for the exam. Students rarely get the chance to develop their talents at school (practical activities). Students' lack of the creative and scientific abilities needed for the job market may also be caused by surface learning. The current research shows that students' positive conceptions encourage them to employ deep learning techniques more frequently. These concepts ought to be taught to pupils in order to direct them toward more purposeful learning.

REFERENCES

Abedin, N. F. Z., Jaafar, Z., Husain, S., & Abdullah, R. (2013). The validity of ASSIST as a measurement of learning approach among MDAB students. Procedia-Social and Behavioral Sciences, 90, 549-557. https://doi.org/10.1016/j.sbspro.2013.07.125

Adams, N. E. (2015). Bloom's taxonomy of cognitive learning objectives. Journal of the Medical Library Association: JMLA, 103(3), 152. https://doi-org.ukzn.idm.oclc.org/10.3163%2F1536-5050.103.3.010

Alamdarloo, G. H., Moradi, S., & Dehshiri, G. R. (2013). The relationship between students' conceptions of learning and their academic achievement. Psychology, 4(01), 44-49. http://dx.doi.org/10.4236/psych.2013.41006

Alt, D. (2018). Science teachers' conceptions of teaching and learning, ICT efficacy, ICT professional development and ICT practices enacted in their classrooms. Teaching and Teacher Education: An International Journal of Research and Studies, 73(1), 141-150. https://www.learntechlib.org/p/202394/

Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). How learning works: Seven research-based principles for smart teaching. John Wiley & Sons. https://books.google.co.za/books?hl=en&lr=&id=6nGaDwAAQBAJ&oi=fnd&pg=PR1&dq=Ambrose

Anderson, J., Austin, K., Barnard, T., & Jagger, J. (1998). Do third-year mathematics undergraduates know what they are supposed to know? International Journal of Mathematical Education in Science & Technology, 29(3), 401-420. https://doi.org/10.1080/0020739980290310

Anderson, T. R., & Schönborn, K. J. (2008). Bridging the educational research-teaching practice gap: Conceptual understanding, part 1: The multifaceted nature of expert knowledge. Biochemistry and Molecular Biology Education, 36(4), 309-315. https://doi-org.ukzn.idm.oclc.org/10.1002/bmb.20209

Atchia. (2017). Educating for the future: Are we failing our kids? Defimedia. Retrieved from https://defimedia.info/educating-future-are-we-failing-ourkids

Avramidis, A., & Norwich, B. (2002). Teachers' attitudes towards integration/inclusion: a review of the literature. European Journal of Special Needs Education, 17(2), 129-147. https://doi.org/10.1080/08856250210129056

Bahcivan, E., & Kapucu, S. (2014). Turkish pre-service elementary science teachers' conceptions of learning science and science teaching efficacy belief: Is there a relationship? International Journal of Environmental & Science Education, 9(4), 429-442. https://files.eric.ed.gov/fulltext/EJ1048084.pdf

Balasooriya, C. D., Toohey, S., & Hughes, C. (2009). The cross-over phenomenon: unexpected patterns of change in students' approaches to learning. Studies in Higher Education, 34(7), 781-794. https://doi.org/10.1080/03075070802699188

Ballantine, J. A., Duff, A., & Larres, P. M. (2008). Accounting and business students' approaches to learning: A longitudinal study. Journal of Accounting Education, 26(4), 188-201. https://doi.org/10.1016/j.jaccedu.2009.03.001

Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. Journal of Personality and Social Psychology, 41(3), 586-598. https://doi.org/10.1037/0022-3514.41.3.586

Baram-Tsabari, A., & Yarden, A. (2005). Characterizing Children's Spontaneous Interests in Science and Technology. Research Report. International Journal of Science Education, 27(7), 803-826. https://doi.org/10.1080/09500690500038389

Baram-Tsabari, A., Sethi, R. J., Bry, L., & Yarden, A. (2006). Using Questions Sent to an Ask-A-Scientist Site to Identify Children's Interests in Science. Science Education, 90(6), 1050-1072. https://doi-org.ukzn.idm.oclc.org/10.1002/sce.20163

Baram-Tsabari, A., Sethi, R. J., Bry, L., & Yarden, A. (2010). Identifying Students' Interests in Biology Using a Decade of Self-Generated Questions. EURASIA Journal of Mathematics, Science & Technology Education, 6(1), 63-75. https://doi.org/10.12973/ejmste/75228

Baruch, Y. (2006). Role-play teaching: Acting in the classroom. Management Learning, 37(1), 43-61. https://doi.org/10.1177/1350507606060980

Beattie, V., Collins, B., & McInnes, B. (1997). Deep and surface learning: A simple or simplistic dichotomy? Accounting Education, 6(1), 1-12. https://doi.org/10.1080/096392897331587

Beaudry, J. S., & Miller, L. (2016). Research literacy: A primer for understanding and using research. Guilford Publications. https://books.google.co.za/books?hl=en&lr=&id=emueCwAAQBAJ&oi=fnd&pg=PP1&dq=Beaudry

Bell, E., Bryman, A., & Harley, B. (2022). Business research methods. Oxford University Press. https://books.google.com/books?hl=en&lr=&id=hptjEAAAQBAJ&oi=fnd&pg=PP1&dq=Bell

Benson, P., & Lor, W. (1999). Conceptions of Language and Language Learning. System, 27(4), 459472. https://doi.org/10.1016/S0346-251X(99)00045-7

Betchoo, N. K. (2017). The impact of nine-year schooling on higher learning in Mauritius. European Scientific Journal, 5(2), 163-175. https://doi.org/10.19044/esj.2017.v13n10p%25p

Beyaztas, D. I., & Senemoglu, N. (2015). Learning approaches of successful students and factors affecting their learning approaches. Egitim ve Bilim, 40(179), 193-216. http://www.openaccess.hacettepe.edu.tr:8080/xmlui/bitstream/handle/11655/20348/4214-32749-1-PB.pdf?sequence=2

Biggs, J. B. (1978). Individual and group differences in study processes. British Journal of Educational Psychology, 48(3), 266-279. https://doi.org/10.1111/j.2044-8279.1978.tb03013.x

Biggs, J. B. (1979). Individual differences in study processes and the quality of learning outcomes. Higher education, 8(4), 381-394. https://doi.org/10.1007/BF01680526

Biggs, J. B. (1987a). Learning Process Questionnaire Manual. Student Approaches to Learning and Studying. Australian Council for Educational Research Ltd. https://files.eric.ed.gov/fulltext/ED308199.pdf

Biggs, J. B. (1987b). Student Approaches to Learning and Studying. Research Monograph. Australian Council for Educational Research Ltd. https://files.eric.ed.gov/fulltext/ED308201.pdf

Biggs, J. B. (1991). Approaches to learning in secondary and tertiary students in Hong Kong: Some comparative studies. Educational Research Journal, 6(1), 27-39. https://www.hkier.cuhk.edu.hk/journal/document/ERJ/erj_v6_27-39.pdf

Biggs, J. B. (1993). What do inventories of students' learning processes really measure? A theoretical review and clarification. British Journal of Educational Psychology, 63(1), 3-19. https://doi-org.ukzn.idm.oclc.org/10.1111/j.2044-8279.1993.tb01038.x

Biggs, J. B. (1994). Asian learners through Western eyes: an astigmatic paradox. Australian and New Zealand Journal of Vocational Education Research, 2(2), 40-63. https://link.springer.com/article/10.1007/BF03219558

Biggs, J., Tang, C., & Kennedy, G. (2022). Teaching for quality learning at university. McGraw-Hill Education. https://books.google.co.za/books?hl=en&lr=&id=pseVEAAAQBAJ&oi=fnd&pg=PR13&dq=Biggs

Biggs, J., Kember, D., & Leung, D. Y. (2001). The revised two-factor study process questionnaire: R-SPQ-2F. British journal of Educational Psychology, 71(1), 133-149. https://doi.org/10.1348/000709901158433

Binali, T., Tsai, C. C., & Chang, H. Y. (2021). University students' profiles of online learning and their relation to online metacognitive regulation and internet-specific epistemic justification. Computers & Education, 175, 104315. https://www.sciencedirect.com/science/article/pii/S0360131521001925

Bliuc, A.M., Ellis, R.A., Goodyear, P., & Piggott, L. (2011). A blended learning approach to teaching foreign policy: Student experiences of learning through face-to-face and online discussion and their relationship to academic performance. Computers & Education, 56(3), 856-64. https://www.learntechlib.org/p/50832

Bonsaksen, T., & Thørrisen, M. M. (2017). Psychometric properties of two interrelated measures: 'conceptions of learning' and 'preferences for different types of courses and teaching'. Ergoterapeuten, 60(4), 32-45. https://www.academia.edu/34434928

Borich, G. D. (2019). Educational psychology A contemporary approach. Harpercollins.

Bovill, C. (2020). Co-creation in learning and teaching: the case for a whole-class approach in higher education. Higher Education, 79(6), 1023-1037. https://link.springer.com/article/10.1007/s10734-019-00453-w

Bowden, M. P., Abhayawansa, S., & Manzin, G. (2015). A multiple cross-cultural comparison of approaches to learning. Compare: A Journal of Comparative and International Education, 45(2), 272-294. https://doi.org/10.1080/03057925.2013.841465

Brown, J. D. (2009). Choosing the right type of rotation in PCA and EFA. JALT Testing & Evaluation SIG Newsletter, 13(3), 20-25. http://www.jalt.org/test/PDF/Brown30.pdf

Brownlee, J., Purdie, N., & Boulton-Lewis, G. (2003). An investigation of student teachers' knowledge about their own learning. Higher Education, 45(1), 109-125. https://doi.org/10.1023/A:1021216618988

Burnett, P. C., Pillay, H., & Dart, B. C. (2003). The Influences of Conceptions of Learning and Learner Self-Concept on High School Students' Approaches to Learning. School Psychology International, 24(1), 54-66. https://doi.org/10.1177/0143034303024001621

Burns, A. (1999). Collaborative action research for English language teachers. Cambridge University Press. https://books.google.mu/books?hl=en&lr=&id=5PHeA-pjvqAC&oi=fnd&pg=PA14&dq=Burns

Byrne, M., & Flood, B. (2004). Exploring the conceptions of learning of accounting students. Accounting Education, 13(1), 25-37. https://doi.org/10.1080/0963928042000310779

Byrne, M., Flood, B., & Willis, P. (2002). The relationship between learning approaches and learning outcomes: A study of Irish accounting students. Accounting Education: an international journal, 11(1), 27-42. https://doi.org/10.1080/09639280210153254

Byrne, M., Flood, B., & Willis, P. (2004). Using the student learning framework to explore the variation in academic performance of European business students. Journal of further and Higher Education, 28(1), 67-78. https://doi.org/10.1080/0309877032000161823

Byrne, M., Flood, B., & Willis, P. (2009). An inter-institutional exploration of the learning approaches of students studying accounting. International Journal of Teaching & Learning in Higher Education, 20(2), 155-167. https://scholar.google.com/scholar?cluster=11821552518442257682

Cai, J., & Nie, B. (2007). Problem solving in Chinese mathematics education: Research and practice. ZDM, 39(5), 459-473. https://doi.org/10.1007/s11858-007-0042-3

Cano, F. (2005). Epistemological beliefs and approaches to learning: Their change through secondary school and their influence on academic performance. British Journal of Educational Psychology, 75(2), 203-221. https://doi.org/10.1348/000709904X22683

Cano, F. (2007). Approaches to learning and study orchestrations in high school students. European Journal of Psychology of Education, 22(2), 131-151. https://doi.org/10.1007/BF03173518

Carlsson-Paige, N., & Lantieri, L. (2005). A Changing Vision of Education. Reclaiming Children and Youth, 14(2), 97-103. https://scholar.google.com/scholar?cluster=5230524043591661411

Carson, D., Gilmore, A., Perry, C., & Gronhaug, K. (2005). Qualitative marketing research. SAGE Publications. https://doi.org/10.4135/9781849209625

Case, J. M., & Gunstone, R. F. (2003). Approaches to learning in a second-year chemical engineering course. International Journal of Science Education, 25(7), 801-819. https://doi.org/10.1080/09500690305033

Case, J. M., & Marshall, D. (2009). Approaches to learning. The Routledge International Handbook of Higher Education, 9-22. https://doi.org/10.1080/09500690305033

Cassidy, S. (2004). Learning styles: an overview of theories, models, & measures. Educational Psychology, 24(4), 419-444. https://doi.org/10.1080/0144341042000228834

Cassidy, S., & Eachus, P. (2000). Learning style, academic belief systems, self-report student proficiency and academic achievement in higher education. Educational Psychology, 20(3), 307-322. https://doi.org/10.1080/713663740

Chan, K. W. (2007). Hong Kong teacher education students: Epistemological beliefs and their relations with conceptions of learning and learning strategies. The Asia-Pacific Education Researcher, 16(2), 199-214. https://scholar.google.com/scholar?cluster=17764392439365533178

Chan, K. W., & Elliott, R. G. (2004). Relational analysis of personal epistemology and conceptions about teaching and learning. Teaching and Teacher Education, 20(8), 817-831. https://doi.org/10.1016/j.tate.2004.09.002

Chen, Y., Chow, S. C. F., & So, W. W. M. (2022). School-STEM professional collaboration to diversify stereotypes and increase interest in STEM careers among primary school students. Asia Pacific Journal of Education, 42(3), 556-573. https://doi.org/10.1080/02188791.2020.1841604

Chen, Q., May, L., Klenowski, V., & Kettle, M. (2014). The enactment of formative assessment in English language classrooms in two Chinese universities: Teacher and student responses. Assessment in Education: Principles, Policy & Practice, 21(3), 271-285. https://www.tandfonline.com/doi/abs/10.1080/0969594X.2013.790308

Cheng, M. H. M., & Wan, Z. H. (2016). Unpacking the paradox of Chinese science learners: Insights from research into Asian Chinese school students' attitudes towards learning science, science learning strategies, and scientific epistemological views. Studies in Science Education, 52(1), 29-62. https://www.tandfonline.com/doi/abs/10.1080/03057267.2015.1112471

Chin, C., & Brown, D. E. (2000). Learning in science: a comparison of deep and surface approaches. Journal of Research Science Teaching, 37, 109-138. https://doi.org/10.1002/(SICI)1098-2736(200002)37:2<109::AID-TEA3>3.0.CO;2-7

Chin, W. W. (1998). The Partial Least Squares Approach to Structural Equation Modeling. In G. A. Marcoulides (Ed.), Modern Methods for Business Research. Lawrence Erlbaum Associates. https://scholar.google.com/scholar?cluster=6098596860897922819

Chiou, G. L., & Liang, J. C. (2012). Exploring the structure of science self-efficacy: A model built on high school students' conceptions of learning and approaches to learning in science. The Asia-Pacific Education Researcher, 21(1), 83-91. http://hdl.handle.net/11536/15881

Chiou, G. L., Lee, M. H., & Tsai, C. C. (2013). High school students' approaches to learning physics with relationship to epistemic views on physics and conceptions of learning physics. Research in Science & Technological Education, 31(1), 1-15. https://doi-org.ukzn.idm.oclc.org/10.1080/02635143.2013.794134

Chiou, G. L., Liang, J. C., & Tsai, C. C. (2012). Undergraduate Students' Conceptions of and Approaches to Learning in Biology: A study of their structural models and gender differences. International Journal of Science Education, 34(2), 167-195. https://doi-org.ukzn.idm.oclc.org/10.1080/09500693.2011.558131

Chiu, Y. L., Lin, T. J., & Tsai, C. C. (2016). The conceptions of learning science by laboratory among university science-major students: qualitative and quantitative analyses. Research in Science & Technological Education, 34(3), 359-377. https://doi-org.ukzn.idm.oclc.org/10.1080/02635143.2016.1222518

Clark, V. L. P. (2019). Meaningful integration within mixed methods studies: Identifying why, what, when, and how. Contemporary Educational Psychology, 57, 106-111. https://www.sciencedirect.com/science/article/pii/S0361476X19300128

Coffield, F., Moseley, D., Hall, E., & Ecclestone, K. (2004). Learning styles and pedagogy in post-16 learning: A systematic and critical review. The Learning and Skills Research Centre. http://hdl.voced.edu.au/10707/69027

Cohen, J. (1988). Set correlation and contingency tables. Applied Psychological Measurement, 12(4), 425-434. https://journals.sagepub.com/doi/abs/10.1177/014662168801200410

Colucci, E. (2007). "Focus groups can be fun": The use of activity-oriented questions in focus group discussions. Qualitative Health Research, 17(10), 1422-1433. https://doi-org.ukzn.idm.oclc.org/10.1177/1049732307308

Cooksey, R., & McDonald, G. (2019). Surviving and thriving in postgraduate research. Springer Singapore. https://link-springer-com.ukzn.idm.oclc.org/content/pdf/10.1007/978-981-13-7747-1.pdf

Creswell, J. W. (2009). Research design: Qualitative, Quantitative, and Mixed Methods Approaches (3rd ed.). SAGE Publications. https://www.ucg.ac.me/skladiste/blog_609332/objava_105202/fajlovi/Creswell.pdf

Creswell, J. W. (2011). Controversies in mixed methods research. The Sage Handbook of Qualitative Research, 4, 269-284. https://www.sagepub.com/sites/default/files/upm-binaries/40426_Chapter15.pdf

Creswell, J. W. (2012). Educational Research. Planning, Conducting and Evaluating Quantitative and Qualitative Research (4th ed.). Pearson. http://www.repository.unmas.ac.id/medias/journal/EBK-00121.pdf

Creswell, J. W. (2014). Qualitative, Quantitative and Mixed Methods Approaches (4th ed.). SAGE Publications. http://155.0.32.9:8080/jspui/bitstream/123456789/1091/1

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. Psychometrika, 16(3), 297-334. https://doi-org.ukzn.idm.oclc.org/10.1007/BF02310555

Cuthbert, P. F. (2005). The student learning process: learning styles or learning approaches? Teaching in Higher Education, 10(2), 235-249. https://doi-org.ukzn.idm.oclc.org/10.1080/1356251042000337972

Dahlgren, L. O., & Marton, F. (1978). Students' conceptions of subject matter: An aspect of learning and teaching in higher education. Studies in Higher Education, 3(1), 25-35. https://doi-org.ukzn.idm.oclc.org/10.1080/03075077812331376316

Dahlin, B., & Regmi, M. P. (1997). Conceptions of learning among Nepalese students. Higher Education, 33(4), 471-493. https://doi-org.ukzn.idm.oclc.org/10.1023/A:1002992411868

Dahlin, B., & Watkins, D. (2000). The role of repetition in the processes of memorising and understanding: A comparison of the views of German and Chinese secondary school students in Hong Kong. British Journal of Educational Psychology, 70(1), 65-84. https://doi-org.ukzn.idm.oclc.org/10.1348/000709900157976

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. Applied Developmental Science, 24(2), 97-140. https://www.tandfonline.com/doi/abs/10.1080/10888691.2018.1537791

Darlington, E. (2019). Shortcomings of the 'approaches to learning' framework in the context of undergraduate mathematics. Journal of Research in Mathematics Education, 8(3), 293-311. https://doi.org/10.17583/redimat.2019.2541

Dart, B. C., Burnett, P. C., Purdie, N., Boulton-Lewis, G., Campbell, J., & Smith, D. (2000). Students' Conceptions of Learning, the Classroom Environment, and Approaches to Learning. The Journal of Educational Research, 93(4), 262-270. https://doi-org.ukzn.idm.oclc.org/10.1080/00220670009598715

Denscombe, M. (2008). Communities of practice: A research paradigm for the mixed methods approach. Journal of Mixed Methods Research, 2(3), 270-283. https://doi-org.ukzn.idm.oclc.org/10.1177/1558689808316807

Deters, K. M. (2003). What should we teach in high school chemistry? Journal of Chemical Education, 80(10), 1153-1155. https://doi-org.ukzn.idm.oclc.org/10.1021/ed080p1153

Dijkstra, T. K., & Henseler, J. (2015). Consistent Partial Least Squares Path Modeling. MIS Quarterly, 39(2), 297-316. https://www.jstor.org/stable/26628355

Donche, V., De Maeyer, S., Coertjens, L., Van Daal, T., & Van Petegem, P. (2013). Differential use of learning strategies in first-year higher education: The impact of personality, academic motivation, and teaching strategies. British Journal of Educational Psychology, 83(2), 238-251. https://bpspsychub.onlinelibrary.wiley.com/doi/abs/10.1111/bjep.12016

Duarte, A. M. (2007). Conceptions of learning and approaches to learning in Portuguese students. Higher Education, 54(6), 781-794. https://doi.org/10.1007/s10734-006-9023-7

Duarte, F. P. (2013). Conceptions of good teaching by good teachers: Case studies from an Australian university. Journal of University Teaching & Learning Practice, 10(1), 5. https://doi.org/10.53761/1.10.1.5

Duff, A., & Mckinstry, S. (2007). Students' Approaches to Learning. Issues in Accounting Education, 22(2), 183-214. https://doi.org/10.2308/iace.2007.22.2.183

Duff, A., Boyle, E., Dunleavy, K., & Ferguson, J. (2004). The relationship between personality, approach to learning and academic performance. Personality and Individual Differences, 36(8), 1907-1920. https://doi.org/10.1016/j.paid.2003.08.020

Edmunds, R., & Richardson, J. T. (2009). Conceptions of learning, approaches to studying and personal development in UK higher education. British Journal of Educational Psychology, 79(2), 295-309. https://doi-org.ukzn.idm.oclc.org/10.1348/000709908X368866

Eklund-Myrskog, G. (1998). Students' conceptions of learning in different educational contexts. Higher Education, 35(3), 299–316. https://doi.org/10.1023/A:1003145613005

Ellis, R. A., & Bliuc, A. M. (2019). Exploring new elements of the student approaches to learning framework: The role of online learning technologies in student learning. Active Learning in Higher Education, 20(1), 11-24. https://doi.org/10.1177/1469787417721384

Ellis, R. A., Goodyear, P., Prosser, M., & O'Hara, A. (2006). How and what university students learn through online and face-to-face discussion: Conceptions, intentions and approaches. Journal of Computer Assisted Learning, 22(4), 244-256. https://doi.org/10.1111/j.1365-2729.2006.00173.x

Ellis, R., & Goodyear, P. (2013). Students' experiences of e-learning in higher education: the ecology of sustainable innovation. Routledge. https://www.taylorfrancis.com/books/mono/10.4324/9780203872970

English, L., Luckett, P., & Mladenovic, R. (2004). Encouraging a deep approach to learning through curriculum design. Accounting Education: An International Journal, 13(4), 461–488. https://doi.org/10.1080/0963928042000306828

Entwistle, N. (1997a). Introduction: Phenomenography in higher education. Higher Education Research & Development, 16(2), 127–134. https://doi.org/10.1080/0729436970160202

Entwistle, N. (1997b). Reconstituting approaches to learning: a response to Webb. Higher Education, 33(2), 213-218. https://doi.org/10.1023/A:1002930608372

Entwistle, N. J., & Peterson, E. R. (2004). Conceptions of learning and knowledge in higher education: Relationships with study behaviour and influences of learning environments. International Journal of Educational Research, 41(6), 407-428. https://doi.org/10.1016/j.ijer.2005.08.009

Entwistle, N., & Entwistle, D. (2003). Preparing for examinations: The interplay of memorising and understanding, and the development of knowledge objects. Higher Education Research & Development, 22(1), 19-41. https://doi.org/10.1080/0729436032000056562

Entwistle, N., & McCune, V. (2004). The conceptual bases of study strategy inventories. Educational Psychology Review, 16(4), 325-345. https://doi.org/10.1007/s10648-004-0003-0

Entwistle, N., & Walker, P. (2000). Strategic alertness and expanded awareness within sophisticated conceptions of teaching. Instructional Science, 28, 335–362. https://doi.org/10.1023/A:1026579005505

Entwistle, N., Hanley, M., & Hounsell, D. (1979). Identifying distinctive approaches to studying. Higher Education, 8(4), 365-380. https://doi.org/10.1007/BF01680525

Entwistle, N., McCune, V., & Walker, P. (2001). Conceptions, styles, and approaches within higher education: Analytical abstractions and everyday experience. In R. J. Sternberg & L.-f. Zhang (Eds.), The educational psychology series. Perspectives on thinking, learning, and cognitive styles (pp. 103-136). Lawrence Erlbaum Associates Publishers. https://www.researchgate.net/publication/232455563

Entwistle, N., Tait, H., & McCune, V. (2000). Patterns of response to an approaches to studying inventory across contrasting groups and contexts. European Journal of psychology of Education, 15(1), 33-48. https://doi.org/10.1007/BF03173165

Ferla, J., Valcke, M., & Schuyten, G. (2008). Relationships between student cognitions and their effects on study strategies. Learning and Individual Differences, 18(2), 271-278. https://doi.org/10.1016/j.lindif.2007.11.003

Ferla, J., Valcke, M., & Schuyten, G. (2009). Student models of learning and their impact on study strategies. Studies in Higher Education, 34(2), 185-202. https://doi.org/10.1080/03075070802528288

Field, A. (2013). Discovering statistics using IBM SPSS statistics. SAGE Publications. https://scholar.google.com/scholar?cluster=15648026967332983277

Fink, A. (2003). Reliable and valid survey instruments. The Survey Handbook. SAGE Publications. https://scholar.google.com/scholar?cluster=16758785303786098443

Flick, U. (2018). Designing qualitative research. SAGE Publications. https://books.google.com/books?hl=en&lr=&id=b_1QDwAAQBAJ&oi=fnd&pg=PP1&dq=Designing

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. Journal of Marketing Research, 18(1), 39-50. https://doi.org/10.1177/002224378101800104

Galloway, K. R., & Bretz, S. L. (2015). Using cluster analysis to characterize meaningful learning in a first-year university chemistry laboratory course. Chemistry Education Research and Practice, 16(4), 879-892. https://pubs.rsc.org/en/content/articlehtml/2015/rp/c5rp00077g

Gao, J. (2020). Sources of mathematics self-efficacy in Chinese students: a mixed-method study with Q-sorting procedure. International Journal of Science and Mathematics Education, 18(4), 713-732. https://link.springer.com/article/10.1007/s10763-019-09984-1

Geisser, S. (1975). The Predictive Sample Reuse Method with Applications. Journal of the American Statistical Association, 70(350), 320-328. https://doi.org/10.2307/2285815

George, D., & Mallery, P. (2019). IBM SPSS statistics 26 step by step: A simple guide and reference. Routledge. https://www.taylorfrancis.com/books/mono/10.4324/9780429056765

Gibbs, G., & Coffey, M. (2004). The impact of training of university teachers on their teaching skills, their approach to teaching and the approach to learning of their students. Active learning in Higher Education, 5(1), 87-100. https://doi.org/10.1177/1469787404040463

Gijbels, D., Van de Watering, G., Dochy, F., & Van den Bossche, P. (2005). The relationship between students' approaches to learning and the assessment of learning outcomes. European Journal of Psychology of Education, 20(4), 327-341. https://doi.org/10.1007/BF03173560

Gilakjani, A. P. (2012). A match or mismatch between learning styles of the learners and teaching styles of the teachers. International Journal of Modern Education and Computer Science, 4(11), 51. https://scholar.google.com/scholar?cluster=18215943405694292030

Goodfriend, W. (2014). What is learning: Understanding effective classroom strategies. Education Portal. Retrieved from https://study.com/academy/lesson/what-is-learning-understandingeffective-classroom-strategies.html

Google. (n.d.). [Map data 2015 Google, IN: Terms Indian Ocean Mauritius]. Retrieved March 24, 2021, from https://www.google.com/maps/d/view?mid=1h3vGc6XIIMyvyr_9sj1Rr_w23wg&ll=-8.40190432685756%2C66.52256019990229&z=4

Gow, L., & Kember, D. (1990). Does higher education promote independent learning? Higher Education, 19(3), 307-322. https://doi.org/10.1007/BF00133895

Gow, L., & Kember, D. (1993). Conceptions of teaching and their relationship to student learning. British Journal of Educational Psychology, 63(1), 20-23. https://doi.org/10.1111/j.2044-8279.1993.tb01039.x

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Towards a conceptual framework for mixed methods evaluation designs. Educational Evaluation and Policy analysis, 11(3), 255-274. https://doi.org/10.3102/01623737011003255

Grosser, M. (2007). Effective teaching: linking teaching to learning functions. South African Journal of Education, 27(1), 37-52. https://scholar.google.com/scholar?cluster=11024928039370772088

Guest, G., MacQueen, K. M., & Namey, E. E. (2012). Applied thematic analysis. SAGE Publications. https://dx.doi.org/10.4135/9781483384436

Guo, K., Kuramochi, K., & Huang, W. (2017). Learning and learners in early childhood curricula: Australia, Japan and China. Curriculum Perspectives, 1(37), 39-49. https://www.infona.pl/resource/bwmeta1.element.springer-doi-10_1007-S41297-017-0007-9

Guo, M., & Leung, F. K. (2021). Achievement goal orientations, learning strategies, and mathematics achievement: A comparison of Chinese Miao and Han students. Psychology in the Schools, 58(1), 107-123. https://onlinelibrary.wiley.com/doi/abs/10.1002/pits.22424

Haggis, T. (2003). Constructing images of ourselves? A critical investigation into 'approaches to learning' research in higher education. British Educational Research Journal, 29(1), 89-105. https://doi.org/10.1080/0141192032000057401

Haggis, T. (2009). What have we been thinking of? a critical overview of 40 years of student learning research in higher education. Studies in Higher Education, 34(4), 377-390. https://doi.org/10.1080/03075070902771903

Hailikari, T. K., & Parpala, A. (2014). What impedes or enhances my studying? The interrelation between approaches to learning, factors influencing study progress and earned credits. Teaching in Higher Education, 19(7), 812-824. https://doi.org/10.1080/13562517.2014.934348

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. Journal of Marketing Theory and Practice, 19, 139-151. https://doi.org/10.2753/MTP1069-6679190202

Hair, J. F., Sarstedt, M., & Ringle, C. M. (2019). Rethinking some of the rethinking of partial least squares. European Journal of Marketing, 53(4), 566-584. https://www.ingentaconnect.com/content/mcb/007/2019/00000053/00000004/art00001

Harasim, L. (2017). Learning theory and online technologies. Routledge. https://www.taylorfrancis.com/books/mono/10.4324/9781315716831

Heng, T. T. (2018). Different is not deficient: Contradicting stereotypes of Chinese international students in US higher education. Studies in Higher Education, 43(1), 22-36. https://www.tandfonline.com/doi/abs/10.1080/03075079.2016.1152466

Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009). The Use of Partial Least Squares Path Modeling in International Marketing. Advances in International Marketing, 20, 277-319. https://doi.org/10.1108/S1474-7979(2009)0000020014

Hess, R. D., & Azuma, H. (1991). Cultural support for schooling: Contrasts between Japan and the United States. Educational Researcher, 20(9), 2-9.

https://doi.org/10.3102/0013189X020009002

Ho, S. (2020). Culture and Learning: Confucian Heritage Learners, Social-Oriented Achievement, and Innovative Pedagogies. Diversity and Inclusion in Global Higher Education, 117. https://library.oapen.org/bitstream/handle/20.500.12657/23168/1006985.pdf

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. Contemporary Educational Psychology, 25(4), 378–405. https://doi.org/10.1006/ceps.1999.1026

Howard, M. C. (2016). A review of exploratory factor analysis decisions and overview of current practices: What we are doing and how can we improve? International Journal of Human-Computer Interaction, 32(1), 51-62. https://doi.org/10.1080/10447318.2015.1087664

Howell Smith, M. C., & Shanahan Bazis, P. (2021). Conducting mixed methods research systematic methodological reviews: A review of practice and recommendations. Journal of Mixed Methods Research, 15(4), 546-566. https://journals.sagepub.com/doi/abs/10.1177/1558689820967626

Hsieh, W. M., & Tsai, C. C. (2018). Learning illustrated: An exploratory cross-sectional drawing analysis of students' conceptions of learning. The Journal of Educational Research, 111(2), 139-150. https://doi.org/10.1080/00220671.2016.1220357

Hulin, C., Netemeyer, R., & Cudeck, R. (2001). Can a reliability coefficient be too high? Journal of Consumer Psychology, 10, 55-58. https://doi.org/10.1207/S15327663JCP1001&2_05

Huynh, T., Hatton-Bowers, H., & Howell Smith, M. (2019). A critical methodological review of mixed methods designs used in mindfulness research. Mindfulness, 10(5), 786-798. https://link.springer.com/article/10.1007/s12671-018-1038-5

Iqbal, H. M., Nageen, T., & Pell, A. W. (2008). Attitudes to school science held by primary children in Pakistan. Evaluation & Research in Education, 21(4), 269-302. https://doi.org/10.1080/09500790802307829

Jaidin, J. H. (2018). Scenario-based interview: An alternative approach to interviewing children. Asia-Pacific Journal of Research in Early Childhood Education, 12(1), 23-37. https://www.researchgate.net/profile/Jainatul-Jaidin-2/publication/322204645

Jentoft, N., & Olsen, T. S. (2019). Against the flow in data collection: How data triangulation combined with a 'slow'interview technique enriches data. Qualitative Social Work, 18(2), 179-193. https://journals.sagepub.com/doi/abs/10.1177/1473325017712581

Jogulu, U. M. & Pansiri, J. (2011). Mixed methods: a research design for management doctoral dissertations. Management Research Review, 34(6), 687-701. https://doi.org/10.1108/01409171111136211

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. Educational Researcher, 33(7), 14-26. https://doi.org/10.3102/0013189X033007014

Jufrida, J., Kurniawan, W., Astalini, A., Darmaji, D., Kurniawan, D. A., & Maya, W. A. (2019). Students' Attitude and Motivation in Mathematical Physics. International Journal of Evaluation and Research in Education, 8(3), 401-408. https://eric.ed.gov/?id=EJ1231046

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. Educational and Psychological Measurement, 20(1), 141-151. https://doi.org/10.1177/001316446002000116

Kang, H. S., Lee, J. Y., Choi, S., Kim, H., Park, J. H., Son, J. Y., ... & Noh, S. D. (2016). Smart manufacturing: Past research, present findings, and future directions. International Journal of Precision Engineering and Manufacturing-green Technology, 3(1), 111-128. https://doi.org/10.1007/s40684-016-0015-5

Ke, L., Sadler, T. D., Zangori, L., & Friedrichsen, P. J. (2020). Students' perceptions of socio-scientific issue-based learning and their appropriation of epistemic tools for systems thinking. International Journal of Science Education, 42(8), 1339-1361. https://www.tandfonline.com/doi/abs/10.1080/09500693.2020.1759843

Kember, D. (1996). The intention to both memorise and understand: Another approach to learning? Higher Education, 31(3), 341-354. https://doi.org/10.1007/BF00128436

Kember, D. (2000). Misconceptions about the learning approaches, motivation and study practices of Asian students. Higher Education, 40(1), 99-121. https://doi.org/10.1023/A:1004036826490

Kember, D. (2016). Why do Chinese students out-perform those from the West? Do approaches to learning contribute to the explanation?. Cogent Education, 3(1), 1248187. https://www.tandfonline.com/doi/abs/10.1080/2331186X.2016.1248187

Kember, D., & Gow, L. (1991). A challenge to the anecdotal stereotype of the Asian student. Studies in Higher Education, 16(2), 117-128. https://doi.org/10.1080/03075079112331382934

Kember, D., & Kwan, K. P. (2000). Lecturers' approaches to teaching and their relationship to conceptions of good teaching. Instructional Science, 28(5), 469-490. https://doi.org/10.1023/A:1026569608656

Kember, D., & Leung, D. Y. (1998). The dimensionality of approaches to learning: An investigation with confirmatory factor analysis on the structure of the SPQ and LPQ. British Journal of Educational Psychology, 68(3), 395-407. https://doi.org/10.1111/j.2044-8279.1998.tb01300.x

Kember, D., Biggs, J., & Leung, D. Y. (2004). Examining the multidimensionality of approaches to learning through the development of a revised version of the Learning Process Questionnaire. British Journal of Educational Psychology, 74(2), 261-279. https://doi.org/10.1348/000709904773839879

Kember, D., Jamieson, Q. W., Pomfret, M., & Wong, E. T. (1995). Learning approaches, study time and academic performance. Higher Education, 29(3), 329-343. https://doi.org/10.1007/BF01384497

Kember, D., Wong, A., & Leung, D. Y. (1999). Reconsidering the dimensions of approaches to learning. British Journal of Educational Psychology, 69(3), 323-343. https://doi.org/10.1348/000709999157752

Kim, S. W. (2020). Meta-analysis of parental involvement and achievement in East Asian countries. Education and Urban Society, 52(2), 312-337. https://journals.sagepub.com/doi/abs/10.1177/0013124519842654

King, P. M., & Kitchener, K. S. (1994). Developing Reflective Judgment: Understanding and Promoting Intellectual Growth and Critical Thinking in Adolescents and Adults. Jossey-Bass. https://eric.ed.gov/?id=ED368925

King, P. M., & Kitchener, K. S. (2004). The reflective judgment model: Twenty years of research on epistemic cognition. In B. K. Hofer, & P. R. Pintrich (Eds.), Personal Epistemology: The Psychology of Beliefs about Knowledge and Knowing (pp. 37 – 62).

Routledge. https://books.google.com/books?hl=en&lr=&id=dUEeYuvj-PsC&oi=fnd&pg=PA37&dq=King

Kirkgöz, Y. (2013). Students' approaches to learning in an English-medium higher education. The Journal of Language Learning and Teaching, 3(2), 30-39. https://dergipark.org.tr/en/pub/jltl/issue/22505/240596

Kivunja, C., & Kuyini, A. B. (2017). Understanding and Applying Research Paradigms in Educational Contexts. International Journal of Higher Education, 6(5), 26-41. https://doi.org/10.5430/ijhe.v6n5p26

Klein, R., & Rai, A. (2009). Interfirm Strategic Information Flows in Logistics Supply Chain Relationships. MIS Quarterly, 33(4), 735-762. https://doi.org/10.2307/20650325

Kocakaya, S., & Kocakaya, F. (2014). A Structural Equation Modeling on Factors of How Experienced Teachers Affect the Students' Science and Mathematics Achievements. Education Research International. http://dx.doi.org/10.1155/2014/490371

Kolb, D. A. (2005). The Kolb Learning Style Inventory—Version 3.1: Self-scoring and interpretation booklet. Hay Group. http://webkelley.com/HBS/Kolb_learning%20_style.pdf

Lam, B. H., & Kember, D. (2006). The relationship between conceptions of teaching and approaches to teaching. Teachers and Teaching: Theory and Practice, 12(6), 693-713. https://doi.org/10.1080/13540600601029744

Laurillard, D. (2013). Teaching as a design science: Building pedagogical patterns for learning and technology. Routledge. https://doi.org/10.4324/9780203125083

Lee, M. H., Johanson, R. E., & Tsai, C. C. (2008). Exploring Taiwanese high school students' conceptions of and approaches to learning science through a structural equation modeling analysis. Science Education, 92(2), 191-220. https://doi.org/10.1002/sce.20245

Lee, M. H., Lin, T. J., & Tsai, C. C. (2013). Proving or Improving Science Learning? Understanding High School Students' Conceptions of Science Assessment in Taiwan. Science Education, 97(2), 244-270. https://doi.org/10.1002/sce.21046

Li, J. (2003). U.S. and Chinese cultural beliefs about learning. Journal of Educational Psychology, 95(2), 258 – 267. https://doi.org/10.1037/0022-0663.95.2.258

Li, M., Zheng, C., Liang, J. C., Zhang, Y., & Tsai, C. C. (2018). Conceptions, self-regulation, and strategies of learning science among Chinese high school students. International Journal of Science and Mathematics Education, 16(1), 69-87. https://doi.org/10.1007/s10763-016-9766-2

Li, W. T., Liang, J. C., & Tsai, C. C. (2013). Relational Analysis of College Chemistry-major Students' Conceptions of and Approaches to Learning Chemistry. Chemistry Education Research and Practice, 14, 555–565. https://doi.org/10.1039/C3RP00034F

Li, L., & Liu, Y. (2022). An integrated model of principal transformational leadership and teacher leadership that is related to teacher self-efficacy and student academic performance. Asia Pacific Journal of Education, 42(4), 661-678. https://www.tandfonline.com/doi/abs/10.1080/02188791.2020.1806036

Liang, J. C., & Tsai, C. C. (2010). Relational Analysis of College Science-Major Students' Epistemological Beliefs Toward Science and Conceptions of Learning Science. International Journal of Science Education, 32(17), 2273-2289. https://doi.org/10.1080/09500690903397796

Liang, J. C., Su, Y. C., & Tsai, C. C. (2015). The assessment of Taiwanese college students' conceptions of and approaches to learning computer science and their relationships. The Asia-Pacific Education Researcher, 24(4), 557-567. https://doi.org/10.1007/s40299-014-0201-6

Lin, C. C., & Tsai, C. C. (2009). The relationships between students' conceptions of learning engineering and their preferences for classroom and laboratory learning environments. Journal of Engineering Education, 98(2), 193-204. https://doi.org/10.1002/j.2168-9830.2009.tb01017.x

Lin, C. L., Tsai, C. C., & Liang, J. C. (2012). An investigation of two profiles within conceptions of learning science: An examination of confirmatory factor analysis. European Journal of Psychology of Education, 27(4), 499-521. https://doi.org/10.1007/s10212-011-0092-3

Lin, H. M., & Tsai, C. C. (2008). Conceptions of learning management among undergraduate students in Taiwan. Management Learning, 39(5), 561–578. https://doi.org/10.1177/1350507608096041

Lin, T. J., & Tsai, C. C. (2013). An investigation of Taiwanese high school students' science learning self-efficacy in relation to their conceptions of learning science. Research in Science & Technological Education, 31(3), 308-323. https://doi.org/10.1080/02635143.2013.841673

Lin, Y. C., Liang, J. C., & Tsai, C. C. (2012). The relationships between epistemic beliefs in biology and approaches to learning biology among biology-major university students in Taiwan. Journal of Science Education and Technology, 21, 796-807. https://doi.org/10.1007/s10956-012-9367-y

Lin, Y. H., Liang, J. C., & Tsai, C. C. (2012). Effects of different forms of physiology instruction on the development of students' conceptions of and approaches to science learning. Advances in Physiology Education, 36(1), 42-47. https://doi.org/10.1152/advan.00118.2011

Liu, J., Peng, P., & Luo, L. (2020). The relation between family socioeconomic status and academic achievement in China: A meta-analysis. Educational Psychology Review, 32(1), 49-76. https://link.springer.com/article/10.1007/s10648-019-09494-0

Lloyd, D, (2017). What is learning? In Social Sciences, Centre for Teacher Education: Forum. Warwick University. Retrieved from https://study.com/academy/lesson/what-is-learning-understandingeffective-classroom-strategies.html

Lonka, K., Olkinuora, E., & Mäkinen, J. (2004). Aspects and prospects of measuring studying and learning in higher education. Educational Psychology Review, 16(4), 301-323. https://doi.org/10.1007/s10648-004-0002-1

Lonka, K., Ketonen, E., & Vermunt, J. D. (2021). University students' epistemic profiles, conceptions of learning, and academic performance. Higher Education, 81(4), 775-793. https://link.springer.com/article/10.1007/s10734-020-00575-6

Lucas, U., & Mladenovic, R. (2004). Approaches to Learning in Accounting Education. Accounting Education: An International Journal, 13(4), 399-407. https://doi.org/10.1080/0963928042000306783

Mackenzie, N., & Knipe, S. (2006). Research dilemmas: paradigms, methods and methodology. Issues in Educational Research, 16, 1-15.http://iier.org.au/iier16/mackenzie.html

Magnusson, E., & Marecek, J. (2015). Doing interview-based qualitative research: A learner's guide. Cambridge University Press.

https://books.google.com/books?hl=en&lr=&id=fZiNCgAAQBAJ&oi=fnd&pg=PA1&dq=Magnusson

Mahinay, R. A. (2014). Structural Equation Model on Learners' Conceptions of Learning and Approaches to Learning as Predictors of Physics Self-Efficacy. IAMURE International Journal of Education, 10(1), 111-123. https://www.researchgate.net/profile/Ray-Butch-Mahinay/publication/281929895

Malcolm, J., & Zukas, M. (2001). Bridging pedagogic gaps: conceptual discontinuities in higher education. Teaching in Higher Education, 6(1), 33-42. https://doi.org/10.1080/13562510020029581

Mandiudza, L. (2013). Child friendly schools. Greener Journal of Education Research, 3(6), 283-288. https://pdfs.semanticscholar.org/a540/4fabaa4c69ce3c566ae4e4a9e747cdd460cc.pdf

Marshall, D., & Case, J. (2005). 'Approaches to learning' research in higher education: a response to Haggis. British Educational Research Journal, 31(2), 257-267. https://doi.org/10.1080/0141192052000340242

Marton, F. (1981). Phenomenography-describing conceptions of the world around us. Instructional Science 10(2), 177–200. https://doi.org/10.1007/BF00132516

Marton, F., & Säljö, R. (1976). On qualitative differences in learning: I—Outcome and process. British journal of Educational Psychology, 46(1), 4-11. https://doi.org/10.1111/j.2044-8279.1976.tb02980.x

Marton, F., Dall'Alba, G., & Beaty, E. (1993). Conceptions of Learning. International Journal of Educational Research, 19, 277–299.

https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?ReferenceID=681142

Marton, F., Watkins, D., & Tang, C. (1997). Discontinuities and continuities in the experience of learning: An interview study of high-school students in Hong Kong. Learning and Instruction, 7(1), 21-48. https://doi.org/10.1016/S0959-4752(96)00009-6

Marton, F., Wen, Q., & Nagle, A. (1996). Views on learning in different cultures. Comparing patterns in China and Uruguay. Anales de Psicologia, 12(2), 123-32. https://www.um.es/analesps/v12/v12_2/02-12-2.pdf

Maulloo, A. K., & Naugah, J. (2017). Upper secondary education in Mauritius: a case study. Broad and Balanced: What is the future of our post-16 curriculum? [Paper Presentation]. Royal Society's Commonwealth Science Conference: 2017, Singapore. https://royalsociety.org/~/media/policy/topics/education-skills/Broadening%20the%20curriculum/mauritius-case-study.pdf

Mays, N. & Pope, C. (1995). Rigor and qualitative research. BMJ: British Medical Journal. 311(6997), 109-112. https://doi.org/10.1136/bmj.311.6997.109

Mayya, S. S., & Krishna Rao, A. (2004). Learning approaches, learning difficulties and academic performance of undergraduate students of physiotherapy. Internet Journal of Allied Health Sciences and Practice, 2(4), 6. https://nsuworks.nova.edu/ijahsp/vol2/iss4/6/

McQuitty, S., & Wolf, M. (2013). Structural Equation Modeling: A Practical Introduction. Journal of African Business, 14(1), 58-69. https://doi.org/10.1080/15228916.2013.765325

Meyer, J. H. F. (2000). Variation in contrasting forms of 'memorising' and associated variables. British Journal of Educational Psychology, 70, 163-176. https://doi.org/10.1348/000709900158029

Minasian-Batmanian, L. C., Lingard, J., & Prosser, M. (2006). Variation in student reflections on their conceptions of and approaches to learning biochemistry in a first-year health sciences' service subject. International Journal of Science Education, 28(15), 1887-1904. https://doi.org/10.1080/09500690600621274

Minbashian, A., Huon, G. F., & Bird, K. D. (2004). Approaches to studying and academic performance in short-essay exams. Higher Education, 47(2), 161-176. https://doi.org/10.1023/B:HIGH.0000016443.43594.d1

Ministry of Education, Culture and Human Resources. (2008). Strategy plan 2008-2020. IVTB. https://education.govmu.org/Documents/Documents/Publications/EHRSP%202008-2020.pdf

Mogre, V., & Amalba, A. (2015). Approaches to learning among Ghanian students following a PBL-based medical curriculum. Education in Medicine Journal, 7(1), 38-44. https://doi-org.ukzn.idm.ocla.org/10.595/eimj.v7il.319

Monroy, F., & González-Geraldo, J. L. (2017). Teaching conceptions and approaches: do qualitative results support survey data? Revista de Investigación Educativa, 35(1), 167-180. https://doi.org/10.6018/rie.35.1.237621

Mystakidis, S. (2021). Deep meaningful learning. Encyclopedia, 1(3), 988-997. https://www.mdpi.com/2673-8392/1/3/75

Norton, L. S., & Crowley, C. M. (1995). Can students be helped to learn how to learn? An evaluation of an approaches to learning programme for first-year degree students. Higher Education, 29(3), 307-328. https://doi.org/10.1007/BF01384496

Novak, J. D. (1978). An alternative to Piagetian psychology for science & mathematics education. Studies in Science Education, 5(1), 1-30. https://doi.org/10.1080/03057267808559855

OECD. (2008). Tertiary education for the knowledge society OECD—Thematic Review of Tertiary Education: Synthesis Report. Retrieved from http://www.oecd.org/dataoecd/20/4/40345176.pdf

Olatoun, A. (2012). Resource utilization and internal efficiency in Nigerian secondary schools: Implications for socio problems of education. International Journal of Sociology and Anthropology, 4(1), 23-30. https://doi.org/10.5897/IJSA11.035

Pang, M. F. (2003). Two faces of variation: On continuity in the phenomenographic movement. Scandinavian Journal of Educational Research, 47(2), 145-156. https://doi.org/10.1080/00313830308612

Park, J., & Jeon, D. (2015). Correlation of students' brain types to their conceptions of learning science and approaches to learning science. Eurasia Journal of Mathematics, Science and Technology Education, 11(5), 1141-1149. https://doi.org/10.12973/eurasia.2015.1388a

Piaget, J. (1959). The Language and Thought of the Child. Routledge & Kegan Paul. https://scirp.org/reference/referencespapers.aspx?referenceid=1569782

Pillay, H., & Boulton-Lewis, G. (2000). Variations in Conceptions of Learning in Construction Technology: Implications for learning. Journal of Education and Work, 13(2), 163-181. https://doi.org/10.1080/713676984

Potvin, P., & Hasni, A. (2014). Analysis of the Decline in Interest Towards School Science and Technology from Grades 5 Through 11. Journal of Science Education and Technology, 23(6), 784-802. https://doi.org/10.1007/s10956-014-9512-x

Pratt, D. D. (1992). Chinese conceptions of learning and teaching: A Westerner's attempt at understanding. International Journal of Lifelong Education, 11(4), 301-319. https://doi.org/10.1080/0260137920110404

Prichard, C. (2009). Three moves for engaging students in critical management studies. Management Learning, 40(1), 51-68. https://doi.org/10.1177/1350507608099313

Prosser, M., & Trigwell, K. (1999). Understanding learning and teaching: The experience in higher education. McGraw-Hill Education. https://books.google.com/books?hl=en&lr=&id=2UHlAAAAQBAJ&oi=fnd&pg=PP1&dq=Prosser

Prosser, M., & Webb, C. (1994). Relating the Process of Undergraduate Essay Writing to the Finished Product. Studies in Higher Education, 19(2), 125-38. https://doi.org/10.1080/03075079412331381987

Purdie, N. M., & Hattie, J. (2002). Assessing students' conceptions of learning. Australian Journal of Educational and Developmental Psychology, 2, 17-32. https://www.scirp.org/(S(i43dyn45teexjx455qlt3d2q))/reference/ReferencesPapers.aspx?ReferenceID=681147

Purdie, N., Hattie, J., & Douglas, G. (1996). Student conceptions of learning and their use of self-regulated learning strategies: A cross-cultural comparison. Journal of Educational Psychology, 88(1), 87-100. https://doi.org/10.1037/0022-0663.88.1.87

Ramburuth, P., & Mladenovic, R. (2004). Exploring the relationship between students' orientations to learning, the structure of students' learning outcomes and subsequent academic performance. Accounting Education: An International Journal, 13(4), 507-527. https://doi.org/10.1080/0963928042000306774

Ramsden, P. (1979). Student learning and perceptions of the academic environment. Higher Education, 8(4), 411-427. https://doi.org/10.1007/BF01680529

Ramsden, P. (1983). Institutional variations in British students' approaches to learning and experiences of teaching. Higher Education, 12(6), 691-705. http://www.jstor.org/stable/3446124

Ramsden, P. (2003). Learning to teach in higher education. Routledge. https://doi.org/10.4324/9780203507711

Ramsden, P., & Entwistle, N. J. (1981). Effects of academic departments on students' approaches to studying. British Journal of Educational Psychology, 51(3), 368-383. https://doi.org/10.1111/j.2044-8279.1981.tb02493.x

Ramsden, P., Martin, E., & Bowden, J. (1989). School environment and sixth form pupils' approaches to learning. British Journal of Educational Psychology, 59(2), 129-142. https://doi.org/10.1111/j.2044-8279.1989.tb03086.x

Reid, A., Duvall, E., & Evans, P. (2007). Relationship between assessment results & approaches to learning & studying in year two medical students. Medical Education, 41(8), 754-762. https://doi.org/10.1111/j.1365-2923.2007.02801.x

Reid, A., Wood, L. N., Smith, G. H., & Petocz, P. (2005). Intention, approach and outcome: University mathematics students' conceptions of learning mathematics. International

Journal of Science and Mathematics Education, 3(4), 567-586. https://doi.org/10.1007/s10763-004-5818-0

Richardson, J. T. (2011). Approaches to studying, conceptions of learning and learning styles in higher education. Learning and Individual Differences, 21(3), 288-293. https://doi.org/10.1016/j.lindif.2010.11.015

Richardson, J. T. E. (2010). Conceptions of learning and approaches to studying among white and ethnic minority students in distance education. British Journal of Education Psychology, 80(4), 535-56. https://doi.org/10.1348/000709910X489283

Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: a systematic review and meta-analysis. Psychological Bulletin, 138(2), 353. https://doi.org/10.1037/a0026838

Rienties, B., Beausaert, S., Grohnert, T., Niemantsverdriet, S., & Kommers, P. (2012). Understanding academic performance of international students: the role of ethnicity, academic and social integration. Higher Education, 63(6), 68-700. https://doi.org/10.1007/s10734-011-9468-1

Rumjaun, A., Atchia, S., & Reiss, M. J. (2022). Policy responses to the decline in the number of students choosing biology beyond compulsory school level in Mauritius. *Journal of Biological Education*, 1-18. https://www.tandfonline.com/doi/abs/10.1080/00219266.2021.2012226

Sadi, O. (2015). The Analysis of High School Students' Conceptions of Learning in Different Domains. International Journal of Environmental & Science Education, 10(6), 813-827. https://eric.ed.gov/?id=EJ1082066

Sadi, Ö., & Çevik, M. (2016). Investigating of conceptions of learning biology with respect to gender, grade level and school type. SHS Web of Conferences, 26, 01025. EDP Sciences. https://www.shs-conferences.org/articles/shsconf/abs/2016/04/shsconf_erpa2016_01025

Sadi, Ö., & Dağyar, M. (2015). High School Students' Epistemological Beliefs, Conceptions of Learning, and Self-efficacy for Learning Biology: A Study of Their Structural Models. Eurasia Journal of Mathematics, Science & Technology Education, 11(5). https://doi.org/10.12973/eurasia.2015.1375a

Sadi, O., & Lee, M. H. (2015). The conceptions of learning science for science-mathematics groups and literature-mathematics groups in Turkey. Research in Science & Technological Education, 33(2), 182-196. https://doi.org/10.1080/02635143.2014.996543

Sadi, O., & Lee, M. H. (2018). Exploring Taiwanese and Turkish high school students' conceptions of learning biology. Journal of Biological Education, 52(1), 18-30. https://doi.org/10.1080/00219266.2017.1285799

Sadi, Ö., & Uyar, M. (2014). The Turkish adaptation of the Conceptions of Learning Science Questionnaire: The study of Validity and Reliability. Journal of Educational and İnstructional Studies in the World, 4(2), 73-85. https://www.researchgate.net/publication/263441715

Saldana, J. (2021). The Coding Manual for Qualitative Researchers. SAGE Publications. https://www.torrossa.com/gs/resourceProxy?an=5018667&publisher=FZ7200

Saleh, S. (2014). Malaysian Students' Motivation towards Physics Learning. European Journal of Science and Mathematics Education, 2(4), 223-232. https://eric.ed.gov/?id=EJ1107653

Säljö, R. (1979). Learning about learning. Higher Education, 8(4), 443-451. https://doi.org/10.1007/BF01680533

Samuelowicz, K. (1987). Learning problems of overseas students: Two sides of a story. Higher Education Research and Development, 6(2), 121-133. https://doi.org/10.1080/0729436870060204

Sarstedt, M., Ringle, C. M., & Hair, J. F. (2017). Partial least squares structural equation modeling. Handbook of Market Research, 26(1), 1-40. https://doi.org/10.1007/978-3-319-57413-4_15

Sarstedt, M., Ringle, C. M., & Hair, J. F. (2021). Partial least squares structural equation modeling. In Handbook of market research (pp. 587-632). Springer International Publishing. https://link.springer.com/content/pdf/10.1007/978-3-319-57413-4_15.pdf

Sarwar, M., Naz, A., & Noreen, G. (2011). Attitudes toward science among school students of different nations: A review study. Journal of College Teaching & Learning (TLC), 8(2), 45-50. https://doi.org/10.19030/tlc.v8i2.3555

Schmeck, R. R. (Ed.). (2013). Learning strategies and learning styles. Springer Science & Business Media. https://books.google.com/books?hl=en&lr=&id=5wzyBwAAQBAJ&oi=fnd&pg=PA3&dq=Schmeck

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. Journal of Educational Psychology, 82(3), 498-504. https://doi.org/10.19030/tlc.v8i2.3555

Schommer, M. (1998). The influence of age and education on epistemological beliefs. British Journal of Educational Psychology, 68, 551–562. https://doi.org/10.1111/j.2044-8279.1998.tb01311.x

Schuh, K. L. (2004). Students' spontaneous use of information from media sources: what and how do they link? International Journal of Instructional Media, 31(4), 333-344. https://eric.ed.gov/?id=EJ725515

Scotland, J. (2012). Exploring the philosophical underpinnings of research: Relating ontology and epistemology to the methodology and methods of the scientific, interpretive, and critical research paradigms. English Language Teaching, 5(9), 9-16. http://dx.doi.org/10.5539/elt.v5n9p9

Scouller, K. (1998). The influence of assessment method on students' learning approaches: Multiple choice question examination versus assignment essay. Higher Education, 35(4), 453-472. https://doi.org/10.1023/A:1003196224280

Shan, Y. (2022). Philosophical foundations of mixed methods research. Philosophy Compass, 17(1), e12804. https://onlinelibrary.wiley.com/doi/abs/10.1111/phc3.12804

Shen, K. M., Lee, M. H., Tsai, C. C., & Chang, C. Y. (2016). Undergraduate students’ earth science learning: relationships among conceptions, approaches, and learning self-efficacy in Taiwan. International Journal of Science Education, 38(9), 1527-1547. https://doi.org/10.1080/09500693.2016.1198060

Simon, S. (2009). A Review of: “Statistical Rules of Thumb, by G. van Belle”. Journal of Biopharmaceutical Statistics, 19(4), 752-754. https://doi.org/10.1080/10543400902964217

Sinatra, G. M. (2001). Knowledge, beliefs, and learning. Educational Psychology Review, 13(4), 321–323. https://www.jstor.org/stable/23363495

Sit, H. H. W. (2013). Characteristics of Chinese students' learning styles. International Proceedings of Economics Development and Research, 62, 36. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=45b827fc2effc6857329293023bcbe576b0c42a6

Skjott Linneberg, M., & Korsgaard, S. (2019). Coding qualitative data: a synthesis guiding the novice. Qualitative Research Journal, 19(3), 259-270. https://doi.org/10.1108/QRJ-12-2018-0012

Skinner, D. (2022). Applying for teacher training. In Get Set for Teacher Training (pp. 188-189). Edinburgh University Press. https://www.degruyter.com/document/doi/10.1515/9780748626205-014/html?lang=en

Smith, R., Snow, P., Serry, T., & Hammond, L. (2021). The role of background knowledge in reading comprehension: A critical review. *Reading Psychology*, *42*(3), 214-240. https://www.tandfonline.com/doi/abs/10.1080/02702711.2021.1888348

Spates, C. R., & Kanfer, F. H. (1977). Self-monitoring, self-evaluation, and self-reinforcement in children's learning: A test of a multistage self-regulation model. Behavior Therapy, 8(1), 9-16. https://doi.org/10.1016/S0005-7894(77)80115-9

Ste-Marie, D. M., Carter, M. J., & Yantha, Z. D. (2019). Self-controlled learning: Current findings, theoretical perspectives, and future directions. Skill Acquisition in Sport, 119-140. https://www.taylorfrancis.com/chapters/edit/10.4324/9781351189750-7

Stenbacka, C. (2001). Qualitative research requires quality concepts of its own. Management Decision, 36(7), 551-555. https://doi.org/10.1108/EUM0000000005801

Stone, M. (1974). Cross-validation Choice and Assessment of Statistical Predictions. Journal of the Royal Statistical Society Series B, 36(2), 111-147. https://doi.org/10.1111/j.2517-6161.1974.tb00994.x

Struyven, K., Dochy, F., & Janssens, S. (2005). Students' perceptions about evaluation and assessment in higher education: A review. Assessment & Evaluation in Higher Education, 30(4), 325-341. https://doi.org/10.1080/02602930500099102

Tan, K., & Choo, F. (1990). A note on the academic performance of deep-elaborative versus shallow-reiterative information processing students. Accounting & Finance, 30(1), 67-81. https://doi.org/10.1111/j.1467-629X.1990.tb00114.x

Taylor, G., & Ali, N. (2017). Learning and living overseas: Exploring factors that influence meaningful learning and assimilation: How international students adjust to studying in the UK from a socio-cultural perspective. Education Sciences, 7(1), 35. https://www.mdpi.com/183760

Thomson, K. (2017). Exploring learning conceptions in a culturally diverse post-graduate science classroom (Doctoral Dissertation). University of Sterling. https://dspace.stir.ac.uk/bitstream/1893/25959/1/Karen Thesis Master_final.pdf

Tickle, S. (2001). What have we learnt about student learning? A review of the research on study approach and style. Kybernetes: The International Journal of Systems & Cybernetics, 30(7-8), 955-969. https://doi.org/10.1108/EUM0000000005918

Torney-Purta, J. (1990). Research news and comment: International comparative research in education: Its role in educational improvement in the US. Educational Researcher, 19(7), 32-35. https://doi.org/10.3102/0013189X019007032

Trigwell, K., & Prosser, M. (1991). Improving the quality of student learning: the influence of learning context and student approaches to learning on learning outcomes. Higher Education, 22(3), 251-266. https://doi.org/10.1007/BF00132290

Trigwell, K., Prosser, M., & Waterhouse, F. (1999). Relations between teachers' approaches to teaching and students' approaches to learning, Higher Education, 37(1), 57-70. https://doi.org/10.1023/A:1003548313194

Tsai, C. C. (2004). Conceptions of Learning Science among High School Students in Taiwan: A Phenomenographic Analysis. International Journal of Science Education, 26(14), 1733-1750. https://doi.org/10.1080/0950069042000230776

Tsai, C. C. (2006). Biological knowledge is more tentative than physics knowledge: Taiwan high school adolescents' views about the nature of biology and physics. Adolescence, 41(164), 691–703. https://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope

Tsai, C. C. (2009). Conceptions of learning versus conceptions of web-based learning: The differences revealed by college students. Computers & Education, 53(4), 1092-103. https://doi.org/10.1016/j.compedu.2009.05.019

Tsai, C. C., & Kuo, P. C. (2008). Cram school students' conceptions of learning and learning science in Taiwan. International Journal of Science Education, 30, 353-375. https://doi.org/10.1080/09500690701191425

Tsai, C. C., Ho, H. N. J., Liang, J. C., & Lin, H. M. (2011). Scientific Epistemic Beliefs, Conceptions of Learning Science and Self-efficacy of Learning Science among High School Students. Learning and Instruction, 21(2), 757-769. https://doi.org/10.1016/j.learninstruc.2011.05.002

Tsai, P. S., & Tsai, C. C. (2014). College students' skills of online argumentation: The role of scaffolding and their conceptions. The Internet and Higher Education, 21, 1-8. https://doi.org/10.1016/j.iheduc.2013.10.005

Tynjala, P. (1997). Developing education students' conceptions of the learning process in different learning environments. Learning and Instruction, 7, 277-292. https://doi.org/10.1016/S0959-4752(96)00029-1

UNESCO. (2005). Global Monitoring Report: Education for All: The Quality Imperative. United Nations Education, Scientific and Cultural Organization (UNESCO). https://unesdoc.unesco.org/ark:/48223/pf0000137333

UNICEF. (2019). For every child, every right the convention on the rights of the child at a crossroads. United Nations Children's Fund (UNICEF). https://resourcecentre.savethechildren.net/document/every-child-every-right-convention-rights-child-crossroads

Van Rossum, E. J., & Hamer, R. (2010). The meaning of learning and knowing. Brill. https://books.google.com/books?hl=en&lr=&id=l30fEAAAQBAJ&oi=fnd&pg

Van Rossum, E. J., & Schenk, S. M. (1984). The relationship between learning conception, study strategy and learning outcome. British Journal of Educational Psychology, 54(1), 73-83. https://doi.org/10.1111/j.2044-8279.1984.tb00846.x

Vedenpää, I., & Lonka, K. (2014). Teachers' and teacher students' conceptions of learning and creativity. Creative Education, 5(20), 1821-1833. https://www.scirp.org/html/6-6302309_51547.htm?pagespeed=noscript

Veloo, A., Nor, R., & Khalid, R. (2015). Attitude towards physics and additional mathematics achievement towards physics achievement. International Education Studies, 8(3), 35-43. https://eric.ed.gov/?id=EJ1060855

Vermunt, J. D. (1996). Metacognitive, cognitive and affective aspects of learning styles and strategies: a phenomenographic analysis. Higher Education, 31(1), 25-50.

https://doi.org/10.1007/BF00129106

Vermunt, J. D., & Vermetten, Y. J. (2004). Patterns in student learning: Relationships between learning strategies, conceptions of learning, and learning orientations. Educational Psychology Review, 16(4), 359-384. https://doi.org/10.1007/s10648-004-0005-y

Virtanen, V., & Lindblom-Ylanne, S. (2010). University Students' and Teachers' Conceptions of Teaching and Learning in the Biosciences. Instructional Science, 38(4), 355-370. https://doi.org/10.1007/s11251-008-9088-z

Waheed, H., Hassan, S. U., Aljohani, N. R., Hardman, J., Alelyani, S., & Nawaz, R. (2020). Predicting academic performance of students from VLE big data using deep learning models. Computers in Human behavior, 104, 106189. https://www-sciencedirect-com.ukzn.idm.oclc.org/science/article/pii/S0747563219304017

Wahyuni, D. (2012). The Research Design Maze: Understanding Paradigms, Cases, Methods and Methodologies. Journal of Applied Management Accounting Research, 10(1), 69-80. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2103082

Watkins, D. (2000). Learning and teaching: A cross-cultural perspective. School Leadership & Management, 20(2), 161-173. https://doi.org/10.1080/13632430050011407

Watkins, D., & Dahlin, B. (1997). Assessing study approaches in Sweden. Psychological Reports, 81(1), 131-136. https://doi.org/10.2466/pr0.1997.81.1.13

Watkins, D., & Hattie, J. (1985). A longitudinal study of the approaches to learning of Australian tertiary students. Human Learning: Journal of Practical Research & Applications, 4, 127-141. https://psycnet.apa.org/record/1987-14084-001

Watkins, D., & Regmi, M. (1990). An investigation of the approach to learning of Nepalese tertiary students. Higher Education, 20(4), 459-469. https://doi.org/10.1007/BF00136223

Watkins, D., Reghi, M., & Astilla, E. (1991). The-Asian-learner-as-a-rote-learner Stereotype: myth or reality? Educational Psychology, 11(1), 21-34. https://doi.org/10.1080/0144341910110102

Webb, G. (1997). Deconstructing deep & surface: towards a critique of phenomenography. Higher Education, 33(2), 195-212. https://doi.org/10.1023/A:1002905027633

Whiting, L. S. (2008). Semi-structured interviews: Guidance for novice researchers. Nursing Standard, 22(23). https://search.proquest.com/openview/83e4ab6fced2e8e9e434c5d680d289c3/1

Williams, R. T. (2022).Rresearch methods in education: A book review. European Journal of Education Studies, 9(11). http://oapub.org/edu/index.php/ejes/article/view/4582

Willig, C. (2013). Introducing qualitative research in psychology. McGraw-Hill Education. https://books.google.com/books?hl=en&lr=&id=yDtFBgAAQBAJ&oi=fnd&pg=PR7&dq=Willig

Winstone, N., & Boud, D. (2019). Exploring cultures of feedback practice: the adoption of learning-focused feedback practices in the UK and Australia. Higher Education Research & Development, 38(2), 411-425. https://www.tandfonline.com/doi/abs/10.1080/07294360.2018.1532985

Wong, K. C., & Wen, Q. (2001). The impact of university education on conceptions of learning: A Chinese study. International Education Journal, 2(5), 138-147. https://openjournals.library.sydney.edu.au/index.php/IEJ/article/download/6777/7422#page=142

Wong, K. K. K. (2013). Partial least squares structural equation modeling (PLS-SEM) techniques using SmartPLS. Marketing Bulletin, 24(1), 1-32.

https://www.researchgate.net/file.PostFileLoader.html?id=55d6fbae5dbbbdb3608b45e0&assetKey=AS%3A273837248188417%401442299297149

Wong, N. Y., Lin, W. Y., & Watkins, D. (1996). Cross-cultural validation of models of approaches to learning: An application of confirmatory factor analysis. Educational Psychology, 16(3), 317-327. https://doi.org/10.1080/0144341960160308

Yang, X., Leung, F., & Zhang, S. (2019). Junior secondary school students' conceptions of and approaches to learning mathematics and their relationships in mainland China. Sustainability, 11(9), 2476. https://doi.org/10.3390/su11092476

Yang, Y. F., & Tsai, C. C. (2010). Conceptions of and approaches to learning through online peer assessment. Learning and Instruction, 20(1), 72-83. https://doi.org/10.1016/j.learninstruc.2009.01.003

Yang, Y. F., & Tsai, C. C. (2017). Exploring in-service preschool teachers' conceptions of and approaches to online education. Australasian Journal of Educational Technology, 33(1), 134-147. https://doi.org/10.14742/ajet.2635

Young, T. J., Sercombe, P. G., Sachdev, I., Naeb, R., & Schartner, A. (2013). Success factors for international postgraduate students' adjustment: exploring the roles of intercultural competence, language proficiency, social contact and social support. European Journal of Higher Education, 3(2), 151-171. https://doi.org/10.1080/21568235.2012.743746

Zakariya, Y. F., Nilsen, H. K., Bjørkestøl, K., & Goodchild, S. (2021). Analysis of relationships between prior knowledge, approaches to learning, and mathematics performance among engineering students. International Journal of Mathematical Education in Science and Technology, 1-19. https://www.tandfonline.com/doi/abs/10.1080/0020739X.2021.1984596

Zeegers, P. (2001). Approaches to learning in science: A longitudinal study. British Journal of Educational Psychology, 71(1), 115-132. https://doi.org/10.1348/000709901158424

Zheng, L., Dong, Y., Huang, R., Chang, C. Y., & Bhagat, K. K. (2018). Investigating the interrelationships among conceptions of, approaches to, and self-efficacy in learning science. International Journal of Science Education, 40(2), 139-158. https://doi.org/10.1080/09500693.2017.1402142

Zhu, C., Valcke, M., & Schellens, T. (2008). A cross-cultural study of Chinese and Flemish university students: Do they differ in learning conceptions and approaches to learning? Learning and Individual Differences, 18(1), 120-127. https://doi.org/10.1016/j.lindif.2007.07.004

Zimmerman, B. J., & Martinez-Pons, M. (1986). Development of a structured interview for assessing student use of self-regulated learning strategies. American Educational Research Journal, 23(4), 614-628. https://doi.org/10.3102/00028312023004614

Zimmerman, B. J., & Martinez-Pons, M. (1990). Student differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. Journal of Educational Psychology, 82(1), 51-59. https://doi.org/10.1037/0022-0663.82.1.51

APPENDICES

Appendix A: Permission to do Research in Mauritian Secondary School

REPUBLIC OF MAURITIUS
MINISTRY OF EDUCATION AND HUMAN RESOURCES, TERTIARY EDUCATION AND SCIENTIFIC RESEARCH

ME/305/3T17 **05 April 2019**

Mr Deenesh Patpur
La Source
Central Flacq

Dear Sir

Subject: Authorisation to enter school premises to conduct research

Please refer to your correspondence dated 18 March 2019 on the above subject.

2. This is to inform you that permission has been granted to you to collect data from the schools at Annex, subject to the following:

i). Informed consent of parents of the sampled students would have to be sought and obtained before you proceed with the collection of data;
ii). Anonymity of participants and confidentiality of data would have to be maintained; and
iii). At no point should the smooth running of classes be disturbed by the research exercise.

3. We advise that you liaise with the Rector of the school to make all necessary prior arrangements.

4. You will have to submit a copy of your findings to the Ministry upon completing the study.

Yours faithfully,

[redacted]

C. Surajbali-Bissoonauth (Mrs)
for Acting Senior Chief Executive

Cc: Director Zone 2
Director, Zone 4
Director Schooling, MGI

MITD House, Phoenix 73544 - MAURITIUS
Tel. No: 601 3458 Fax No: (230) 697 5305
E-mail: moe-secedu@govmu.org

Appendix B: Ethical Clearance

UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

09 September 2019

Mr Deenesh Patpur (218081480)
School of Education
Edgewood Campus

Dear Mr Patpur,

Protocol reference number: HSS/0523/019D
Project title: Exploring Mauritian Upper Secondary students' conceptions of and approaches to learning Biology

Approval Notification – Expedited Application

In response to your application received on 29 April 2019, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 1 year from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

[redacted]

....

Professor Urmilla Bob

Appendix C: Parent's Terms of Reference Letter and Consent Form

Dear Parent/Responsible party

I am currently enrolled on a PhD in Education at the University of KwaZulu-Natal (UKZN) in Durban, South Africa. I request your consent to allow your son/daughter/ward to participate in my research project which is entitled: *Exploring Mauritian Upper Secondary Students' Conceptions of and Approaches to Learning Biology*. The aim of my study is to find out what are Mauritian upper secondary school students' conceptions of learning and approaches to learning Biology.

For the purpose of data collection, your son/daughter/ward will be administered a survey questionnaire. He/she will be asked to respond to the questionnaire voluntarily. The cover page of the questionnaire will inform him/her about the aim and objectives of the study and his/her right to withdrawal. He/she may be selected for an interview. Data will be collected from May to October 2019 during school hours.

I wish to inform you that, should my presence have any effect on the class; I will leave the premises immediately. All considerations pertaining to ethics of consent, anonymity, right to withdraw and safekeeping of all research records and for the disposal of information are covered by the UKZN Ethics committee requirements. All students will be issued consent forms outlining the research focus and the necessary clauses that address their constitutional rights pertaining to privacy.

Please note that:

- Participation in the study will be voluntary
- All data collected will be used for research purposes.
- Your child will be free to withdraw at any point without being penalized. However, all data collected before his/her withdrawal may be used in the research process. It would be appreciated if I am informed in advance.
- No monetary rewards will be given.
- There are no known risks involved.
- Request to conduct research was approved by the Ministry of Education and the management of the school.
- All information about your child's name and school will be kept confidential.

- At the end of the data collection process copies of transcripts of the interviews, audio and video recordings will be made available to you upon completion.

If you agree to your child taking part in this research study, please sign and submit the attached declaration form.

If you wish to have any further information about any aspect of the study, feel free to contact me on 57851455 or on dpatpur@yahoo.com . You may also contact my supervisors or the UKZN Research Office:

Dr Tamirirofa Chirikure (Supervisor)
School of Education, College of Humanities; University of KwaZulu-Natal
Private Bag X03, Ashwood 3605, South Africa
Email: chirikure@ukzn.ac.za; Tel: +27 31 260 3470

Dr Angela James (Supervisor)
School of Education, College of Humanities; University of KwaZulu-Natal
Private Bag X03, Ashwood 3605, South Africa
Email: jamesa1@ukzn.ac.za; Tel: +27 31 260 3438

Dr A B Rumjaun (MRSB, UK)
Associate Professor (Biosciences Education)
Head, School of Science and Maths; Mauritius Institute of Education
Reduit; Mauritius
Tel: (230) 401-6555; Fax: (230) 467-5159; Mobile: +23057756523

Research Office: HSSREC – Ethics
University of KwaZulu-Natal Govan Mbeki Building
Private Bag X54001, Durban 4000, South Africa
Tel: +27 31 260 4557; Fax: +27 31 260 1609

Thanking you in advance for your co-operation.

Yours faithfully

Deenesh Patpur

PARENT'S/GUARDIAN'S CONSENT - DECLARATION

Title of the research: Exploring Mauritian Upper Secondary Students' Conceptions of and Approaches to Learning Biology.

I, ………………………………………………………., the undersigned parent/guardian of …….……………………………………….…...... agree/disagree that she/he should participate in Mr Deenesh Patpur's study.

I understand that:

- My child will participate voluntarily and I am at liberty to withdraw him/her from the project at any time should I so desire with no negative consequences.
- I voluntarily give permission for the study's activities to be digitally recorded.
- My child's identity will not be disclosed and that a pseudonym will be used to protect his/her identity.

I hereby: *(please tick in the appropriate box in table below)*

Agree to audio-recording	
Do not agree to audio-recording	

I hereby: *(please tick in the appropriate box in table below)*

Agree to photographing and video-recording	
Do not agree to photographing and video-recording	

Signature of parent/guardian ………………………. Date …………………...

Appendix D: Participant's Information Sheet and Assent Form for Questionnaire Survey and Interview

Dear student

I am currently enrolled on a PhD in Education at the University of KwaZulu-Natal (UKZN) in Durban, South Africa. My research project is entitled: *Exploring Mauritian Upper Secondary Students' Conceptions of and Approaches to Learning Biology*. The aim of my study is to find out are Mauritian upper secondary school students' conceptions of learning and approaches to learning Biology. I would be pleased if you could agree to participate in my research.

In line with my research, I shall need to gather enough data for analysis, therefore all the collected data will be used for my research. The gathered information will be kept confidential and be used only in line with my research project. For the purpose of data collection, you will be administered a survey questionnaire. You will be asked to respond to the survey questionnaire voluntarily. You may also be selected for a video/audiotaped interview. Please note that:

- Participation in the study will be voluntary
- You will be free to withdraw at any point without being penalized. However, it would be appreciated if I am informed in advance.
- No monetary rewards will be given.
- There are no known risks involved.
- Request to conduct research was approved by the Ministry of Education and the management of your school.
- All information about your name and school will be kept confidential.
- At the end of the data collection process copies of transcripts of the interviews, audio and video recordings will be made available to you and your school upon completion.

If you agree to take part in this research study, please sign and submit the attached declaration form.
It would be appreciated if you discuss your involvement with your parent or guardian before you complete the form below to indicate whether you agree or disagree to take part in this study.
If you wish to have any further information about any aspect of the study, feel free to contact me on 57851455 or on dpatpur@yahoo.com . You may also contact my supervisors or the UKZN Research Office:

Dr Tamirirofa Chirikure (Supervisor)
School of Education, College of Humanities; University of KwaZulu-Natal

Private Bag X03, Ashwood 3605, South Africa
Email: chirikure@ukzn.ac.za; Tel: +27 31 260 3470

Dr Angela James (Supervisor)
School of Education, College of Humanities; University of KwaZulu-Natal
Private Bag X03, Ashwood 3605, South Africa
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Dr A B Rumjaun (MRSB, UK)
Associate Professor (Biosciences Education)
Head, School of Science and Maths; Mauritius Institute of Education
Reduit; Mauritius
Tel: (230) 401-6555; Fax: (230) 467-5159; Mobile: +23057756523

Research Office: HSSREC – Ethics
University of KwaZulu-Natal Govan Mbeki Building
Private Bag X54001, Durban 4000, South Africa
Tel: +27 31 260 4557; Fax: +27 31 260 1609

Thanking you in advance for your co-operation.

Yours faithfully

Deenesh Patpur

Declaration

I, …………………………………………………………………. agree/disagree to participate in Mr Deenesh Patpur's study. The purpose, terms and conditions of the research have been explained to me. I understand that I may withdraw from the project at any time.

I hereby: *(please tick in the appropriate box in table below)*

Agree to audio-recording	
Do not agree to audio-recording	

I hereby: *(please tick in the appropriate box in table below)*

Agree to photographing and video-recording	
Do not agree to photographing and video-recording	

Signature of participant ……………………………... Date ……………………………

Appendix E: Survey Questionnaire

Section A: The Questionnaire Items on the COLB						
For each of the listed statements, please tick (√) the one response that best expresses the extent to which you agree or disagree with the statement						
	Memorising	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
M1	Learning biology means memorising the definitions, formulae, and laws found in a biology textbook.					
M2	Learning biology means memorising the important concepts found in a biology textbook.					
M3	Learning biology means memorising the proper nouns found in a biology textbook that can help solve the teacher's questions.					
M4	Learning biology means remembering what the teacher lectures about in the biology class.					
M5	Learning biology means memorising biological symbols, biological concepts, and facts.					
M6	Learning biology is just like learning history or geography, the most important thing is to memories the content of the textbook.					
M7	When learning biology, I need to memorise the biological definitions and formulae well or I will forget them.					
	Testing	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
T1	Learning biology means getting high scores in examinations.					
T2	If there are no tests, I will not learn biology.					

T3	There are no benefits to learning biology other than getting high scores in examinations. In fact, I can get along well without knowing many biological facts.					
T4	The major purpose of learning biology is to get more familiar with test materials					
T5	I learn biology so that I can do well in biology-related tests.					
T6	There is a close relationship between learning biology and taking tests.					
T7	Learning biology means answering the questions correctly in the examination.					
	Calculating and Practicing	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
CP1	Learning biology involves a series of calculations and problem-solving.					
CP2	I think that learning calculation or problem-solving will help me improve my performance in biology courses.					
CP3	Learning biology means knowing how to use the correct formulae when solving problems.					
CP4	The way to learn biology well is to constantly practice calculations and problem solving.					
CP5	There is a close relationship between learning biology, being good at calculations, and constant practice.					
CP6	Learning biology means constantly practicing calculations and problem solving.					
	Increasing one's Knowledge	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
IK1	Learning biology means acquiring knowledge that I did not know before.					
IK2	I am learning biology when the teacher tells me biological facts that I did not know before.					

IK3	Learning biology means acquiring more knowledge about natural phenomena and topics related to nature.					
IK4	Learning biology helps me acquire more facts about nature.					
IK5	I am learning biology when I increase my knowledge of natural phenomena and topics related to nature.					
	Applying	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
A1	The purpose of learning biology is learning how to apply methods I already know to unknown problems.					
A2	Learning biology means learning how to apply knowledge and skills I already know to unknown problems.					
A3	We learn biology to improve the quality of our lives.					
A4	Learning biology means solving or explaining unknown questions and phenomena.					
A5	Learning biology means solving or explaining unknown questions and phenomena.					
A6	Learning biology means acquiring knowledge and skills to enhance the quality of our lives.					
	Understanding & Seeing in a New Way	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
US1	Learning biology means understanding biological knowledge.					
US2	Learning biology means understanding the connection between biological concepts.					
US3	Learning biology helps me view natural phenomena and topics related to nature in new ways.					
US4	Learning biology means changing my way of viewing natural phenomena and topics related to nature.					
US5	Learning biology means finding a better way to view natural phenomena or topics related to nature.					

US6	I can learn more ways about thinking about natural phenomena or topics related to nature by learning biology.					
Section B: The Questionnaire Items on the ALB						
For each of the listed statements, please tick (√) the one response that best expresses the extent to which you agree or disagree with the statement						
	Deep Approach ***Deep motive***	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
DM1	I find that at times studying biology makes me feel really happy and satisfied.					
DM2	I feel that biology topics can be highly interesting once I get into them.					
DM3	I work hard at studying biology because I find the material interesting.					
DM4	I always greatly look forward to go to the biology class.					
DM5	I spend a lot of my free time finding out more about interesting topics which were discussed in the biology class.					
DM6	I come to the biology class with questions in my mind that I want to be answered.					
DM7	I find that I continually go over my biology classwork in my mind even whenever I am not in the biology class.					
DM8	I like to work on biology topics by myself so that I can form my own conclusions and feel satisfied.					
	Deep strategy	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
DS1	I try to relate what I have learned in biology to what I learn in other subjects.					

DS2	I like constructing theories to fit odd things together when I am learning biology topics.					
DS3	I try to find the relationship between the contents of what I have learned in biology.					
DS4	I try to relate new material to what I already know about the topic when I am studying biology.					
DS5	I try to understand the meaning of the contents I have read in biology textbooks.					
DS6	I can ask myself, possibly, to understand the subject matter I have learned in the biology class.					
	Surface Approach ***Surface motive***	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
SM1	I am discouraged by a poor mark in biology tests and worry about how I will do on the next text.					
SM2	Even when I have studied hard for a biology test, I worry that I may not be able to do well in it.					
SM3	I worry that my performance in the biology class may not satisfy my teacher's expectations.					
SM4	I want to get a good achievement in biology so that I can get a better job in the future.					
SM5	I want to do well in biology so that I can please my family and the teacher.					
SM6	No matter if I like it or not, I know that getting a good achievement in biology could help me to get an ideal job in the future.					
	Surface strategy	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
SS1	I see no point in learning biology materials that are not likely to be on the examinations.					

SS2	As long as I feel I am doing well enough to pass the examination, I devote as little time as I can to studying biology. There are many more interesting things to do with my time.					
SS3	I, generally, will restrict my study to what is specially set because I think it is unnecessary to do anything extra in learning a biology topic.					
SS4	I find that studying each topic in depth is not helpful or necessary when I am learning biology. There are too many examinations to pass and too many subjects to be learned.					
SS5	I find the best way to pass biology examinations is to try to remember the answers to likely questions.					
SS6	When learning biology, I try to memorise the content again and again till I remember it very well.					
SS7	I find that memorising the most important content makes me get high scores in the examinations instead of understanding it.					

Appendix F: Invitation for Students Selected to Participate in Interviews

Dear student

You may remember that a few weeks ago you kindly completed a questionnaire about conceptions of learning and approaches to learning biology. You were asked if you would be willing to participate in an interview to further explore conceptions of learning and approaches to learning, to which you agreed. I've finished collecting data for my questionnaire and am now doing interviews. You have been selected to participate in an interview which will be held during school hours in your school. The date and time of the interview will be communicated to you in due course. The discussion will focus on your learning experiences, as well as learning conceptions. There is no need to prepare, and there are no proper answers or expected opinions. The conversation will be recorded, but nothing you say will be made public; only the researcher, me, will listen to the recording.

I hope to see you again soon, and I am grateful for your contribution to my studies.

Kind regards

Deenesh Patpur

Appendix G: Interview Schedule

1. What strategies do you use to learn biology?
2. What strategies do you use to learn biology when there is a test or exam
    (a) in one month?
    (b) in one week?
    (c) in one day?
3. Why do you use the strategies you have mentioned to learn biology?

This is the end of the interview

Thank you for your time and cooperation!

Appendix H: Students' Responses to the COLB and ALB Questionnaires

	Section A: The Questionnaire Items on the COLB					
	Memorising	Strongly agree %	Agree %	No opinion %	Disagree %	Strongly disagree %
M1	Learning biology means memorising the definitions, formulae, and laws found in a biology textbook.	17.3	49.5	7.8	18.3	7.1
M2	Learning biology means memorising the important concepts found in a biology textbook.	23.1	55.1	9.1	9.9	2.8
M3	Learning biology means memorising the proper nouns found in a biology textbook that can help solve the teacher's questions.	17.8	39.2	20.1	16.7	6.2
M4	Learning biology means remembering what the teacher lectures about in the biology class.	29.4	45.1	8.4	13.3	3.8
M5	Learning biology means memorising biological symbols, biological concepts, and facts.	23.1	41.5	17.3	12.7	5.4
M6	Learning biology is just like learning history or geography, the most important thing is to memories the content of the textbook.	9.5	19.7	14.1	34.4	22.3
M7	When learning biology, I need to memorise the biological definitions and formulae well or I will forget them.	29.0	40.6	14.5	11.9	4.0
	Testing	Strongly agree %	Agree %	No opinion %	Disagree %	Strongly disagree %
T1	Learning biology means getting high scores in examinations.	16.3	26.8	19.1	24.7	13.1
T2	If there are no tests, I will not learn biology.	8.2	23.9	10.3	38.7	18.9
T3	There are no benefits to learning biology other than getting high scores in examinations. In fact, I can get along well without knowing many biological facts.	4.0	24.5	11.3	50.5	9.7
T4	The major purpose of learning biology is to get more familiar with test materials	10.8	33.4	18.9	27.2	9.7
T5	I learn biology so that I can do well in biology-related tests.	21.7	46.1	12.5	13.9	5.8
T6	There is a close relationship between learning biology and taking tests.	15.3	36.7	24.5	17.5	6.0

T7	Learning biology means answering the questions correctly in the examination.	18.3	30.8	18.3	22.9	9.7
	Calculating and Practicing	Strongly agree %	Agree %	No opinion %	Disagree %	Strongly disagree %
CP1	Learning biology involves a series of calculations and problem-solving.	6.0	19.1	15.1	35.5	24.3
CP2	I think that learning calculation or problem-solving will help me improve my performance in biology courses.	15.5	27.8	18.1	19.5	19.1
CP3	Learning biology means knowing how to use the correct formulae when solving problems.	10.9	35.6	18.9	24.9	9.7
CP4	The way to learn biology well is to constantly practice calculations and problem solving.	6.0	23.7	18.5	34.6	17.2
CP5	There is a close relationship between learning biology, being good at calculations, and constant practice.	9.1	29.0	22.0	25.8	14.1
CP6	Learning biology means constantly practicing calculations and problem solving.	5.4	21.9	18.9	33.6	20.2
	Increasing one's Knowledge	Strongly agree %	Agree %	No opinion %	Disagree %	Strongly disagree %
IK1	Learning biology means acquiring knowledge that I did not know before.	50.5	35.3	8.2	4.4	1.6
IK2	I am learning biology when the teacher tells me biological facts that I did not know before.	47.3	35.6	10.9	4.8	1.4
IK3	Learning biology means acquiring more knowledge about natural phenomena and topics related to nature.	43.7	38.4	9.9	5.4	2.6
IK4	Learning biology helps me acquire more facts about nature.	44.9	37.8	8.5	6.2	2.6
IK5	I am learning biology when I increase my knowledge of natural phenomena and topics related to nature.	36.8	38.9	13.5	6.8	4.0
	Applying	Strongly agree %	Agree %	No opinion %	Disagree %	Strongly disagree %
A1	The purpose of learning biology is learning how to apply methods I already know to unknown problems.	18.9	39.8	23.9	12.7	4.7
A2	Learning biology means learning how to apply knowledge and skills I already know to unknown problems.	18.5	40.3	21.7	14.5	5.0
A3	We learn biology to improve the quality of our lives.	40.8	41.1	8.9	6.0	3.2
A4	Learning biology means solving or explaining unknown questions and phenomena.	19.1	37.8	25.6	13.7	3.8

A5	Learning biology means solving or explaining unknown questions and phenomena.	27.8	41.9	17.1	8.5	4.7
A6	Learning biology means acquiring knowledge and skills to enhance the quality of our lives.	33.6	39.6	14.3	10.1	2.4
	Understanding & Seeing in a New Way	Strongly agree %	Agree %	No opinion %	Disagree %	Strongly disagree %
US1	Learning biology means understanding biological knowledge.	40.4	42.3	9.9	4.4	3.0
US2	Learning biology means understanding the connection between biological concepts.	28.8	43.7	19.1	5.4	3.0
US3	Learning biology helps me view natural phenomena and topics related to nature in new ways.	37.8	40.3	12.5	5.8	3.6
US4	Learning biology means changing my way of viewing natural phenomena and topics related to nature.	33.7	38.8	15.5	6.0	6.0
US5	Learning biology means finding a better way to view natural phenomena or topics related to nature.	29.9	47.7	15.6	3.6	3.2
US6	I can learn more ways about thinking about natural phenomena or topics related to nature by learning biology.	25.6	41.4	19.1	9.5	4.4
Section B: The Questionnaire Items on the ALB						
	Deep Approach ***Deep motive***	Strongly agree %	Agree %	No opinion %	Disagree %	Strongly disagree %
DM1	I find that at times studying biology makes me feel really happy and satisfied.	34.1	37.4	15.3	7.4	5.8
DM2	I feel that biology topics can be highly interesting once I get into them.	42.5	37.8	10.1	6.6	3.0
DM3	I work hard at studying biology because I find the material interesting.	29.2	36.8	18.3	11.1	4.6
DM4	I always greatly look forward to go to the biology class.	27.6	39.4	16.5	11.9	4.6
DM5	I spend a lot of my free time finding out more about interesting topics which were discussed in the biology class.	19.7	31.8	18.3	21.5	8.7
DM6	I come to the biology class with questions in my mind that I want to be answered.	27.0	40.8	18.1	9.1	5.0
DM7	I find that I continually go over my biology classwork in my mind even whenever I am not in the biology class.	13.9	30.6	24.7	21.1	9.7
DM8	I like to work on biology topics by myself so that I can form my own conclusions and feel satisfied.	24.6	32.9	22.2	13.2	7.1
	Deep strategy	Strongly agree	Agree	No opinion	Disagree	Strongly disagree

		%	%	%	%	%
DS1	I try to relate what I have learned in biology to what I learn in other subjects.	23.7	35.9	19.5	14.7	6.2
DS2	I like constructing theories to fit odd things together when I am learning biology topics.	17.5	33.2	27.6	17.5	4.2
DS3	I try to find the relationship between the contents of what I have learned in biology.	24.4	39.2	22.1	9.5	4.8
DS4	I try to relate new material to what I already know about the topic when I am studying biology.	20.2	40.4	20.9	12.9	5.6
DS5	I try to understand the meaning of the contents I have read in biology textbooks.	26.8	46.9	12.1	8.0	6.2
DS6	I can ask myself, possibly, to understand the subject matter I have learned in the biology class.	23.9	43.6	23.5	6.6	2.4
	Surface Approach ***Surface motive***	Strongly agree %	Agree %	No opinion %	Disagree %	Strongly disagree %
SM1	I am discouraged by a poor mark in biology tests and worry about how I will do on the next text.	37.6	34.4	11.7	9.3	7.0
SM2	Even when I have studied hard for a biology test, I worry that I may not be able to do well in it.	34.0	34.2	12.9	13.5	5.4
SM3	I worry that my performance in the biology class may not satisfy my teacher’s expectations.	30.0	35.6	15.7	12.9	5.8
SM4	I want to get a good achievement in biology so that I can get a better job in the future.	45.3	28.6	13.7	8.2	4.2
SM5	I want to do well in biology so that I can please my family and the teacher.	41.4	26.2	13.9	11.7	6.8
SM6	No matter if I like it or not, I know that getting a good achievement in biology could help me to get an ideal job in the future.	36.8	34.3	16.5	8.0	4.4
	Surface strategy	Strongly agree %	Agree %	No opinion %	Disagree %	Strongly disagree %
SS1	I see no point in learning biology materials that are not likely to be on the examinations.	10.3	14.9	25.1	27.2	22.5
SS2	As long as I feel I am doing well enough to pass the examination, I devote as little time as I can to studying biology. There are many more interesting things to do with my time.	14.0	24.9	22.7	23.9	14.5

SS3	I, generally, will restrict my study to what is specially set because I think it is unnecessary to do anything extra in learning a biology topic.	9.7	16.8	28.0	29.8	15.7
SS4	I find that studying each topic in depth is not helpful or necessary when I am learning biology. There are too many examinations to pass and too many subjects to be learned.	12.9	21.1	21.3	28.2	16.5
SS5	I find the best way to pass biology examinations is to try to remember the answers to likely questions.	21.9	36.4	13.9	16.9	10.9
SS6	When learning biology, I try to memorise the content again and again till I remember it very well.	27.6	40.4	13.3	13.1	5.6
SS7	I find that memorising the most important content makes me get high scores in the examinations instead of understanding it.	23.9	25.0	15.1	22.3	13.7

Appendix I: Component Transformation Matrix

Table 1

Component Transformation Matrix for Conceptions of Learning Biology

Component	Calculating and Practicing	Exploring real life and natural phenomena	Increasing One's Knowledge	Testing	Memorising	Applying
Calculating and Practicing	.569	.648	.315	.235	.139	.289
Exploring real life and natural phenomena	.706	-.483	-.432	.272	.044	-.078
Increasing One's Knowledge	-.288	-.159	.222	.675	.602	-.158
Testing	.253	-.201	.338	-.626	.594	-.193
Memorising	.090	-.509	.689	.109	-.386	.311
Applying	-.154	-.151	-.276	-.109	.338	.867

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Table 2

Component Transformation Matrix for Approaches to Learning Biology

Component	Deep motive	Surface Strategy	Deep Strategy	Surface motive
Deep motive	.818	-.212	.528	.091
Surface Strategy	.005	.775	.200	.600
Deep Strategy	.226	.592	.021	-.773
Surface motive	.530	.067	-.825	.183

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalizati

Appendix J: Communalities

Table 3

Communalities for Conceptions of Learning

Items on the questionnaire depicting conceptions of learning	Initial	Extraction
Learning biology means memorising the definitions, formulae, and laws found in a biology textbook.	1.000	.650
Learning biology means memorising the proper nouns found in a biology textbook that can help solve the teacher's questions.	1.000	.512
Learning Biology means remembering what the teacher lectures about in the biology class.	1.000	.501
Learning biology means getting high scores in examinations.	1.000	.465
I learn biology so that I can do well in biology-related tests.	1.000	.461
There is a close relationship between learning biology and taking tests.	1.000	.510
Learning biology means answering the questions correctly in the examination.	1.000	.410
Learning biology involves a series of calculations and problem-solving.	1.000	.509
I think that learning calculation or problem-solving will help me improve my performance in biology courses.	1.000	.457
Learning biology means knowing how to use the correct formulae when solving problems.	1.000	.501
The way to learn biology well is to constantly practice calculations and problem solving.	1.000	.614
There is a close relationship between learning biology, being good at calculations, and constant practice.	1.000	.451
Learning biology means constantly practicing calculations and problem solving.	1.000	.517
Learning biology means acquiring knowledge that I did not know before.	1.000	.599
I am learning biology when the teacher tells me biological facts that I did not know before.	1.000	.667
Learning biology means acquiring more knowledge about natural phenomena and topics related to nature.	1.000	.547
I am learning biology when I increase my knowledge of natural phenomena and topics related to nature.	1.000	.457
The purpose of learning biology is learning how to apply methods I already know to unknown problems.	1.000	.711
Learning biology means learning how to apply knowledge and skills I already know to unknown problems.	1.000	.654
We learn biology to improve the quality of our lives.	1.000	.437
Learning biology means acquiring knowledge and skills to solve the problems happened in the real life.	1.000	.448
Learning biology means acquiring knowledge and skills to enhance the quality of our lives.	1.000	.521
Learning biology means finding a better way to view natural phenomena or topics related to nature.	1.000	.548
I can learn more ways about thinking about natural phenomena or topics related to nature by learning biology.	1.000	.474

Table 4

Communalities for Approaches to Learning

	Initial	Extraction
I find that at times studying biology makes me feel really happy and satisfied.	1.000	.538
I feel that biology topics can be highly interesting once I get into them.	1.000	.539
I work hard at studying biology because I find the material interesting.	1.000	.557
I always greatly look forward to go to the biology class.	1.000	.499
I spend a lot of my free time finding out more about interesting topics which were discussed in the biology class.	1.000	.467
I come to the biology class with questions in my mind that I want to be answered.	1.000	.348
I find that I continually go over my biology class work in my mind even whenever I am not in the biology class.	1.000	.403
I try to relate what I have learned in biology to what I learn in other subjects.	1.000	.473
I like constructing theories to fit odd things together when I am learning biology topics.	1.000	.551
I try to find the relationship between the contents of what I have learned in biology.	1.000	.534
I try to relate new material to what I already know about the topic when I am studying biology.	1.000	.506
I am discouraged by a poor mark in biology tests and worry about how I will do on the next test.	1.000	.577
Even when I have studied hard for a biology test, I worry that I may not be able to do well in it.	1.000	.630
I worry that my performance in the biology class may not satisfy my teacher's expectations.	1.000	.589
I see no point in learning biology materials that are not likely to be on the examinations.	1.000	.481
As long as I feel I am doing well enough to pass the examination, I devote as little time as I can to studying biology. There are many more interesting things to do with my time.	1.000	.480
I, generally, will restrict my study to what is specially set because I think it is unnecessary to do anything extra in learning a biology topic.	1.000	.588
I find that studying each topic in depth is not helpful or necessary when I am learning biology. There are too many examinations to pass and too many subjects to be learned.	1.000	.485

Appendix K: Interview Data

Student 1 (S1)

R **What strategies do you use to learn biology?**

S1 I work a lot of past exam papers. When I work out past exam papers, I memorise the answers, particularly those of 'essay type' questions so that I may get full marks.

R **What other strategies do you use to learn biology?**

S1 I work out past exam papers. Apart from CIE, I also work on another site 'IGCSE Past Papers Revision'. The questions are from UK. They are a bit tough, but they are like CIE.

R **Does working out past exam papers make it easier for you to learn biology?**

S1 Yes. I find that it makes it easier because when I work out past exam papers, I find that the questions are similar. There are questions which change but most of them are the same. Then, I can answer questions correctly and score maximum marks in exams.

R **Do you work out past exam papers after each chapter that you have done in class or when you have done many chapters?**

S1 Once the teacher has finished a chapter in class, I work out the past exam papers for that chapter.

R **What other strategies do you use to learn biology?**

S1 Sometimes I watch films on YouTube. For example, I didn't understand how cells developed during reproduction. Those films have helped me to understand.

R **What other biology films have you watched on YouTube?**

S1 I have watched films on enzymes, photosynthesis, respiration.

R **Do you also learn Biology to increase your general knowledge?**

S1 Yes. There are things that I didn't know in the past, but which I came to know when I learned biology. There are things which I was not doing well in the past, now that I know, I know what to do.

R What are the things that you did not know before and which you learned in biology?

S1 For example, balanced diet, reproductive system, how my body works. Sometimes I share this information with my family.

R What strategies do you use to learn biology when there is a test or exam in one month?

S1 First, I start memorising topics that I find difficult such as genetics and reproduction. I also memorise definitions in certain chapters so that I may answer questions correctly in exams and obtain full marks. Then I look at the essay type questions in past exam papers. I find out what questions have been frequently asked. Then I give more attention to these questions. Then I work out past exam papers as much as I can.

R What strategies do you use to learn biology when there is one week remaining before a test or exam? Do you change your strategy?

S1 No. I don't change my technique. I fear that I may fail. I am not a fast learner.

R What strategies do you use to learn biology when there is one day remaining before a test or exam?

S1 I stick to the same technique. I don't change.

Student 2 (S2)

R What strategies do you use to learn biology?

S2 I do a lot of practicing. There's a lot of theory which I won't be able to memorise. There are ATP (alternative to practical) questions. We should practice these questions.

R Why do you practice a lot of ATP questions?

S2 There are questions which repeat. It is important to do practicals in the laboratory but if you don't work out the questions, it becomes difficult for the exams. I also work out past exam papers. Working out questions allows me to score maximum marks in exams.

R Why do you work out past exam papers; how does it help you?

S2 When I work out past exam questions, I find that sometimes questions repeat. You can predict which questions may come out for the exams. Sometimes if you have already worked out a question and it comes out, it becomes easier to answer the question. I also consult the examiner's comments. How to answer the question. The examiner also tells you for which answer you get maximum marks, and for which answers you don't get marks.

R What other strategies do you use to learn biology?

S2 I ask my teacher to send me 'links'. When I watch the videos on internet, I find that it explains more in detail. Above all it shows questions. It is well elaborated.

R How does this strategy help you to learn biology?

S2 The 'links' help me to understand the topic better. When it is done in class, it takes me some time to understand it. When I watch videos on that topic, I understand it better.

R Do you also learn biology to increase your general knowledge?

S2 Yes. There are topics that help me understand how my body functions. There are topics like pollution, genetics, biotechnology, biodiversity that have increased my general knowledge. For example, Covid 19; I know that it is caused by a virus, and I know what a virus is.

R Do you apply what you have learned in biology in your everyday life?

S2 Yes. Topics like balanced diet, care of the teeth helps me to stay in good health.

R Do you memorise certain topics in biology?

S2 Not all. For example, I understand definitions first and then I memorise them so that I don't miss anything for the exams so that I score maximum marks. I must also practice drawing diagrams and memorise the labeling.

R How do you learn biology when there is a test or exam in one month?

S2 When I finish doing the chapters, I don't wait for the eve to revise because Biology is not a subject that you can learn on the eve of a test.

R How do you learn biology when there is one week remaining before a test or exam?

S2 I work out a lot of past exam papers.

R How do you learn biology when there is one day remaining before a test or exam?

S2 I make a summary of each chapter and I memorise the main points and definitions.

Student 3 (S3)

R What strategies do you use to learn biology?

S3 Normally, after the teacher has finished explaining a topic in class, there are only two things that I do, I work out past exam papers and do some research on internet. For example, if the teacher has explained a topic on cells today, when I go home, I revise whatever he has given me and I try to discover related things on the internet. It becomes very interesting to discover that it is related with many other topics.

R Why do you work out past exam papers; how does it help you?

S3 After each chapter, I work out classified questions. At the end, just to test myself, I work out a whole past exam paper, which I give my teacher to correct. It makes it easier for me to answer questions in tests and exams.

R Do you memorise certain topics in biology?

S3 I very rarely memorise; I prefer using logic.

R What other strategies do you use to learn biology?

S3 I watch films which interest me, at home. At times when the teacher explains, it's abstract; with the help of audio visuals, it becomes more concrete.

R Do you also learn biology to increase your general knowledge?

S3 Yes. I have learned a lot about my body, about living things, about the environment.

R Do you apply what you have learned in biology in your everyday life?

S3 Yes. I take proper care of my body, what I eat and the environment.

R How do you learn biology when there is a test or exam in one month?

S3 I read my notes and I practice past exam papers.

R How do you learn biology when there is one week remaining before a test or exam?

S3 I do more of memorising. I try to remember all the definitions and the answers to questions from past exam papers so that I may score maximum marks in the exams.

R How do you learn biology when there is one day remaining before a test or exam?

S3 I read the questions and their answers again and again.

Student 4 (S4)

R What strategies you use to learn biology?

S4 I work out past exam questions. The teacher gives us to work out past exam questions at the end of each chapter. It becomes easier, I think, instead of working out the questions when we finish the syllabus.

R What are the advantages of working out past exam questions?

S4 I practice questions because sometimes the questions repeat in the exams; then it becomes easier to answer the questions.

R What other strategies do you use to learn biology?

S4 If I can memorise the answers of past exam questions, it becomes easier because it is only 2 or 3 lines. The answer of an essay type question would be more difficult to memorise in detail, therefore I memorise only the main points. I think that memorising a definition of 3 or 4 lines would be easier. But we have to practice a lot of essay type questions.

R **Why do you memorise the answers to past exam papers?**

S4 Very often, the questions repeat in the exams. Therefore, it becomes easier for me to answer the questions.

R **Do you use other strategies to learn biology?**

S4 Yes. When the teacher has finished explaining a topic, at home, I watch films on that topic on YouTube. This enables me to understand the topic better.

R **How do these films help you?**

S4 I understand the topics better because they are visual. There are films on the environment, on genetically modified organisms which are very interesting.

R **Do you also learn biology to increase your general knowledge?**

S4 Yes. Topics on environment, ecology, microorganisms, genetics.

R **Do you apply what you have learned in biology in your everyday life?**

S4 Yes. There are topics like nutrition. I try to eat a balanced diet but sometimes it is not possible. There is a topic on care of the teeth; this I do apply.

R **How do you learn biology when there is a test or exam in one month?**

S4 I work out past exam papers, read them once again, but under exam conditions. I do it according to the time indicated on the question paper.

R **How do you learn biology when there is one week remaining before a test or exam?**

S4 I work it out exam style, that is, exam conditions. I will work out the past exam paper, but I will consult my notes if I don't know the answer to a particular question, however I will answer the questions by myself as much as I can.

R **How do you learn biology when there is one day remaining before a test or exam?**

S4 I work strictly under exam conditions without consulting my notes.

Student 5 (S5)

R **What strategies do you use to learn biology?**

S5 When the teacher has finished explaining a chapter, I practice past exam papers. I refer to my notes. If I get it wrong, I do it again and again until I understand.

R **Why do you practice past exam papers?**

S5 The questions have a tendency to repeat with small modifications. When I practice past exam papers, it becomes easier for me to answer questions in exams.

R **What other strategies do you use to learn biology?**

S5 Sometimes I memorise definitions. I understand it first, then I practice past exam papers, then I memorise the definitions.

R **Why do you memorise definitions?**

S5 So that I can answer questions well in the exams.

R **Any other strategy that you use to learn biology?**

S5 I watch biology films on YouTube. It makes it easier to understand and increase my general knowledge. For example, I have learned how bacteria are used to manufacture cheese and yoghurt. There are films on enzymes, respiration, heart, photosynthesis, brain, ecology, evolution which are very interesting.

R **How do you learn biology when there is a test or exam in one month?**

S5 I work out a past exam paper, then I look for the mistakes I have done. I examine all the mistakes and learn the parts I have not understood.

R **How do you learn biology when there is one week remaining before a test or exam?**

S5 I read my notes again. I work out past exam questions. I memorise definitions and diagrams.

R **How do you learn biology when there is one day remaining before a test or exam?**

S5 I read my notes again.

Student 6 (S6)

R **What strategies do you use to learn biology?**

S6 The teacher gives some work to do in class. We practice the questions in class, and when I reach home, I do some research on that chapter in my biology textbook. I note the key points. Then I learn them. After that, I practice questions from past exam papers.

R **Why do you practice questions in past exam papers?**

S6 The teacher gives the questions. Then he corrects the answers. I know what mistakes I have done. Then, I know how to answer questions in the exams.

R **What other strategies do you use to learn biology?**

S6 The teacher sends me videos on WhatsApp which I watch at home. I watch certain videos by myself.

R **How do these videos help you to learn biology?**

S6 They help me to understand the topic better. For example, the circulatory system. The videos show how the blood circulates, double circulation, how the heart pumps blood.

R **Do you apply what you have learned in biology in your everyday life?**

S6 Yes. For example, I have learned what a balanced diet is. Now I know what to eat to remain in good health. I also know that I have to exercise for blood to circulate properly.

R **How do you learn biology when there is a test or exam in one month?**

S6 Then I start revising. I learn by rote. I work out questions. I practice past exam papers.

R **What do you learn by rote?**

S6 I learn definitions by rote. I understand them first and then I learn them by rote. It becomes easier for me to answer in exams. It allows me to score full marks in exams.

R **How do you learn biology when there is one week remaining before a test or exam?**

S6 I practice a lot of past exam papers.

R **Why do you practice past exam papers?**

S6 The questions repeat. There is a great chance the questions come again; then it becomes easier for me to answer in exams.

R **How do you learn biology when there is one day remaining before a test or exam?**

S6 I revise my notes and I learn the main points.

Student 7 (S7)

R **What strategies do you use to learn biology?**

S7 First, I memorise all my notes. If I don't understand something, I watch videos on YouTube. I try to look for questions on that topic. I work out exam papers. If I encounter any difficulty, I refer to my notes.

R **You learn everything by rote?**

S7 Yes, almost all. I prepare my own notes, first I understand them, and then I memorise them. I write down the notes in my own words. There are words that are difficult to remember, I repeat them several times till I remember.

R **Why do you learn your notes by rote?**

S7 It becomes easier for me to answer questions. They remain in my mind. I don't have to think a lot.

R **What other strategies do you use to learn biology?**

S7 I practice past exam papers after each chapter. I work in classified.

R **Why do you practice past exam papers after each chapter?**

S7 I know what type of questions come out in exams. The teacher guides us how to answer the questions.

R **What other strategies do you use to learn biology?**

S7 I watch films on YouTube at home. I do some research. When there are outings, for example in an island like "Ile aux Aigrettes", it helps me to better understand biodiversity, you interact with nature. Once there was a caravan which came to school. They brought a microscope and showed us very interesting slides. They also showed us films on coral reefs. Then I could understand better.

R **Do you visit "places of scientific interest"?**

S7 Yes. We visited the "Rajiv Gandhi Science Centre". I saw very interesting things there. Educational tours are very important; they help me to understand better.

R **Do you also learn biology to increase your general knowledge?**

S7 Yes. I have learned a lot about things I did not know before. For example, how my body functions, how plants carry out photosynthesis, carbon cycle, greenhouse effect, pollution, how animals and plants reproduce.

R **Do you apply what you have learned in biology in your everyday life?**

S7 Yes. Now I know what to eat to remain healthy. I know what effect pollution has on the environment.

R **How do you learn biology when there is a test or exam in one month?**

S7 I revise. I work out past exam questions. I review my notes.

R **How do you learn biology when there is one week remaining before a test or exam?**

S7 I learn definitions and practice past exam questions.

R **How do you learn biology when there is one day remaining before a test or exam?**

S7 I read my notes several times so that I don't forget and, therefore I can answer questions correctly in the exams.

Student 8 (S8)

R **What strategies do you use to learn biology?**

S8 In fact, for me, it depends on the chapter that I have to learn. There are certain chapters that are interesting. I find that I understand them and I can learn them. For example, "inheritance". We have not yet done it, but it is a chapter that I want to do because I can understand certain things. There are other chapters that are easy for me to learn because I am interested and I know that I can understand how my body works. The chapter on "cells" is also interesting but I prefer to revise it to pass because I know that it will come for the exams.

R How do you learn a topic in biology?

S8 I prepare my notes. I read my notes once and then I summarize them. I prepare "flash cards" with notes in bullet form and questions on one side and the answers at the back. When I revise, it becomes easier for me when I utilise these "flash cards". When a chapter is bulky and there is a lot of information to learn, I watch video films on YouTube. There are films on genetics, evolution, natural selection, conservation that are very interesting. I have also learned how my body functions through films on topics like cells, blood circulation respiration, nutrition, reproduction. There are cartoon versions that help me to better understand the topic.

R What other strategies do you use to learn biology?

S8 I work out past exam papers. At the end of each chapter, the teacher gives us past exam questions to work at home.

R What are the advantages of working past exam papers?

S8 I know what type of questions come out in the exams. The teacher explains to us how to answer the questions.

R What other strategies do you use to learn biology?

S8 When I do practical in the laboratory, I understand the chapter better.

R How do you learn biology when there is a test or exam in one month?

S8 I prepare short notes on each chapter and then I revise them.

R How do you learn biology when there is one week remaining before a test or exam?

S8 I use the same technique. I prepare short notes and revise them.

R How do you learn biology when there is one day remaining before a test or exam?

S8 On the eve of exams; I know that I have already prepared my notes. At times, I don't want to look at them because I can't learn so much by rote. I prefer to watch video films and read bullet points.

Student 9 (S9)

R What strategies do you use to learn biology?

S9 The explanation given by the teacher in class is very important to understand the chapter. I must understand it first and then I can learn it. Sometimes I work out questions in past exam papers and I have to write to be able to understand and remember.

R Why do you work out questions in past exam papers?

S9 When I write the answers, I remember. Therefore, it becomes easier to answer questions in exams.

R What other strategies do you use to learn biology?

S9 I memorise definitions, functions, examples.

R Why do you memorise definitions, functions, examples?

S9 So that I don't forget in the exams. Then, I do not lose marks.

R What other strategies do you use to learn biology?

S9 I also work out past exam papers, but not so much by myself. I work them more often at school. Before an exam, the teacher gives us past exam papers to work because very often the questions that come out for the exams are taken from past exam papers.

R Do you also learn biology to increase your general knowledge?

S9 Yes. I watch films on YouTube after the teacher has explained a topic on biology. This allows me to increase my general knowledge.

R **What films have you watched that have increased your general knowledge?**

S9 Films on reproduction in animals and plants, respiration, photosynthesis, nutrition, ecology, pollution, inheritance.

R **Do you apply what you have learned in biology in your everyday life?**

S9 Yes. For example, balanced diet, care of the teeth, hygiene, practicing sport regularly.

R **How do you learn biology when there is a test or exam in one month?**

S9 I read my notes again. Whenever I don't understand something, I seek the help of my teacher. Our teacher does revision work and gives us past exam papers to work out.

R **How do you learn biology when there is one week remaining before a test or exam?**

S9 I prefer to work out past exam questions by myself and I memorise definitions.

R **How do you learn biology when there is one day remaining before a test or exam?**

S9 On the eve, I prefer to read my notes so that I remember them.

Student 10 (S10)

R **What strategies do you use to learn biology?**

S10 I prepare my own notes, and then I memorise them so that I can use them to answer questions in the exams. The notes I prepare by myself, I remember, and whenever I don't understand, I watch videos on YouTube. When the teacher has finished explaining a topic in class, I look for videos on YouTube to watch at home. If I have missed something or I haven't understood something, I can learn it by myself through videos.

R **What are the things that you have learned through video films?**

S10 There are videos that show, for example, how and why we have to recycle plastic, paper, glass. There are also videos which show the causes of pollution, how to conserve forests, how animals and plants reproduce, the process of photosynthesis and many other topics.

R **What other strategies do you use to learn biology?**

S10 I practice past exam papers. The teacher gives us past exam papers to work out.

R **Why do you practice past exam papers?**

S10 I know what type of questions comes out for exams and I also know how to answer them.

R **Do you apply what you have learned in biology in your everyday life?**

S10 Yes, for example, I used to brush my teeth only in the morning. The teacher has explained why we must brush our teeth at night also. Now I brush my teeth both in the morning and at night.

R **How do you learn biology when there is a test or exam in one month?**

S10 Then I revise all my notes from the beginning so that I remember them.

R **How do you learn biology when there is one week remaining before a test or exam?**

S10 Then, I work out past exam papers because the questions can come out again. I work out the questions again by myself. I use the marking scheme to correct them myself.

R **How do you learn biology when there is one day remaining before a test or exam?**

S10 Then I review the questions and try to memorise the answers.

Student 11 (S11)

R **What strategies do you use to learn biology?**

S11 When the teacher has explained a topic, I work out questions on the topic at home. The next day, I wake up early in the morning and try to understand the topic by myself.

R **What other strategies do you use to learn biology?**

S11 I memorise definitions and main points.

R Why do you memorise definitions and main points?

S11 I leave fewer mistakes when I write the answers in tests and exams.

R What other strategies do you use to learn biology?

S11 I work out past exam papers.

R Why do you work out past exam papers?

S11 To know how to answer questions. Then, it becomes easier to answer questions in the exams because very often questions repeat.

R Do you also learn biology to increase your general knowledge?

S11 Yes. When the teacher has finished explaining a topic, I do some research on that topic on internet. Some topics have enabled me to understand how my body functions and others have enabled me to understand the environment, the ecosystem, evolution.

R Do you apply what you have learned in biology in your everyday life?

S11 Yes. There are topics that help me in my everyday life. For example, nutrition, respiration, effects of smoking and alcohol on health.

R How do you learn biology when there is a test or exam in one month?

S11 Then, I work more of past exam papers.

R How do you learn biology when there is one week remaining before a test or exam?

S11 I memorise certain things like definitions, I practice drawing diagrams and all that.

R How do you learn biology when there is one day remaining before a test or exam?

S11 I concentrate on my notes and I read them again; I look at the main points.

Student 12 (S12)

R What strategies do you use to learn biology?

S12 When the teacher has finished explaining in class, I ask him to explain the things that I have not understood again. At home, I review my notes. When the teacher finishes a chapter, then I practice questions, chapter wise. Then I make "mind maps". It becomes easier for me to understand it. Instead of reading all the notes, I prefer to look at the "mind map", I understand it better.

R What other strategies do you use to learn biology?

S12 I watch video films on YouTube. It is well explained. I understand it better and I learn many additional things which are related to the chapter. For example, wildlife, pollution and all that.

R Do you learn by rote?

S12 No, I don't learn by rote. I prefer to write it down in my own words; then I can remember.

R How do you learn biology when there is a test or exam in one month?

S12 Rather, the "mind maps" help me; there's everything in there. Then I work out past exam questions. I know which type of questions come for the exams.

R Why do you practice questions?

S12 So that I know what mistakes I have done and so that I do not repeat the same mistakes for the exams. Thus, I minimize the number of mistakes. My aim is to minimize mistakes in the exams.

R Do you apply what you have learned in biology in your everyday life?

S12 Yes, I have learned many things about my body which I can use.

R How do you learn biology when there is a test or exam in one month?

S12 I use the "mind maps" to learn.

R How do you learn biology when there is one week remaining before a test or exam?

S12 I practice past exam questions because they can come out again for the exams.

R **How do you learn biology when there is one day remaining before a test or exam?**

S12 I use the "mind maps" to revise.

Student 13 (S13)

R **What strategies do you use to learn biology?**

S13 I work out past exam questions. I prepare my own notes and I practice how to draw diagrams.

R **What other strategies do you use to learn biology?**

S13 I memorise functions, definitions and important points.

R **What other strategies do you use to learn biology?**

S13 I use the internet to watch animated films because they explain more in detail and, therefore, it helps to better understand the chapter.

R **What other strategies do you use to learn biology?**

S13 I work out past exam questions because they show us how the questions the questions that usually come out are structured. Then. If I get a similar question for the exams, I can answer it very easily.

R **Do you also learn biology to increase your general knowledge?**

S13 Yes, when the teacher has finished explaining a chapter, I watch films on YouTube, I learn many interesting things on that topic. For example, the importance of photosynthesis, respiratory diseases, metabolism, the process of natural selection and evolution.

R **Do you apply what you have learned in biology in your everyday life?**

S13 Yes, I think that all the topics in biology are linked with our life and I apply them in my everyday life. For example, nutrition, balanced diet, care of the teeth.

R **How do you learn biology when there is a test or exam in one month?**

S13 I revise my notes. I note the main points. I work out past exam questions.

R **How do you learn biology when there is one week remaining before a test or exam?**

S13 I prefer to watch films on the topics that we have done in biology. It makes it easier for me to remember whatever we have to study for the exams.

R **How do you learn biology when there is one day remaining before a test or exam?**

S13 I learn the main points in each chapter.

Student 14 (S14)

R **What strategies do you use to learn biology?**

S14 Sir, in fact, I like doing biology since I was a child. After my secondary education, I want to continue my studies in the field of biology. When the teacher has finished explaining, I look at my notes. It becomes easier for me to understand when the teacher uses models to explain and makes us manipulate the models. For example, I constructed a DNA model; it has become easier for me to understand and remember. I don't wait for the exams to learn. As soon as a chapter is over, I read its notes at home. When I finish revising, then I practice past exam papers. I practice a lot of past exam papers. Whenever I get a difficulty in a chapter, I go and see my teacher. Then he explains it to me again.

R **Why do you work out past exam papers?**

S14 Every year, in the exam papers, the questions change but the concept remains the same. I only need to understand the question and I know what to answer.

R **What other strategies do you use to learn biology?**

S14 My teacher sends me videos to watch. I watch many biology films on the internet by myself. There are things that are shown but are not in the biology syllabus. However, I can relate them with what I am studying. For example, evolution, DNA replication, diseases, wild life.

R **When do you watch those videos; before the teacher explains the topic or after?**

S14 In fact, sir, when the teacher tells us that he is going to do a topic in the next lesson, I read about it in my textbook beforehand so as to get an idea about the topic and be able to ask questions to the teacher. When it has been explained in class, then, to enable me to better understand what the teacher has explained, I look for that topic on YouTube. Sometimes the teacher sends me videos.

R **Do you also learn biology to increase your general knowledge?**

S14 Yes, the videos I watch on YouTube and those sent by my teacher allow me to increase my general knowledge.

R **Do you apply what you have learned in biology in your everyday life?**

S14 I apply topics like nutrition, respiration, pollution in my everyday life.

R **How do you learn biology when there is a test or exam in one month?**

S14 I look at all the chapters from the beginning. I work out past exam papers. I consult my notes whenever I get some difficulty to answer a question.

R **How do you learn biology when there is one week remaining before a test or exam?**

S14 I rather learn from the notes that I have prepared by myself.

R **How do you learn biology when there is one day remaining before a test or exam?**

S14 I just read my notes to refresh my mind.

R **Do you sometimes learn by rote?**

S14 I can't learn by rote. However, sometimes I learn certain definitions and the labelling of certain diagrams by rote so that I may score maximum marks for the exams.

Student 15 (S15)

R **What strategies do you use to learn biology?**

S15 The first step is to read my notes, try to understand their meaning. Once it is done, I study to grasp the concept then perhaps go towards the past exam papers to find out which type of questions I can get for the exams. Sometimes I am compelled to learn by rote, mainly definitions.

R **Why do you work out past exam questions?**

S15 In fact, it's more about how to prepare for the exams because one can see which type of questions are given and, what is interesting is that the same type of questions repeats. Finally, I become used to how to answer correctly and how I can get maximum marks.

R Are there other techniques that you use to learn biology?

S15 Sometimes I try to relate what I have learned with the world and the environment. For example, I do sports; I ask myself, what happens in my body, my heart beats faster and all that. Why do I sweat and all that?

R How do you learn biology when there is a test or exam in one month?

S15 I increase the amount of work that I do. I work more of past exam papers to see what my mistakes are and then correct them but, also to review all that I thought I knew but in fact I don't know.

R How do you learn biology when there is a test or exam in one week?

S15 When exams are near, I will perhaps work a bit more of past exam papers.

R How do you learn biology when there is a test or exam in one day?

S15 I prefer to read my notes to refresh my mind.

Student 16 (S16)

R What strategies do you use to learn biology?

S16 After the teacher has finished explaining a chapter, I learn it. The teacher gives questions to work at home. When he corrects them, I know what are the mistakes that I have done are and also how to answer the questions.

R What other strategies do you use to learn biology?

S16 When the teacher tells us that he will start a new chapter, I do some research on that chapter, beforehand. It becomes easier to understand it. When the teacher has finished the chapter, I work out past exam questions. When I don't know how to answer a question, I ask the teacher to explain it to me.

R Why do you work out past exam questions?

S16 When I work out past exam questions, I refer to my notes. It's a way for me to better understand the chapter and learn it at the same time. Most of the time, the questions repeat. It becomes easier if you know what to write.

R What other strategies do you use to learn biology?

S16 Sometimes the teacher asks us to prepare a topic and do a PowerPoint presentation in class. This helps me to better understand and remember the topic.

R Do you also learn biology to increase your general knowledge?

S16 I have learned many topics that I did not know before. For example, biotechnology, genetics, natural selection.

R Do you apply what you have learned in biology in your everyday life?

S16 I have learned how to take care of my body. I also avoid alcohol, cigarette and drugs because they can cause harm to my health.

R How do you learn biology when there is a test or exam in one month?

S16 I revise a bit of all chapters and I do "mind maps" and I put the main points. Then, it becomes easier for me to learn.

R How do you learn biology when there is one week remaining before a test or exam?

S16 I memorise definitions and main points so that I don't forget and score maximum marks in the exams.

R How do you learn biology when there is one day remaining before a test or exam?

S16 I have done a summary of each chapter in a notebook. I learn from it.

Note. R = Researcher

Initial/Predetermined codes. Memorising

Testing

Calculating and practicing

Increasing one’s knowledge

Applying

Understanding

Exploring real life and natural phenomena

Appendix L: Editing Certificate

18 Languedoc Street
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Bloemfontein
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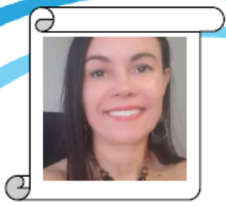
elginettek@gmail.com

PROFESSIONAL LANGUAGE EDITING SERVICES



STRIVING FOR EXCELLENCE

BA- English major; BA Hons. Integrated Organisational Communication;
UCT Cert. in Copy-Editing; UFS Cert. in Labour Law, PGCE, TESOL Cert

SPECIALISING IN THE LANGUAGE EDITING OF THESES, DISSERTATIONS, JOURNAL ARTICLES, PROPOSALS, POLICIES AND PUBLICATIONS.

EDITING CERTIFICATE FOR LANGUAGE EDITING OF DOCTOR OF PHILOSOPHY:

Deenesh Patpur

UNIVERSITY OF KWAZULU-NATAL

This is to certify that Deenesh Patpur's Dissertation submitted in fulfilment of the requirements for the degree Doctor Of Philosophy in Education, specialising in International Relations at the University of Kwazulu-Natal, research topic: Exploring Mauritian Upper Secondary Students' Conceptions of and Approaches to Learning Biology, was edited for the following:

- Language editing (correct, spelling, grammar, punctuation)
- Automated table of contents, figures and tables
- Correcting of in-text references and list of references according to APA style guide
- Layout and formatting to ensure that the document looks neat and presentable

The editor will not be held accountable for any later additions or changes to the document that were not edited by the editor, nor if the client rejects/ignores any of the changes, suggestions or queries, which he/she is free to do. The editor can also not be held responsible for errors in the content of the document or whether or not the client passes or fails. It is the client's responsibility to review the edited document before submitting it for evaluation.

[redacted]

E. Kassim **DATE: 28/12/2022**

THANK YOU FOR YOUR SUPPORT

Appendix M: Turnitin Report

Exploring Mauritian Upper Secondary Students' Conceptions of and Approaches to Learning Biology

ORIGINALITY REPORT

5%	5%	4%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	researchspace.ukzn.ac.za Internet Source	2%
2	www.tandfonline.com Internet Source	1%
3	ir.nctu.edu.tw Internet Source	1%

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